Work Package 2:

Strategic Environmental Assessment for the proposed Boegoebaai Port, Special Economic Zone and Namakwa Region

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Edited by Greg Schreiner, Babalwa Mqokeli, Luanita Snyman-Van der Walt, Paul Lochner and Rinae Tsedu

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Werkpakket 2:

Strategiese Omgewings Assessering vir die voorgestelde Boegoebaai hawe, Spesiale Ekonomiese Sone en Namakwa-Streek

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kumulatiewe biodiversiteit, (d) voëls, (e) vlermuise, en (f) erfenishulpbronne. Fyner skaal sensitwiteitsanalise en -kartering vir die voorgestelde hawe en SES is voltooi onder WP1 van die SOA. 27

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Afkortings and akronieme

CBA	*Critical Biodiversity Area*
CPA	*Community Property Association*
CR	*Critically Endangered*
CSIR	*Council for Scientific and Industrial Research*
DFFE	*Department of Forestry, Fisheries and the Environment*
EMF	*Environmental Management Framework*
EN	*Endangered*
EWR	*Ecological Water Requirement*
FPIC	*Free, Prior and Informed Consent*
GH_2	Groen waterstof
GW	Gigawatt
Ha	Hektaar
IDPs	*Integrated Development Plans*
KBA	*Key Biodiversity Area*
KnX	Krag-na-X
NCEDA	*Northern Cape Economic Development, Trade and Investment Promotion Agency*
NCGHM	*Northern Cape Green Hydrogen Masterplan*
OBM	Opsomming vir Beleidsmakers
OIS	Omgewingsimpakstudie
PDIA	*Problem-Driven Iterative Adaptation*
PV	*Photovoltaic*
RQO	*Resource Quality Objectives*
SANEDI	*South African National Energy Development Institute*
SCC	*Species of Conservation Concern*
SDF	*Spatial Development Framework*
SES	Spesiale Ekonomiese Sone Economic Zone
SOA	Strategiese Omgewings Assessering
TNPA	*Transnet National Ports Authority*
TPC	*Thresholds of Potential Concern*
TVET	*Technical and Vocational Education and Training*
WP1	Werkpakket 1
WP2	Werkpakket 2

1. DIE OORSPRONG, BESTEK, DOEL EN METODES VAN DIE ASSESSERING

Groen waterstof (GH_2)[1] en afgeleide Krag-na-X (PtX) produkte, soos groen ammoniak en groen metanol, kan Suid-Afrika help om na 'n lae-koolstof-ekonomie oor te skakel. Dit kan gedoen word deur koolstofvrystellings in moeilik-om-te-verlaag sektore te verminder en deur streekontwikkeling te ondersteun.

Die Noord-Kaapse Groenwaterstof-Meesterplan (NCGHM, 2023) dui aan dat die Noord-Kaap goed geplaas is om hierdie oorgang te lei. Dit is te danke aan sy wêreldmededingende son- en windhulpbronne, groot stukke grond, en 'n kuslyn van 300 km waar 'n diepseehawe by Boegoebaai ondersoek word. Die provinsie se doelwitte sluit in 5 gigawatt (GW) se elektroliese, ondersteun deur 10 GW hernubare energie teen 2033, wat moet opskaal na 40 GW se elektroliese teen 2050. Om hierdie doelwitte te bereik, sal groot infrastruktuurontwikkeling oor verskeie munisipaliteite en ekosisteme nodig wees, insluitend energie-opwekkingsgebiede, transmissiekorridors, ontsoutingsaanlegte en vervoernetwerke. Hierdie groot ontwikkelinge kan moontlik bots met sensitiewe ekologiese stelsels, kultuurerfenisgebiede en sosio-ekonomiese omgewings in die Namakwa-distrik.

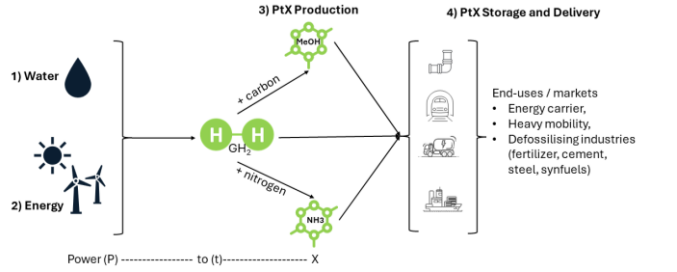
Om hierdie rede is 'n Strategiese Omgewingsbeoordeling (SOA) begin deur saamwerking tussen die South African National Energy Development Institute (SANEDI), die Northern Cape Economic Development, Trade and Investment Promotion Agency (NCEDA) en Transnet National Ports Authority (TNPA). Die Raad vir Wetenskaplike en Nywerheidsnavorsing (NWNN/CSIR) is aangewys om die onafhanklike SOA-proses te lei en te koördineer, met gebruik van gevestigde kundigheid in SOA, hernubare energie, hawebeplanning en groen waterstof.

Blok OBM 1: What is Groen Waterstof (GH_2) en Krag-na-X (KnX) produkte ?

GH_2 is 'n vorm van waterstofbrandstof wat geproduseer word deur elektrolise (dit wil sê deur water in waterstof en suurstof te verdeel) met behulp van hernubare energiebronne (bv. wind/son). PtX is 'n breër konsep wat verskeie tegnologieë en prosesse insluit (insluitend GH2) om elektriese energie, afkomstig van hernubare bronne, om te skakel in verskillende vorme van energiedraers, chemikalieë of materiale. Hierdie omskakeling maak dit moontlik om waterstof te stoor, te vervoer en te gebruik ("Power-to-Hydrogen"), sintetiese brandstowwe ("Power-to-Liquid"), en selfs chemikalieë ("Power-to-Chemicals"). Dit verbreed die toepassings van hernubare energie—veral belangrik vir sektore waar groen elektrifisering moeilik is, soos swaardiensvervoer, seevaart en lugvaart (die sogenaamde "hard-to-abate" sektore).

Infrastruktuurkomponente en prosesse wat nodig is om GH_2 en PtX-produkte te produseer en aan eindgebruikers te lewer:

- **Waterbron (H_2O)** – ontsoute seewater / afvalwater wat spesifiek vir GH_2/PtX-produksie voorsien word.
- **Energiebron** – elektrisiteitsopwekking deur wind / son-PV vir GH2/PtX-produksie, batterystoor en transmissie (Tx).
- **GH2/PtX-produksie** – 'n elektroliseerder verdeel $H_2O \rightarrow H_2 + O$ om GH_2 te vorm. GH_2 kan gestoor en versprei word, of verder gesintetiseer word in groen ammoniak (NH_3) met die toevoeging van stikstof, of in metanol (MeOH) met die toevoeging van volhoubaar verkrygde koolstof.
- **GH_2/KnX-berging en -verspreiding** – bergingstenks, vragmotors, spoorvervoer, pypleidings en skeepsvervoer om KnX-produkte na markte te vervoer (vir uitvoer of gebruik in plaaslike nywerhede).



Kern komponente die Gh2 en KnX ontwikkelingsprosesse the

[1]. There are many different definitions and perspectives on the concept of "green". Here, we use the term in the narrow sense, meaning a product developed where upstream production facilities are supplied by renewable energy sources.

Blok OBM 2: Waterstof-veiligheidsrisiko's

Waterstof kan veilig hanteer word, maar dit vereis noukeurige ontwerp en bestuur omdat dit hoogs vlambaar is, maklik aansteek, en kan brand met 'n vlam wat moeilik is om in daglig te sien. Klein lekkasies kan vinnig versprei, in ingeslote ruimtes ophoop, en risiko's vir brand, ontploffing of suurstofverplasing skep; sekere materiale kan ook bros word wanneer dit in waterstofdiens gebruik word. Hierdie risiko's vereis gevaarbeoordeling op projekvlak, lekaantekening (lekopsporing), ventilasie, noodafskakelstelsels en rampbestuursbeplanning (Leinala, 2024; NFPA, 2026; USDoE, n.d.).

1.1 Oorsig van die Voorgestelde Ontwikkeling

Hierdie SOA oorweeg 'n multikomponent-, gefaseerde program van grootskaalse GH_2- en PtX-ontwikkeling in die Noord-Kaap, wat die voorgestelde Boegoebaai-hawe, die Boegoebaai Spesiale Ekonomiese Sone (SES), en streekshernubare energie- en liniêre infrastruktuur insluit. Die Boegoebaai-hawe, in 'n voorgestelde gebied van ongeveer 2 187 hektaar (ha), word beoog om in fases ontwikkel te word.

Die korttermyn phase (**Fase 1A**) sluit in:

- 'n Twee-aanleg-steier vir droë massagoedere, vloeibare massagoedere en veeldoelige vragte, gekoppel aan land deur 'n toegangstralie en beskut teen golfenergie deur 'n betongepantserde golfbreker.
- Ondersteunende infrastruktuur sluit in:
  - geslote stapelterreine en toe pakhuise vir mangaan, lood en sink;
  - skeepslaaiers, ingeslote vervoerbandstelsels, en pypleidings wat aan diesel- en ammoniakopgaartenks gekoppel is;
  - 'n veeldoelige terminaal vir houervrag en stukgoed, 'n uitgegrawe administratiewe vaartuig kom, hawebestuur- en nooddiensgeboue;
  - 'n ontsoutingsaanleg op die terrein (~1 ML/dag), geskeide stormwaterstelsels en rioolbehandelingsisteme;
  - elektriese en inligting- en kommunikasietegnologie-netwerke, sekuriteitstelsels; en
  - vragmotor-stageringsfasiliteite en toegangsbeheer.

Vroeë aktiwiteite sal steun op die R382-pad as die primêre roete vir invoere en uitvoere. Die geprojekteerde uitvoervolumes teen 2033 sluit ~5 miljoen ton per jaar (Mtpa) droë bulk (mangaan), 1 Mtpa stukgoed (lood en sink), 1.4 Mtpa GH_2-afgeleides en 0.2 Mtpa landbouprodukte in. Diesel-invoere word verwag om ~1.3 Mtpa te bereik.

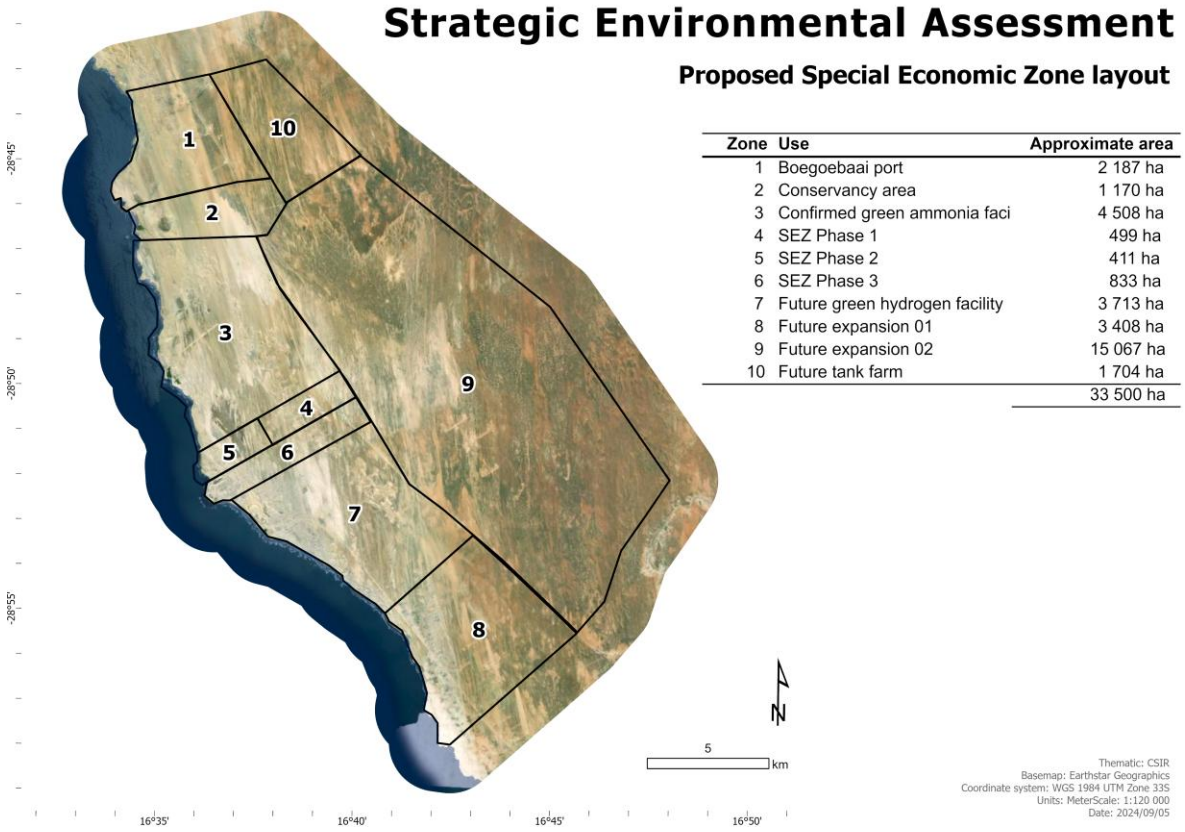
Fase 1B (2035–2050) se planne sluit in die verlenging van die golfbreker, bykomende vloeibare grootmaat- en multi-doelaanlegte, 'n houerterminaal, 'n skeepsherstelwerf, die uitbreiding van voorraadhope en geslote pakhuise, asook ondersteunende pad-oor-spoor brûe, spoorverbindings en tipplerfasiliteite. Die langtermynvisie vir die Boegoebaai-hawe (Fase 1B) is ontwerp met buigsaamheid om

Blok OBM 3: Bewaringsgebied en Onvervangbare Omgewingskenmerke in die SES

Die SES-gebied beplan om 'n bewaringsgebied in te sluit wat voorlopig afgebaken is op grond van aanvanklike bewaringsprioriteite, soos die Boegoeberg-koppies en die robkolonie by die Boegoebaai-punt. WP1 van die SOA verskaf verdere aanbevelings vir bewaringsgebiede binne die voorgestelde SES-gebied. 'n Habitat-eenheid bekend as Swartvygie Heuweltjie Strandveld, geleë net landinwaarts van Boegoebaai, het oor die afgelope eeu uitgebreide skade opgedoen weens mynbou. Die enigste ongeskonde dele word beskerm deur die Buchuberg-tweelingkoppies en verharde paaie wat sanduitskuring voorkom. Dit is van kritieke belang dat enige hawe- en GH_2-projekte hierdie ongeskonde dele en die ander prioriteitsbiodiversiteits- en kulturele kenmerke vermy, aangesien dit nie ge-offset kan word nie. Daar is ook 'n interessante argeologiese terrein by die voorgestelde ontwikkeling – die Boegoebaai-grot/ skuilplek.

toekomstige veranderinge in kommoditeite en bedrywighede te akkommodeer; met die voortgesette uitvoer van Fase 1A-kommoditeite en die potensiële insluiting van ander GH2-afgeleides soos metanol, nafta en e-keroseen. Die totale verwagte uitvoervolumes word beraam om te styg tot 2.15 Mtpa vanaf 2035 tot 2050.

Die voorgestelde Boegoebaai-SES-gebied, wat ongeveer 33 500 ha beslaan (insluitend die hawegebied), beplan om GH_2/PtX-produksie, vervaardiging, logistiek en landbouprosessering te huisves. Daar word verwag dat die SES-gebied 10 sones sal insluit (Figuur OBM 1), soos deur beleidmakers voorgestel, insluitend die hawegebied (Sone 1) en die bewaringsgebied (Sone 2). Die voetspoor van Sone 3 sluit die voorgestelde groen-ammoniakfasiliteit in, met ongeveer 188 ML/dag ontsouting, elektroliseerders, ammoniaksintese-eenhede, lugskeiding, berging vir waterstof, suurstof en ammoniak, en mariene afvoer van brakwater uit ontsoute seewater binne aanvaarbare perke. Sones 4–6 vorm 'n Nywerheidspark wat 'n 2.7 ML/dag ontsoutingsaanleg en twee SEZ-toegangspunte insluit. Sones 7–9 herhaal GH_2-/ammoniakproduksie in toekomstige fases, terwyl Sone 10 binnelandse tenkplaasberging voorsien. Aanvanklike SES-ontwikkelingskonsep sluit 'n 5 GW-elektroliseerder-uitrol teen 2030 in, asook gepaardgaande water-, bergings- en pypleidinginfrastruktuur.



Figuur OBM 1: Die hawe-voetspoor van die voorgestelde Boegoebaai-hawe en fases van die voorgestelde SES (Sones 1–10).

Buite die SES sal 'n verspreide hernubare energie netwerk [wind en son-fotovoltaïes ("PV")] nodig wees om elektrisiteit aan elektroliseerders te voorsien, met projekte wat in redelike nabyheid en ver van Boegoebaai geleë moet wees weens omgewingsensitiwiteit en korrosierisiko's. Elektrisiteit sal deur nuwe en bestaande transmissie-infrastruktuur gerol word, ontwikkel deur onafhanklike kragprodusente en/of die "National Transmission Company of South Africa" ("NTCSA"). Lineêre infrastruktuur sluit nuwe kraglynlyne, toegewyde waterstof- en ammoniakpypleidings (Boegoebaai<>Namibië, Boegoebaai<>Saldanha en Boegoebaai<>Prieska), 'n nuwe spoorwegkorridor wat voorgestel word om Boegoebaai met Kenhardt te verbind en in die bestaande Saldanha–Sishen-spoorroete in te skakel, asook nuwe/opgegradeerde paaie om doeltreffende vervoer van GH_2-afgeleides, grootmaatkommoditeite en HE-komponente moontlik te maak.

Die doel van die SOA is om strategiese beplanning vir die voorgestelde infrastruktuurprogram in en rondom Boegoebaai, asook die breër Namakwa-streek van die Noord-Kaap, te rig. Lesers word herinner dat die SOA nie self 'n besluitnemingsproses is nie, op dieselfde manier as byvoorbeeld 'n Omgewingsimpakstudie (OIS) nie. Die doel van die SOA is om, op 'n deursigtige wyse, afstroomse beplanning en besluitnemingsprosesse te lei wat oor baie jare—of selfs dekades—mág of nié mag plaasvind nie. Deur 'n verskeidenheid beste-praktyk wetenskap-beleid prosesse te integreer, behoort die SOA 'n bewysgebaseerde, kruis-dissiplinêre perspektief te bied op die belangrikste geleenthede en beperkings wat verband hou met die voorgestelde hawe, SES en netwerk van streeks-HE-opwekkingsfasiliteite (wind en son-PV), elektriese netwerk-infrastruktuur, paaie, pypleidings en ander GH_2-ondersteunende infrastruktuurontwikkeling.

Gegewe die multiskaal-aard van die SOA, is die prosesse en uitsette verdeel tussen twee Werkpakkette (WP's) (Tabel OBM 1): WP1 en WP2. **Let asseblief op dat slegs die bevindinge van WP2 in hierdie Opsomming vir Beleidsmakers (OBM) publikasie gerapporteer word.**

Tabel OBM 1: Opsomming van die SOA-werkpakkette oor verskillende ruimtelike skale, metodologieë en data-insamelingspraktyke.

	Werkpakket 1	Werkpakket 2
Ruimtelike skaal	Plaaslik (33 500 ha) – dek die omvang van die voorgestelde hawe en SES. Streekskaal (>5 miljoen ha) – oor vier Plaaslike Munisipaliteite, insluitend die 33 500 ha	Plaaslik (33 500 ha) – dek die omvang van die voorgestelde hawe en SES. Streekskaal (>5 miljoen ha) – oor vier Plaaslike Munisipaliteite, insluitend die 33 500 ha
Tydskaal	Introspektiewe, vaste siening van die tans bestaande sensitiwiteite in die ontvangende omgewings van die voorgestelde hawe en SES.	Breër vooruitsig tot 2050, met inagneming van bestaande grondgebruike en tendense in die ophoping van enige toekomstige streeks-GH_2-infrastruktuur.
Metodes	Hoë resolusie bepaling van die sensitiwiteit van die ontvangende omgewing met die oog op die toepassing van vermyding (bo-aan die mitigasiehiërargie). Bepaling van die kumulatiewe sosiale en ekologiese impakte uitgebreide ontwikkelingscenario's.	Hoë resolusie bepaling van die sensitiwiteit van die ontvangende omgewing met die oog op die toepassing van vermyding (bo-aan die mitigasiehiërargie). Bepaling van die kumulatiewe sosiale en ekologiese impakte uitgebreide ontwikkelingscenario's.
Resolusie	Veldwerk, gekoppel met desktop-hersienings (geëvalueerde en grys literatuur) en ander bronne waar nodig (bv. onderhoude).	Lessenaar-hersienings (geëvalueerde en grys literatuur, onderhoude, ens.) en ander publiek-beskikbare data en bronne.
Uitsette	Plaaslike-skaal uitvoerbaarheid- en beplanningsstudies (veral vir die nuut voorgestelde hawe) en toekomstige besluitnemingsprosesse, soos OIS'e en ander plaaslike-skaal beplanningsprosesse wat moontlik in die toekoms kan plaasvind.	Streeks-/nasionale beplanningsdokumente, deur prosesse soos "Spatial Development Frameworks" ("SDFs"), "Integrated Development Plans" ("IDPs") and "Environmental Management Frameworks" ("EMFs"), nasionale energiebeplanning en enige OIS-prosesse wat in die streek onderneem mag word.

1.2 Werkpakket 1

Vir konteks: WP1 het gefokus op die beoordeling van die sosiale en ekologiese sensitiwiteite van die plaaslik-geskaalde ontvangende omgewing rondom die voorgestelde hawe- en SES-ontwikkeling, oor 'n ruimtelike skaal van ongeveer 33 500 ha. Dit is onderneem met die doel om plaaslike-skaal uitvoerbaarheid- en beplanningsstudies te informeer (veral vir die voorgestelde hawe) en om toekomstige besluitnemingsprosesse te rig, insluitend OIS'e en ander beplanningsprosesse wat verband hou met die hawe en SES.Die sosiale en ekologiese temas wat in die WP1 oorweeg is, sluit in mariene ekologie, terrestriële en akwatiese ekologie, biodiversiteit-kompensasie, erfenis, volhoubare hawebeplanning, en

impakte op visserye en kusgeleefde bestaansmiddele. Die uitsette van WP1 is in Desember 2025 voltooi, en is aanlyn beskikbaar by: Individual Chapters | CSIR[2].

Die WP1-assessering het verskeie belangrike omgewings- en sosiale beperkings binne die voorgestelde hawe- en SEZ-ontwikkelingsvoetspoor uitgelig wat krities is vir die inligting van strategiese beplanning. Dit sluit in die sensitiwiteit van kus- en terrestriële ekosisteme, die belangrikheid van die posisionering van die golfbreker en die uitleg van die hawe en SES om hoëwaarde-habitatte te vermy, die behoefte om reeds versteurde gebiede te prioritiseer waar dit haalbaar is, en die moontlike implikasies vir kusbestaansmiddele soos kleinskaalse vissery.

Hierdie plaaslike bevindinge en aanbevelings (Blok OBM 4) moet saam met die breër streeksbevindinge en aanbevelings van WP2 in ag geneem word vir beplanning en besluitneming rakende die voorgestelde hawe-, SES- en GH_2-verwante infrastruktuurontwikkeling in die Namakwa-streek.

Blok OBM 4: Kernaanbevelings uit WP 1

Aanbevelings - strategiese beplanning

1. Plaas die hawe se breekwater op 'n manier wat sensitiewe Kaapse pelsrob broeikolonie en rotsagtige seekranse vermy. Die tegniese vatbaarheid (b.v. rakende seediepdte) van die hawe se plasing moet natuurlik ondersoek en bepaal word.
2. Plaas infrastruktuur in reeds-versteurde areas, en vermy Baie Hoë en Hoë sensitiewe areas – huidige skattings dui aan dat daar steeds (oor)genoeg plek sal wees om infrastruktuur in reeds-versteurde areas te plaas.
3. Bestuur beweeglike sand, wat wydverspreide ekologiese-, sosiale- en ingeneuring-uitdagings bied.
4. Dink aan ’n strategiese biodiversiteit verrekeningsraamwerk, waar spesifieke areas, b.v. oos van die R382, rondom die Holgatrivier en langs die Oranjerivier ten syde gestel word as teiken area vir langtermyn bewaring.
5. Begin vroegtydig met omgewingsmonitering, nog voór ontwikkeling plaasvind, om data te verryk in hierdie afgesonderde area.
6. Beplan vir ’n volhoubare hawe, wat ekonomiese groei, omgewingsbeskerming en –kwaliteit, en sosiale ontwikkeling balanseer.
7. Vestig en implementeer ’n omvattende, deursigtige en aanhoudende konsultasieplan, vanaf die vroegste projekbeplanning en –bestuursfases. Gerig op regverdige konsultasie en onderhandelinge (insl. ”Free, Prior & Informed Consent (FPIC)” beginsels).

Aanbevelings – impakbestuur

8. Prioritiseer ywerige, pro-aktiewe en top beplannings- en OIS* prosesse.
9. Vermy sensitiewe ekologiese en kulturele areas, soos bevind in die SOA, en verder bevestig deur fynskaalse ondersoek tydens projek-spesifieke OIS.
10. Raadpleeg plaaslike gemeenskappe insl. vissers en herders, rakende areas en praktyke wat belangrik is vir kultuur en lewensbestaan, asook om meganismes vir samebestaan in staat te stel.
11. Belê in plaaslike vaardigheidsontwikkeling.

[2] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/individual-chapters

1.3 Werkpakket 2

WP2 (die fokus van hierdie OBM) bied 'n meer strategiese, streekwye beoordeling van die kumulatiewe sosiale, ekonomiese en ekologiese implikasies van 'n uitgebreide GH_2-ekonomie in die Noord-Kaap, wat verder strek as die gelokaliseerde voetspoor wat in WP1 oorweeg is. Die ruimtelike skaal van WP2 dek dele van die Namakwa-distrik, afgebaken deur die Richtersveld-, Nama Khoi-, Kamiesberg- en Khâi Ma-plaaslike munisipaliteite.

Die streeksomvang maak dit moontlik om sistemiese risiko's en geleenthede te identifiseer en te evalueer wat dalk nie op individuele projekvlak sigbaar is nie, en voorsien 'n robuuste bewysbasis ter ondersteuning van besluitneming oor veelvuldige bestuurs- en beplanningsraamwerke heen. WP2 het ten doel om plaaslike en streeksbeplanning te rig, deur prosesse soos "Spatial Development Frameworks" ("SDFs"), "Integrated Development Plans" ("IDPs") and "Environmental Management Frameworks" ("EMFs"), insluitend enige OIS-prosesse wat in die streek onderneem mag word. Die strategiese kwessies wat in WP2 gedek word, sluit ekologie, biodiversiteit en bewaringsbeplanning (insluitend "biodiversity offsets"), waterbronne en akwatiese ekologie, erfenis, infrastruktuur en beplanning, asook sosio-ekonomiese impakte in.

Blok OBM 5: Die Inhoud van Werkpakket2

WP2 verteenwoordig 'n gesamentlike wetenskaplike poging, bestaande uit sewe Hoofstuks wat ontwikkel is deur 'n span van vier-en-dertig outeurs, en deur dertien onafhanklike kundiges ge-evaleer is. Die inhoud is verder verryk deur bydraes van 'n verskeidenheid belanghebbendes wat by die proses betrokke was via 'n formeel saamgestelde Werkgroep.

Die WP2 Hoofstukke is:

1. "Introduction and context" (Mqokeli et al., 2026)
2. "Ecology, biodiversity and conservation planning" (Desmet and Venter, 2026)
3. "Biodiversity offset" (Botha, 2026)
4. "Water resources and aquatic ecology" (Day et al., 2026)
5. "Heritage" (Orton et al., 2025)
6. "Infrastructure and planning" (Maritz et al., 2026)
7. "Socio-economics" (Atkinson et al., 2026)

Let wel, die SOA verslag is in Engels. Hierdie OBM is 'n omvattende opsomming van kern SOA bevindinge en is 'n vertaling van die oorspronklike Engelse "Summary for Policymakers (SPM)".

1.3.1 Scenarios

'n Belangrike leemte in die huidige kennis- en besluitnemingsbasis rakende GH_2-ontwikkeling in die Noord-Kaap is die afwesigheid van 'n geïntegreerde, kumulatiewe, langtermynbegrip van wat 'n medium- tot grootskaalse GH_2-ekonomie kan behels. Om dit aan te spreek, volg die WP2-SOA 'n interdissiplinêre, scenario-gebaseerde beoordeling wat ontwerp is om beide die skaal en implikasies van GH_2-ontwikkeling in die streek te verken.

Blok OBM 6: Scenario 0 (Dinamiese Basislyn)

Scenario 0 (Dinamiese Basislyn) verteenwoordig nie 'n statiese "geen ontwikkeling"-toekoms nie. Dit verteenwoordig eerder die omgewings- en sosio-ekonomiese toestande wat na verwagting tussen 2023 en 2050 sal plaasvind in die afwesigheid van die voorgestelde Boegoebaai-hawe, spesiale ekonomiese sone (SES) en streeks-GH_2-ekonomie. Dit sluit deurlopende en verwagte streeksontwikkelingstendense in, soos mynbou- en prospekteeraktiwiteite, hernubare energie-ontwikkeling, gepaardgaande uitbreiding van die elektrisiteitsnetwerk, die impak van klimaatsverandering, demografiese verandering, groot ontwikkelingsinisiatiewe en ander bestaande ontwikkelingsdruk. Gevolglik vorm kumulatiewe impakte wat met hierdie aktiwiteite verband hou — insluitend impakte op voëllewe (avifauna) as gevolg van hernubare energie- en netwerkinfrastruktuurontwikkeling — deel van die basislyn of verwysingspunt waaraan die addisionele impakte van die GH_2-ontwikkelingscenario's (Scenario's 1 en 2) gemeet word.

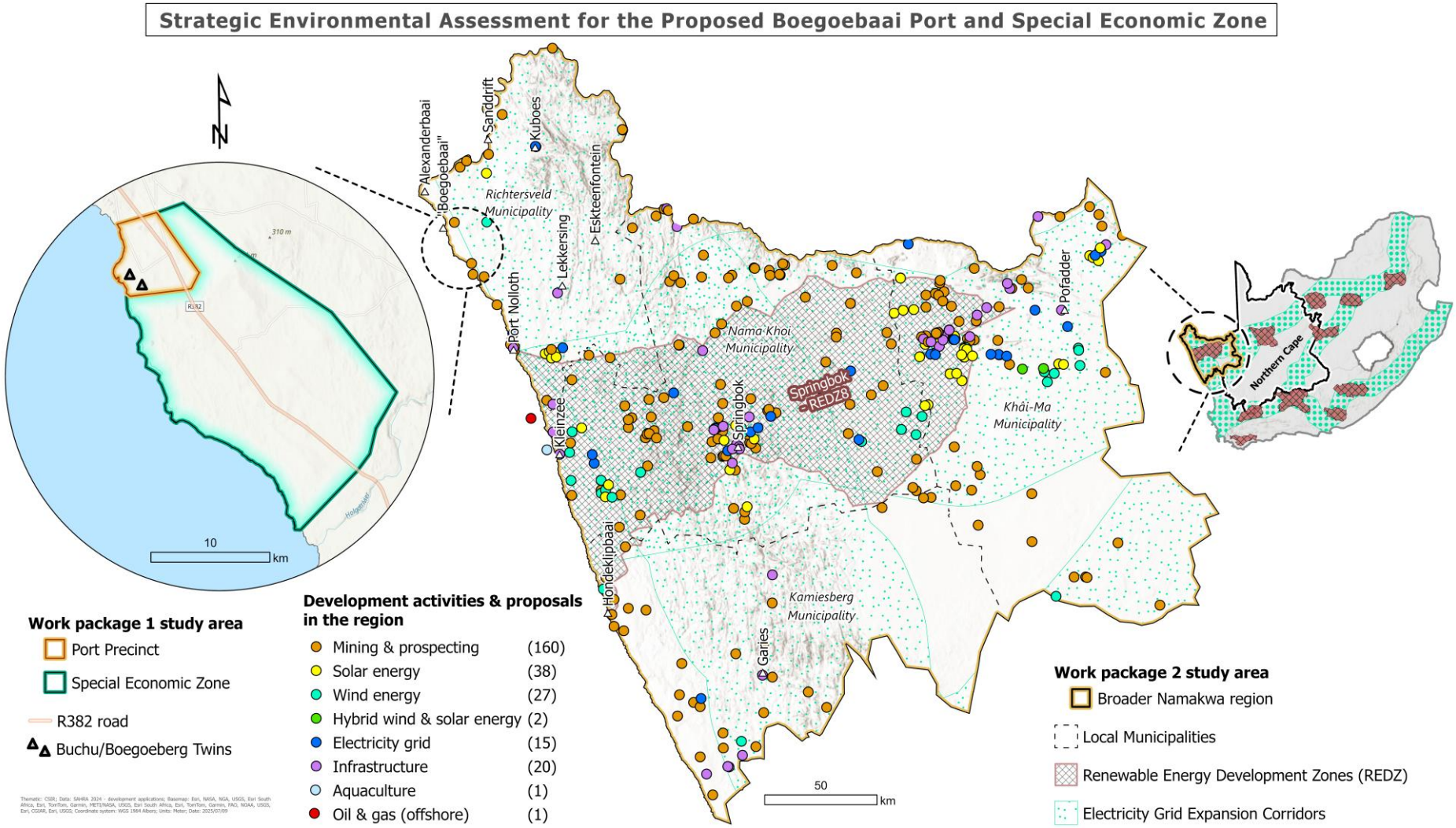
Hierdie scenario-beoordeling dien twee hoofdoeleindes:

1. Om 'n konkrete voorstelling te bied van hoe 'n groot GH_2-ekonomie in die Noord-Kaap kan lyk, in terme van die aard, skaal en ruimtelike voetspoor van infrastruktuur en ontwikkeling.
2. Om die moontlike kumulatiewe positiewe en negatiewe impakte van GH_2-ontwikkeling te skat en strategieë te identifiseer om voordele te versterk en nadelige gevolge te verminder.

Twee ontwikkelingscenario's word in die WP2-beoordeling oorweeg, elk vergelyk met — en bo-op — die Scenario 0 dinamiese basislyn (d.w.s. waar geen GH_2-ontwikkeling plaasvind nie). Die scenario's word verder hieronder opgesom:

- **Scenario 0 (Dinamiese basislyn, 2023–2050): Geen GH_2, geen hawe, geen SES nie.** Streeksverandering gaan voort deur klimaatsvariasie, voortgesette ontwikkelingsaktiwiteite en -voorstelle (Figuur OBM 2), grondgebruikdruk, verlies aan biodiversiteit, waterskaarste, munisipale kapasiteit en markdinamika. Hierdie verwysingscenario word gebruik om bykomende effekte in Scenario's 1–2 te beoordeel.
- **Scenario 1 – "Klein GH_2" (teen 2030): 5 GW** elektrolise, **10 GW hernubare energie (~60% son / 40% wind),** Fase 1A hawefunksies, SEZ Fase 1 (insluitend groen-ammoniak), eerste lineêre pyplyn-/spoor-/kraglynskakels.
- **Scenario 2 – "Groot GH_2" (teen 2050): 40 GW** elektrolise, **80 GW hernubare energie (~60% son / 40% wind),** uitgebreide hawe (Fase 1B-elemente), SES-repliseringsones, uitgebreide pyplyne/spoor/kraglyne.

Scenario-kwantifiserings sluit in die geskatte, aanduidende voetspore vir elektroliseerders, GH_2-/ammoniakberging, ontsoutingsuitsette (bv. Sc1 ~ 35.7 ML/dag vir GH_2-produksie; Sc2 ~ 285.7 ML/dag) en brakwaterafvoere, asook die lengtes/serwitute van paaie, spoorlyne, pypleidings en kraglyne.



Figuur OBM 2: Die voorgestelde Boegoebaai-hawe en SES (WP1-studiegebied) en die Namakwa-streek se studiegebied (WP2-studiegebied) in die Namakwa-distrik van die Noord-Kaap. Ekonomiese aktiwiteite sluit wydverspreide mynbou en prospektering in. 'n Hernubare energie sektor is ook aan die ontwikkel met gevestigde Hernubare-energie-ontwikkelingsones ("REDZ") en Elektrisiteitsnetwerkinfrastruktuur- ("EGI") sones. Hierdie voortgesette en opkomende ontwikkelingsneigings bestaan reeds en gaan voort ongeag of 'n nuwe hawe, SES en GH_2-ontwikkeling realiseer of nie, en vorm deel van Scenario 0 (Dinamiese Basislyn, 2023–2050) wat in die WP2-SOA oorweeg word.

1.4 Multi-outeur Spam Model in die SOA

Die SOA het 'n multi-outeur span model[3] gebruik om spesialiskennis vir beide Werkpakkette te integreer. Die spanne het geëvalueerde (akademies beoordeelde) verslae opgestel, met die WP1-spanne wat gefokus het op die identifisering van die sleutel-sensitiwiteite en impakte wat met die hawe- en SES-ontwikkeling verband hou, terwyl die WP2-span 'n breër, strategiese beoordeling van kumulatiewe risiko's en geleenthede oor die streek heen onderneem het. Die skryfspanne het nou saamgewerk deur die hele OOS-proses om te verseker dat alle relevante kwessies oor die twee WPe heen volledig gedek word. Die bevindinge uit WP2 word opgesom in Afdeling 2 van hierdie OBM, en die inhoud is verder verryk deur bydraes van 'n verskeidenheid belanghebbendes wat by die proses betrokke was via 'n formeel saamgestelde Werkgroep (Blok OBM 7).

1.5 Betrekking van Belanghebbendes

Betrekking van belanghebbendes is sentraal tot die SOA vir die Boegoebaai-hawe, SES en ontwikkeling van streeksinfrastruktuur, en vorm 'n kernproses-element vir beide WP1 en WP2. Dit word geïmplementeer deur 'n gestruktureerde, multi-kanaal deelnameprogram wat die verspreiding van toeganklike inligting via die SOA-webtuiste[4], plaaslike kennisgewings en plakkate, koerantadvertensies, radio-onderhoude en formele Werkgroepvergaderings insluit.

Publieke vergaderings en verskeie Werkgroepsessies is ook gehou om die SOA-proses en ontluikende voorlopige bevindinge voor te stel en te bespreek, insluitend plaaslike openbare sessies oor agt liggings in die Richtersveld en omliggende gebiede vir WP1, tesame met die formele openbare hersiening van die voorlopige WP 1-Hoofstukke. 'n Soortgelyke benadering is gevolg vir WP2, wat Werkgroepbetrokkenheid insluit om die voorlopige spesialisbevindinge voor te stel en te bespreek, asook die tans-gaande formele openbare hersieningsperiode vir die WP2-Hoofstukke (insluitend die inhoud van hierdie OBM en gepaardgaande Hoofstukke), ondersteun deur openbare vergaderings wat in betrokke munisipaliteite binne die Namakwa-streek gehou sal word.

Blok OBM 7: Die SOA Werkgroep

Om te verseker dat die SOA-proses ingelig word deur 'n breë spektrum van kundigheid en perspektiewe, is 'n interdissiplinêre Werkgroep ingestel. Hierdie multi-sektorale span bestaan uit kundiges uit nasionale, provinsiale en plaaslike regeringsdepartemente, staatsinstansies, akademiese en navorsingsinstellings, nie-regerings- en gemeenskapsgebaseerde organisasies, asook die industrie en die privaatsektor.
Die Werkgroep vervul twee sleutelrolle:

1. Om kundige insette te lewer regdeur die SOA om te verseker dat die beoordeling gesteun word deur robuuste en konteks-spesifieke kennis; en
2. Om as 'n inligtingskanaal te funksioneer, wat tweerigting-kommunikasie tussen lede se kiesafdelings en die SOA-span moontlik maak, en sodoende deursigtigheid, inklusiewe betrokkenheid en konsekwente inligtingsdeling oor sektore heen ondersteun.

Letwel: die inhoud van die WP1 en WP2 verslae wat as deel van hierdie SOA-proses opgestel is, weerspieël nie noodwendig die sienings van die Werkgroeplede nie — hetsy in hul individuele hoedanighede of as verteenwoordigers van hul onderskeie instellings.

[3] 'n Multi-outeurspan, in die konteks van 'n SOA, verwys na 'n gestruktureerde, pluralistiese outeurskapmodel wat ontwerp is om uiteenlopende perspektiewe en kundigheid oor die hele assesseringsproses te integreer. Vir die Boegoebaai-SOA is multi-outeurspanne saamgestel deur 'n konsultatiewe proses met die Werkgroep (wat verteenwoordigers van die regering, akademie, Nie-Regeringsorganisasie (NROs) en ander belanghebbendes ingesluit het) om navorsers te nomineer wat oor die nodige nis-kennis van hierdie afgeleë streek beskik, tesame met 'n begrip van strategiese infrastruktuurimpakte, akademiese geloofwaardigheid en kundigheid in hoëvlak-strategiese assesserings.

[4] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/strategic-environmental-assessment/boegoebaai-port

2. KERNBEVINDINGE VAN WERKPAKKET 2

Die volgende afdelings som die sleutelbevindinge uit die onafhanklike, ge-evalueerde spesialis-Hoofstukke van WP2 op, en beklemtoon die streekskaal-oorsig, sensitiwiteite van die ontvangende omgewing (Tabel OBM 2, Figuur OBM 4), asook die risiko's en geleenthede wat verband hou met 'n potensiële toekomstige GH_2-ekonomie.

Tabel OBM 2: Standaard sensitiwiteitskategorieë vir ontvangende omgewings oor die hele studiegebied.

Kategorie	Beskrywing
BAIE HOOG ("VERY HIGH")	Hoogs kwesbaar vir versteuring met min of geen herstelvermoë. Sluit bedreigde spesies, kritieke habitats, erfenis-/sosiale hulpbronne of ekosisteme met baie nou toleransies vir verandering in.
HOOG ("HIGH")	Sensitief vir ekologiese en sosiale verandering, maar met beter herstelpotensiaal. Laer konsentrasies van bedreigde spesies, kritieke habitats, erfenishulpbronne, of ekosisteme met 'n mate van toleransie vir verandering.
MEDIUM ("MODERATE")	'n Mate van veerkragtigheid teenoor stres of verandering. Stelsels kan matige impakte absorbeer sonder langtermynskade of onomkeerbare verlies. Sluit aanpasbare spesies, minder waardevolle sosiale/kulturele hulpbronne en matig sensitiewe habitats in.
LAAG ("LOW")	Waarskynlik reeds ernstig gedegradeer deur vorige versteurings, of beskik oor hoër aanpassingsvermoë en lae kwesbaarheid. Sluit wydverspreide sosiale hulpbronne, ekosisteme of spesies met breë ekologiese nisse en hoë regenerasievermoë in.

2.1 Die Sensitiwiteit van die Omgewing

2.1.1 Streekswye Ekologie (Desmet and Venter, 2026)

Die Namakwa-streek word internasionaal erken vir biodiversiteit ('n sogenaamde "biodiversity hotspot") en verteenwoordig 'n prioriteitsfokusgebied vir biodiversiteits-bewaring. Die streek omvat vyf van Suid-Afrika se biome (Blok OBM 8), gedomineer deur die Sukkulente-Karoo en die Nama-Karoo, met kleiner uitgestrekthede van die Woestyn-, Fynbos- en Asonale biome ook teenwoordig. Die sentrale en westelike dele van die studiegebied vorm deel van die Sukkulente Karoo-bioom van die Richtersveld en die Namakwaland — die wêreld se mees spesiesryke droë streek — met buitengewoon hoë vlakke van plantendemisme en biodiversiteit.

Blok OBM 8: Wat is Biome?

Biome is breë ekologiese eenhede wat gekenmerk word deur spesifieke klimaatstoestande, plantegroeitipes en die gepaardgaande fauna. Suid-Afrika bestaan uit nege hoofbiome, naamlik Grasveld, Fynbos, Savanna, Nama-Karoo, Sukkulente-Karoo, Woestyn, Albany-Ruigte, Indiese Oseaan-Kusgordel en Woude, asook 'n tiende groep van Asonale plantegroei (plantegroei wat klimaats- en geografiese grense oorsteek).
Biome word gedefinieer op grond van die plante en diere wat in daardie gebied voorkom, en word beïnvloed deur faktore soos klimaat (temperatuur en reënval), grondtipe en topografie.

Oor die hele Namakwa-streek heen is biodiversiteit en ekosisteme reeds onder druk van 'n kombinasie van drywers, insluitend — maar nie beperk tot — wydverspreide vee-weiding, historiese en huidige mynbedrywighede, die verwagte groei in mineraalsandontginning, en die vinnige uitrol van son- en windenergie (en gepaardgaande lineêre infrastruktuur) om aan huidige en toekomstige energiebehoeftes te voldoen. Stroping van biodiversiteit word beskou as die belangrikste bedreiging tot biodiversiteit in die streek tans, en dra by tot werklike, onmiddellike bevolkingsafnames SCC-spesies, insl. skaars en endemiese spesies. Hierdie drukfaktore het reeds gelei, of kan lei, tot die agteruitgang en verlies van

natuurlike omgewings, met gevolge vir die streek se vermoë om volhoubare ontwikkeling te bereik. Die beoordeling van die impakte van voorgestelde ontwikkelings vereis dus 'n begrip van die huidige toestand van biodiversiteit, die sleutel mensgemaakte drukfaktore wat ekologiese tendense beïnvloed, en die maniere waarop nuwe ontwikkelings met hierdie drukfaktore kan interaksie hê of dit moontlik kan vererger.

Bo-en-behalwe hierdie drukfaktore lê klimaatsverandering – die mees betekenisvolle (kort-, medium- en langtermyn) bedreiging vir biodiversiteit in die streek. Langtermyn-ontledings van plantegroei-produktiwiteit toon wydverspreide "verbruining" van plantegroei oor groot dele van die streek, veral in die Richtersveld. Gebaseer op hierdie tendense kwalifiseer ongeveer 62–65% van die 71 plantegroeitipe in die streek nou as bedreigde ekosisteme volgens die kriteria van die Rooilys van Ekosisteme ("Red List of Ecosystems"), wat die dringendheid van proaktiewe bewaringsbeplanning beklemtoon (Blok OBM 9).

Blok OBM 9: Klimaatsverandering, Weidingsdruk en Plantegroei-Veerkragtigheid in Namakwaland

Plantegroeitendense oor Namakwaland toon duidelike klimaatsgedrewe afnames, veral in die noordweste, maar verskillende ekosisteme reageer verskillend afhangende van hul onderliggende ekologiese eienskappe. Die plantegroei-ontleding toon ook dat grondgebruik — veral veeweiding — hierdie klimaatsimpakte sterk vererger, terwyl lig bewei-de beskermde gebiede meer stabiel bly. Die bestuur van weidingsdruk word daarom beskou as een van die doeltreffendste klimaatsaanpassingsmaatreëls wat beskikbaar is, en die uitbreiding van goed-bestuurde beskermde areas sal noodsaaklik wees om ekosisteem-veerkragtigheid oor die streek te versterk.

Minder as een-derde (28%) van die streek se ekosisteme word as goed-beskerm beskou, terwyl twee-derdes (66%) swak of glad nie beskerm word nie. Terselfdertyd is meer as 70% van die streek reeds geïdentifiseer in uitbreidingsstrategieë vir beskermde gebiede, wat die nasionale belang daarvan weerspieël vir die bereiking van Suid-Afrika se 30×30-bewaringsdoelwitte[5]. Dit beklemtoon verder die noodsaaklikheid dat enige grootskaalse ontwikkeling in die streek — insluitend GH_2-verwante infrastruktuur — noukeurig belyn moet word met biodiversiteitsprioriteite om te voorkom dat langtermynbewaringsdoelwitte ondermyn word.

Die voël-assessering identifiseer uitgebreide BAIE HOË en HOË voël sensitiwiteitsones oor die Namakwa-streek, veral in verband met impakte wat met windplase geassosieer word. Hierdie risikopatrone word gedryf deur (i) onvervangbare habitats in en rondom Sleutel-biodiversiteitsgebiede ("Key Biodiversity Areas (KBAs)") (Blok OBM 10) en beskermde gebiede, en (ii) die teenwoordigheid van 44 prioriteit-voëlspesies[6], insluitend bedreigde, endemiese en verspreidingsbeperkte voëlspesies. Sensitiwiteit van voëls (LAAG, MEDIUM, HOOG, BAIE HOOG) oor die streek word bepaal deur 'n kombinasie van bewaringsweging (bv. Rooilys-status, endemisme, verspreidingsgebied), habitatgeskiktheid, en vatbaarheid vir vier primêre avifaunale impakweë wat relevant is vir GH_2-verwante ontwikkelingsvoetspore: versteuringsgedrewe verplasing; habitatverlies / fragmentasie; botsings met windturbines en kraglyne; en skokkings op elektriese infrastruktuur.

Blok OBM 10: What is "Key Biodiversity Areas (KBAs)"?

KBAs is areas wat beduidend bydra tot die wêreldwye voortbestaan van biodiversiteit", wat beteken dit is van die belangrikste plekke op aarde vir spesies en hul habitats — of dit nou terrestriële, varswater-, estuariene of mariene ekosisteme is. Areas kwalifiseer as wêreldwye KBA's indien hulle aan die spesifieke gestandaardiseerde kriteria en kwantitatiewe drempels voldoen wat fokus op een of meer van vyf aktiveringsaspekte: bedreigde biodiversiteit, geografies beperkte biodiversiteit, ekologiese integriteit, biologiese prosesse, en onvervangbaarheid (deur kwantitatiewe analise bepaal). Die Namakwa-streek bevat 15 KBA's (verwys na Figuur 3 van Hoofstuk 2a – "Avifauna").

[5] Suid-Afrika se 30×30-bewaringsdoelwit verbind die land daartoe om teen 2030 ten minste 30% van sy terrestriële, binnelandse water-, en kus- en mariene gebiede effektief te beskerm, in belyning met die "Global Biodiversity Framework".

[6] Prioriteitspesies is spesies wat besonder sensitief is vir verplasing as gevolg van versteuring en/of habitatverlies, asook vir die risiko van botsings en elektrokusies; endemiese en naby-endemiese spesies; alle SSC-spesies (spesies van bewaringsbelang / "Species of Conservation Consern"); watervoëls; roofvoëls; en verspreidingsbeperkte spesies.

Vir vlermuise is sensitiwiteitsones gebaseer op die relatiewe belangrikheid van landskappe vir vlermuis-rusplekke, voedingsgebiede en bewaringwaarde. BAIE HOË sensitiwiteitsgebiede is effektief "verbode" op strategiese vlak, veral vir windplase, en word hoofsaaklik gekoppel aan oop waterbronne en permanente riviere, vleilande, die kuslyn, beskermde gebiede en bekende vlermuis-rusplekke ("roosts")[7] — alles belangrike bronne van vog, water, insekte of vrugte wat vlermuisaktiwiteit ondersteun. Rusplekke is veral belangrik weens die potensiaal vir grootskaalse impakte op vlermuispopulasies. **HOË** sensitiwiteitsones word geassosieer met kalksteengeologie, aangesien sulke areas waarskynlik onontdekte grotsisteme kan bevat (hoë rusplekpotensiaal), asook minder omvangryke akwatiese elemente. **MEDIUM** sensitiwiteit hou verband met nie-permanente waterlope, waar seisoenale vog die beskikbaarheid van insekte verhoog en voedsende vlermuise lok. **LAE** sensitiwiteit dek die oorblywende gebiede waar hierdie sleutelkenmerke ontbreek (d.w.s. beperkte rus- en voedingspotensiaal), en is oor die algemeen meer versoenbaar met ontwikkeling — onderhewig aan terreinbevestiging tydens die OIS-fase. Twee addisionele sones — die Rusplek-Ondersoek- en Rusplek-Versigtigheidssones (Figuur OBM 7e) — word rondom bekende vlermuisrusplekke geïdentifiseer. Dit verteenwoordig gebiede wat moontlik intensief deur vlermuise gebruik word en dus noukeurige oorweging vereis, en waar veldverifiëring krities word.

Blok OBM 11: Die Belangrike Rol van Vlermuise in Ekosisteme

Vlermuise is 'n belangrike komponent van biodiversiteit en verskaf sleutel-ekosisteemdienste. Die meeste Suid-Afrikaanse vlermuise is insekvretend en eet groot hoeveelhede insekte, wat bydra tot natuurlike plaagbeheer. Ander spesies speel rolle in bestuiwing en saadverspreiding, wat plantegroei-regenerasie en ekosisteemfunksionering ondersteun. Vlermuise word ook as sleutelspesies in grot-ekosisteme beskou, waar hul guano gespesialiseerde grotbewonende organismes ondersteun. Daarbenewens kan vlermuise dien as ekologiese aanwysers van ekosisteemgesondheid. Vlermuisbevolkings is egter kwesbaar vir versteuring, habitatverlies en infrastruktuur soos windturbines, en hul lae voortplantingstempo beperk hul vermoë om van grootskaalse impakte te herstel.

Die fauna-assessering (diere) karteer die Namakwa-streek in BAIE HOË, HOË en MEDIUM sensitiwiteit (met 'n geleidelike verandering van kus na binneland), gebaseer op die samevloeiing van uitsonderlike endemisme, hoogs gespesialiseerde habitatvereistes, en toenemende ontwikkelingsdruk wat tipies is van die Sukkulente Karoo-biodiversiteit "hotspot". BAIE HOË sensitiwiteit is gekonsentreer langs die kusduingordel en die onderste Oranjerivier-korridor, wat kernhabitats verteenwoordig vir nou endemiese en Rooilys-fauna, veral duin-afhanklike soogdiere en fossorale (graaflewende) amfibieë, insluitend: De Winton se goue mol (krities bedreig, "CR"), Grant se goue mol (kwesbaar, "VU"), Namakwa-duinmolrat (opgegradeer na bedreig, "EN"), Woestynreënpadda ("VU") die mikro-endemiese Branch se reënpadda[8]. Ontwikkeling in hierdie gebiede het 'n hoë waarskynlikheid van onomkeerbare biodiversiteitsverlies en moet as "verbode/streng te vermy" sones hanteer word, tensy daar uitsonderlike regverdiging bestaan. **HOË** sensitiwiteit strek oor die binneland, oor die Namakwaland-Hardeveld, vetplantstruiklande en rotsagtige inselberge, waar onvervangbare mikrohabitats (koppies/rotsuitsteeksels) en sleutel ekologiese prosesse voorkom. Dit word gedryf (tesame met belangrike bestuif- en grondingenieur- prosesse) deur spesies soos: die Gespikkelde Padloper ("EN"), verspreidingsbeperkte gordelakkedisse, verskeie amfibieë wat met tydelike poele en dreineringslyne geassosieer word. tesame met belangrike bestuif- en groningenieur- (soil engineering) prosesse. **MEDIUM** sensitiwiteit dek die breër binnelandse vlaktes wat steeds betekenisvolle faunadiversiteit ondersteun, maar waar meer versteuringsverdraagsame spesiesgemeenskappe oorheers. Ontwikkeling kan hier **haalbaar** wees, mits: noukeurige plasing van infrastruktuur toegepas word, ekologiese korridors behou word, en terreinvlak-verifiëring tydens die OIS-fase plaasvind.

[7] Vlermuis-'rusplekke' ("roosts" in Engels), verwys na enige plek waar vlermuiskolonie hul tyd deurbring terwyl hulle nie aktief vlieg, kos soek of jag nie - bv. 'n grot, gebou se dak, skeur in 'n rots.

[8] Slegs bekend navolge rooi sand naby die Holgatrivier. Hoewel die presiese verspreidingsgebied nog nie bevestig is nie, word die spesie sterk geassosieer met die noordelike kus-duinveld, wat ook as Baie Hoë sensitiwiteit geklassifiseer is.

Die geïntegreerde biodiversiteit-sensitiwiteitsanalise (Blok OBM 12), wat steun op bestaande biodiversiteitsbeplannings-informante en spesifieke biodiversiteitssensitiwiteite wat as deel van die SOA ontwikkel is, identifiseer uitgebreide gebiede van HOË tot BAIE HOË sensitiwiteit oor die Namakwa-streek heen. **BAIE HOË** sensitiwiteitsgebiede bestaan uit beskermde gebiede en **ander onvervangbare** biodiversiteitskenmerke wat biodiversiteitspatrone, ekologiese prosesse en klimaats-vlughawefunksies ("climate refugia") ondersteun. Hierdie landskappe huisves seldsame, endemiese en bedreigde spesies en het geen ekologies gelykwaardige alternatiewe nie. Ontwikkeling in hierdie gebiede sou beduidende en dikwels onomkeerbare risiko's of impakte vir biodiversiteit inhou, met beperkte moontlikhede vir doeltreffende mitigering of kompensasie. Daarom word dit ten sterkste aanbeveel dat hierdie gebiede vermy moet word en ongeskaad behoue moet bly as ankers vir landskapskonnektiwiteit en klimaats-veerkragtigheid.

Blok OBM 12: Hoe die Geïntegreerde Biodiversiteit-Sensitiwiteitsanalise Opgestel Is

Die WP2-streeksbiodiversiteit- sensitiwiteitsanalise integreer ses biodiversiteit-inligtingsbronne op 'n vier-vlak sensitiwiteitsskaal (LAAG, MEDIUM, HOOG, BAIE HOOG). Hierdie inligtingsbronne sluit in: (1) Biodiver-siteitsbeplanningsdatastelle ("Critical Biodiversity Areas [CBA] kaarte, deskundige-gekarteerde prioriteitsgebiede, ekologiese korridors en plantspesie-liggingsrekords); (2) Prioriteite vir die uitbreiding van beskermde areas; WP2 SOA spesialis-sensitiwiteitslae vir (3) voëls, (4) vlermuise, (5) diere, en (6) akwatiese ekosisteme.

Elke laag is gestandaardiseer volgens dieselfde sensitiwiteitsklasse en gekombineer deur twee benaderings:

- 'n Maksimum-van-insette-benadering, wat die hoogste sensitiwiteitsgradering op 'n bepaalde plek weerspieël; en
- 'n Kumulatiewe-insette-sintese, wat aandui hoeveel insette 'n plek as sensitief identifiseer, en sodoende 'n fyner resolusiekaart van kumulatiewe biodiversiteitssensitiwiteit genereer.

Die resulterende geïntegreerde kaart bied 'n strategiese, streekskaal-siftingsinstrument om te beklemtoon waar biodiversiteitsbeperkings waarskynlik is en waar groter beplanningsbuigsaamheid bestaan. Dit vervang nie terreinvlak-spesialisstudies of projekspesifieke OIS'e nie.

HOË sensitiwiteitsgebiede is noodsaaklik om bewaringsteikens te bereik en om sleutel ekologiese prosesse oor die landskap te handhaaf. Ontwikkeling in hierdie gebiede is oor die algemeen ongewens en moet vermy word waar haalbaar. Waar impakte duidelik onvermybaar is, ná volledige toepassing van die mitigasiehiërargie, kan slegs streng beheerste, soortgelyk-vir-soortgelyke biodiversiteitskompensasie ("biodiversity offsets") oorweeg word. Sulke kompensasies moet gerig word op ekologies ekwivalente terreine binne dieselfde beplanningsdomein, met die uitdruklike erkenning dat sekere biodiversiteitskenmerke nie volledig kompenseerbaar is nie en dat residuele ekologiese risiko steeds beduidend kan wees. **MEDIUM** sensitiwiteitsgebiede ondersteun ekologiese funksionaliteit en plaaslike ekologiese konnektiwiteit, insluitend seisoenale bewegingsroetes en ekologiese buffer-sones wat help om die veerkragtigheid van aangrensende **HOË** en **BAIE HOË** sensitiwiteitslandskappe te handhaaf. Hoewel hierdie landskappe sekere ontwikkeling kan akkommodeer, bly impakte moontlik, en ontwikkelingsvoorstelle moet sorgvuldig geplaas en ontwerp word om ekologiese vloei, bewegingsroetes en sleutel mikrohabitats te behou, deur deeglike ondersoek, en toepassing van die mitigasiehiërargie en beste bou- en bedryf-praktyke. **LAE** sensitiwiteitsgebiede kom hoofsaaklik voor in meer homogene dele van die landskap waar biodiversiteitskenmerke minder gekonsentreer is, ekosisteme minder of glad nie bedreig is nie, en minder biodiversiteitsprioriteite ruimtelik oorvleuel. Hierdie gebiede sluit dikwels meer veerkragtige plantegroeitipes of voorheen versteurde grond in, wat vergelyksgewys laer bewaringsbeperkings bied en dus die voorkeurfokus vir nuwe infrastruktuur verteenwoordig, onderhewig aan bevestigende ondersoek en goeie beplannings-, bou- en berdyf-praktyke.

Oorhoofs toon die geïntegreerde maksimum-insette-sensitiwiteitsanalise dat minstens 70% van die Namakwa-streek gekenmerk word deur HOË tot BAIE HOË biodiversiteitssensitiwiteit. Dit weerspieël die streek se status as 'n wêreldwye biodiversiteit "hotspot", waar ekologies belangrike kenmerke wydverspreid is en selde ontbreek. Terselfdertyd toon die kumulatiewe-insette-benadering dat slegs ongeveer 11.5% van die streek Baie Hoë sensitiwiteit vir drie of meer biodiversiteitsinsette het, wat dui op beperkte ruimtelike oorvleueling tussen taksa en ekologiese drywers. Dit beteken dat, hoewel die grootste deel van die landskap 'n vorm van biodiversiteitsbeperking bevat, slegs 'n relatief klein deel veelvuldige,

saamvoorkomende hoogwaarde-sensitiwiteite huisves. Vanuit 'n ontwikkelingsbeplannings-perspektief is hierdie onderskeid belangrik, aangesien gebiede wat as **BAIE HOOG** geklassifiseer is vir slegs een inset moontlik groter buigsaamheid kan bied — onderhewig aan projek-spesifieke-assessering — as gebiede waar verskeie biodiversiteitsprioriteite saamval, minder opsies vir doeltreffende mitigering bestaan, en impakte dus waarskynlik onaanvaarbaar sal wees.

2.1.2 Waterbronne and Akwatiese Ekologie (Day et al., 2026)

Die Namakwa-streek is 'n uiters waterbeperkte landskap, gekenmerk deur hiper-droë of droë toestande, baie lae reënval (60–215 mm per jaar), hoë verdampingsyfers en 'n sterk afhanklikheid van grondwater. Oppervlakwaterbronne is baie beperk en bestaan hoofsaaklik uit tydelike strome en sporadiese afloopgebeurtenisse, met die Oranjerivier as die enigste permanente oppervlakwaterbron in die gebied. Ander riviere is seisoenaal tot tydelik[9], en hoewel vleilande en panne op sekere plekke voorkom, bly oppervlakwater ruimtelik en tydelik skaars.

Blok OBM 13: "Strategic Water Source Areas (SWSAs)"

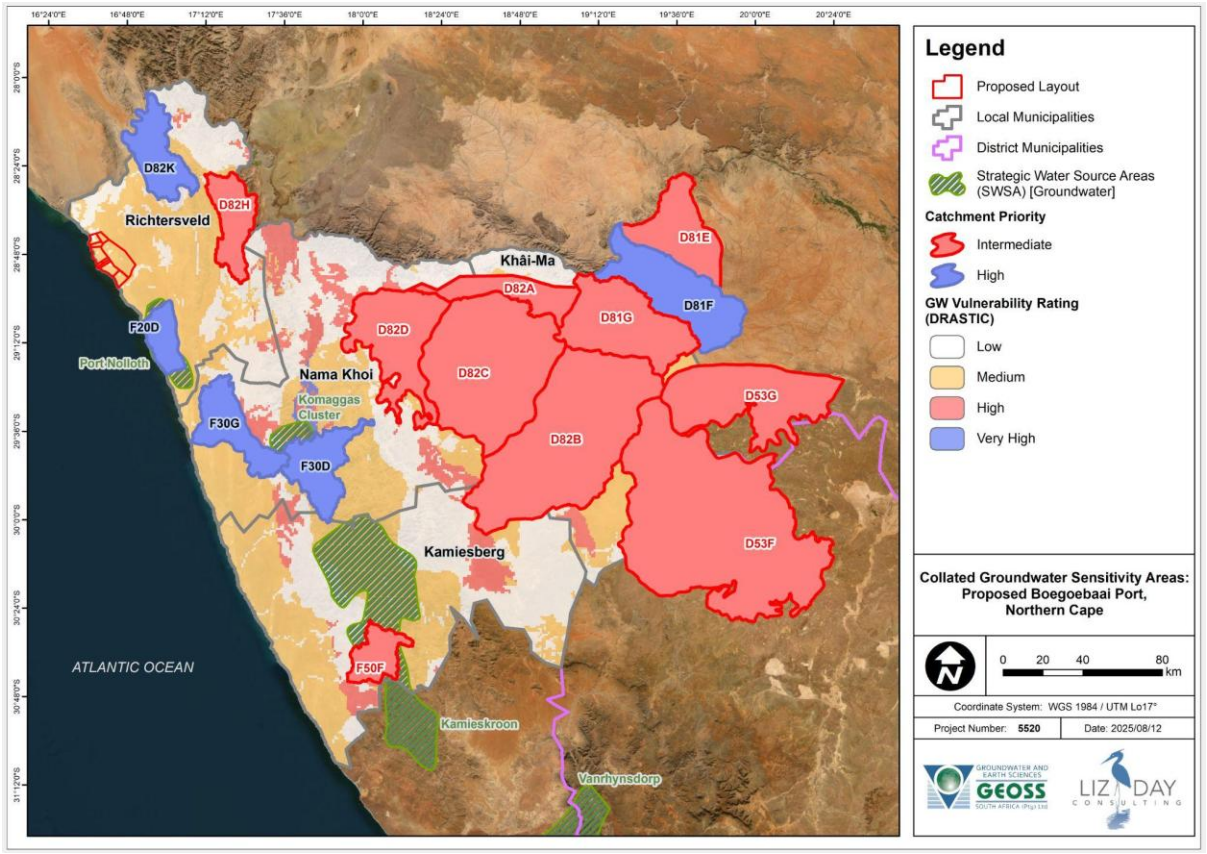
"Strategic Water Source Areas (SWSAs)" is landgebiede wat óf: (1) 'n buitengewoon hoog hoeveelheid gemiddelde jaarlikse oppervlakwater-afloop lewer in verhouding tot hul grootte en dus as nasionaal belangrik beskou word; óf (2) 'n hoë grondwateraanvulling het en waar grondwater 'n nasionaal belangrike hulpbron vorm; óf (3) gebiede wat aan beide kriteria (1) en (2) voldoen. "SWSA" waterdraers ondersteun basisvloei, dra by tot afloop en dra veral by tot vloei in die droë seisoen.

Grondwateraanvulling is oor die algemeen laag en watergehalte is relatief swak[10]. Grondwater kom in sanderige/alluviale waterdraers, verweerde sones (regoliet), en gefragmenteerde kristallyne graniet- en gneisgesteentes voor, wat hidrologies met mekaar verbind is. Die graniet en gneis het egter lae primêre porositeit, met grondwater wat hoofsaaklik deur frakture gestoor en vervoer word – dit lei tot oorhoofse lae en wisselende hidrologiese geleidingsvermoë. Gegewe die hoë afhanklikheid van gemeenskappe op grondwater, is verskeie grondwaterbron-eenhede ("Groundwater Resource Units, GRU's") [11] as hoë prioriteit geïdentifiseer. Verder is drie geïdentifiseerde "Strategic Water Source Areas (SWSAs)" (Blok OBM 13) (Port Nolloth, Kommagas en Kamiesberg) as **BAIE HOË** sensitiwiteit geklassifiseer (Figuur OBM 3).

Oppervlakwaterbronne in die binneland is beperk, met water-afloop wat minder as 10% van die tyd plaasvind en lang droë periodes tussen gebeure. Die Oranjerivierstelsel lewer minder as sy ontwerpeise, en ongeveer 18% van die studiegebied sal waarskynlik binnekort van Droog na Hiper-Droog verander. Voorgestelde nuwe en uitgebreide onttrekkings- en retikulasiesisteme word as **UITERS** sensitief beskou vir swak bestuur en instandhouding, aangesien dit die enigste lewensvatbare waterbron vir groot dele van die streek verteenwoordig. Daarbenewens maak die baie lae frekwensie van water-afloopgebeurtenisse en die lang droë periodes riviere en vloedvlaktes **HOOGS** sensitief, met beperkte tot geen vermoë om van versteuring te herstel.

Akwatiese ekosisteme in die streek, insluitend tydelike riviere, panne, seisoenale en permanente vleilande, is van hoë ekologiese belang maar uiters sensitief vir veranderinge in hidroperiodes, fisiese versteuring, agteruitgang in watergehalte en fragmentasie. Baie van hierdie binnelandse akwatiese ekosisteme word as krities bredreig ("CR") [12] of bedreig ("EN") [13] geklassifiseer, en selfs subtiele veranderinge in hidrologie (soos korter oorstromingsperiodes of voedingstowferryking deur gebrekkige water- en afvalwaterbehandelingsaanlegte) kan onomkeerbare ekologiese verlies veroorsaak, veral vir die gespesialiseerde ongewerwelde diergemeenskappe wat aangepas is vir tydelike wateromstandighede. Vleilande is beperk, hoewel sekere gebiede soos die Kamiesberg belangrike seisoenale en permanente vleilande bevat. Panne is die mees algemene tipe akwatiese ekosisteem, waarvan baie as "CR" of "EN" geklassifiseer is, afhangende van die biostreek waarin hulle voorkom.

[9] Tydelike riviere vloei slegs ná reënvalgebeurtenisse en bly vir die grootste deel van die jaar droog. Dus is hulle hoogs sensitief maak vir versteuring en veranderinge in hidrologie.
[10] Grondwateraanvulling is oor die algemeen 0.1–10 mm/jaar; elektriese geleidingsvermoë wissel van 70 tot meer as 1 000 mS/m.
[11] Meeste "GRU's" is in die Laer-Oranjerivier waterbestuursarea. 'n GRU is 'n grondwatereenheid wat gegroepeer is as 'n enkele betekenisvolle waterbron met soortgelyke kenmerke.
[12] Ekosisteem met 'n **uiters hoë risiko** van uitwissing of ineenstorting.
[13] Ekosisteem met 'n **baie hoë risiko** van uitwissing of ineenstorting.



Figuur OBM 3: Gemiddelde en hoë prioriteit grondwaterbron-eenhede ("GRU's") in die groter Namakwa-streek, Noord-Kaap.

Die Oranjerivier-mond, 'n internasionaal erkende Ramsar-gebied, is die grootste en mees ekologies belangrike riviermond in die streek. Daarbenewens sluit die studiegebied vier kleiner "Cool Temperate Arid Predominantly Closed (CTAPC)" riviermondings in, naamlik die Buffels-, Swartlintjies-, Spoeg- en Groen-estuariums. Die meeste riviere is in 'n goeie ekologiese toestand ["Present Ecological Status (PES)" Kategorieë B/C[14]], behalwe die Kwaganap-, Bitter- en dele van die Groenrivier. Die Oranjerivier-mond en die vier CTAPC-riviermondings in die studiegebied word almal as **bedreigde ("EN")** stelsels geklassifiseer, van **hoë bewaringsprioriteit**.

Vanuit 'n waterbehoefte-perspektief, en met betrekking tot die potensiaal vir besoedeling van bestaande watervoorrade, word bestaande water- en afvalwaterbehandelingsaanlegte en verspreidingsinfrastruktuur as oor die algemeen onderpresterend beskou en dringend in nood van opgraderings. Volgens inligting van die Departement van Water en Sanitasie (DWS) is die Distriksmunisipaliteit reeds onder beduidende waterdruk, en enige bykomende vraag kan hierdie druk op waterdienste aansienlik vererger.

Oor grondwater, oppervlakwater en akwatiese ekosisteme heen toon die sensitiwiteitskartering uitgebreide gebiede van **BAIE HOË** en **HOË** sensitiwiteit, waar ontwikkeling tot onomkeerbare agteruitgang kan lei.

2.1.3 Erfenis (Orton et al., 2026)

Paleontologiese[15] sensitiwiteit is **NIL** of **LAAG** vir die grootste deel van die gebied, met **MEDIUM** sensitiwiteit in die ooste en **HOOG** sensitiwiteit in die berge noordwes van Springbok en in die suidoostelike deel van die studiegebied. Oor die algemeen is die oppervlakkige sedimente van die kusvlakte van LAAG sensitiwiteit, met meer betekenisvolle afsettings wat op dieper vlak voorkom naby die kus en onder 100 m bo seespieël.

[14] Riviere in goeie ekologiese toestand.

[15] Palaeontologie verwys na fossiel oorblyfsels van antieke plante, diere en ander organismes wat in die geologiese rekord bewaar is. Hierdie oorblyfsels word as erfenishulpbronne ingevolge die NHRA beskou weens hul wetenskaplike, kulturele en historiese betekenis.

Die streek bevat argeologiese hulpbronne wat strek oor die Vroeë, Middel en Later Steentydperke, met die kuslyn wat as 'n gebied van HOË argeologiese sensitiwiteit geïdentifiseer is weens die hoë digtheid van hulpbronne. Terrestriële argeologiese hulpbronne sluit in Vroeë Steentydperk materiaal onder die oppervlak van eoliese sand langs die kusvlakte en tussen die gruisafsettings van Boesmanland; Middel Steentydperkmateriaal wat sowel langs die kuslyn as in seldsame binnelandse rotskuilings aangeteken is, soos Spitzkloof en in die basale lae van Wolfkraalgrot en Keurbosgrot in die Kamiesberg; en volop Later Steentydperk hulpbronne wat voorkom langs die kus en binneland rondom holtes in duinvelde, rotsheuwels en panne in Boesmanland. Rotsskilderye is skaars; geometriese rotsgravures kom langs die Oranjerivier voor. Historiese argeologiese oorblyfsels, insluitend dié wat verband hou met die Anglo-Boereoorlog, word aangetref rondom ou plaashuise, permanente of tydelike nedersettings, koper-myngebiede en prospekteringsplekke.

Blok OBM 14: Wetgewing rakende Erfenishulpbronne.

Die "National Heritage Resources Act (NHRA)" (Wet 25 van 1999) beskerm 'n wye reeks erfenishulpbronne, insluitend argeologiese en paleontologiese materiaal, grafte, kulturele landskappe en lewende erfenis – wat hul oorweging in alle ontwikkelingsbeplanning vereis. Kragtens Artikel 38 van die NHRA sal die meeste GH_2-verwante infrastruktuur 'n "Heritage Impact Assessment" vereis- dit is van toepassing op lineêre ontwikkelings langer as 300 m en versteurings groter as 5 000 m^2. Daarom is vroeë ondersoek, vermydingsbeplanning en betrokkenheid met erfenisowerhede noodsaaklik is vir verantwoordelike ontwikkeling in die streek.

Pre-koloniale grafte, hoewel skaars en hoogs gelokaliseerd, is outomaties van BAIE HOË erfenissensitiwiteit wanneer hulle teëgekom word. Pre-koloniale grafte kan regoor die studiegebied voorkom en word meer algemeen geassosieer met kusduinkontekste en gebiede met histories hoër bevolkingsdigtheid. Verskeie grafte is in die streek teenwoordig, insluitend drie bekende grafte aan die westelike voet van Boegoeberg-Suid (verwys na WP1). Die meeste pre-koloniale grafte is ongemerk en kan nie geïdentifiseer word totdat hulle ontbloot word nie, hoewel seldsame klippakgrafte wel voorkom en waarskynlik baie laat/historiese grafte verteenwoordig. Terwyl grafte hoë plaaslike kulturele betekenis (Graad IIIA) het en outomaties van **BAIE HOË** sensitiwiteit is wanneer hulle teëgekom word, is aangetekende voorkomste in Namakwaland en Boesmanland skaars, hoogs gelokaliseerd en gewoonlik ongemerk, wat ruimtelike sensitiwiteitskartering onprakties maak.

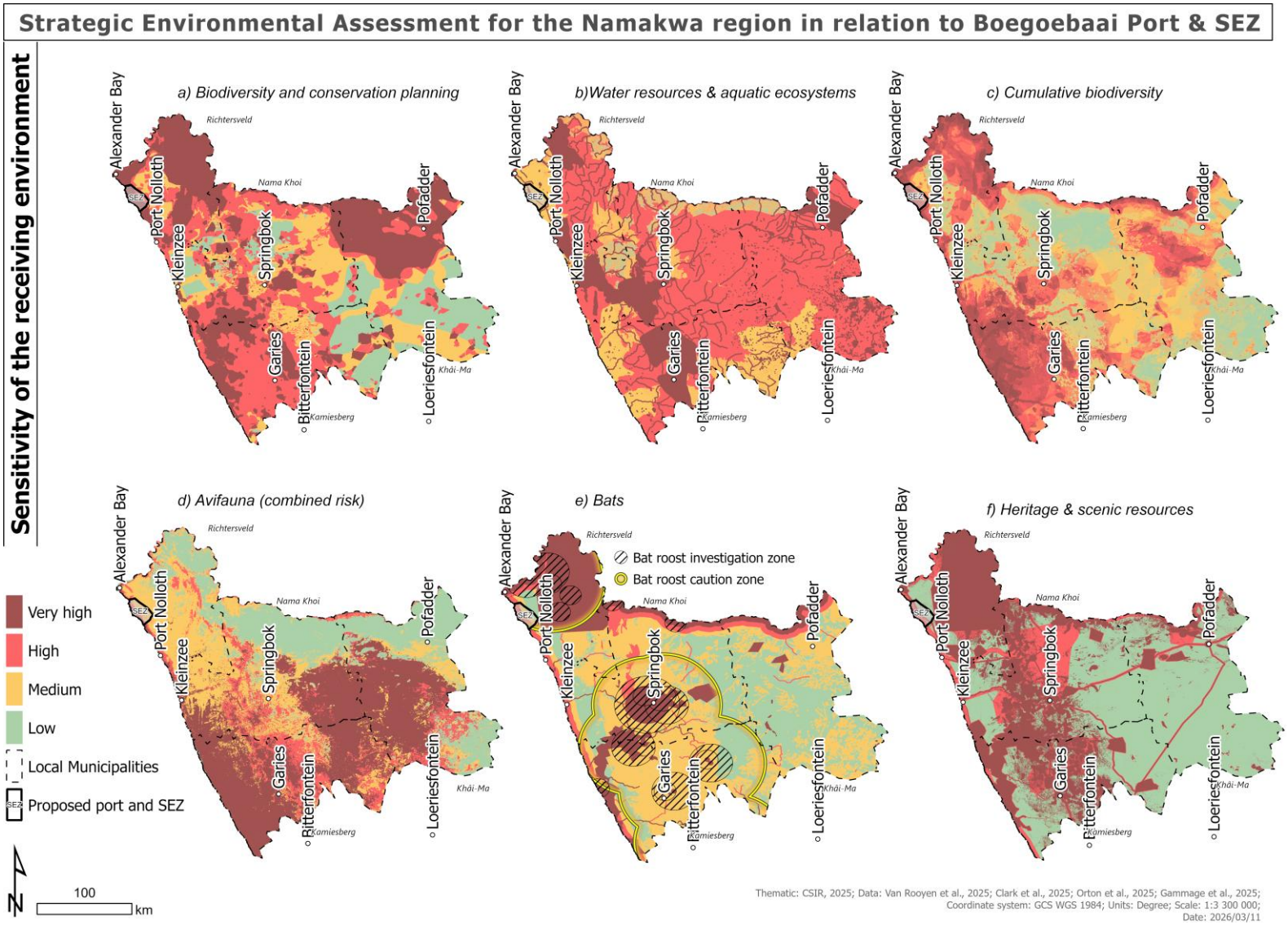
Blok OBM 15: Die waarde van die Richtersveld Kulturele en Botaniese Landskap Wêrelderfenisgebied (RKBL)

Die belangrikste aspek van die kulturele landskap in die Namakwa-streek is die RKBL, geleë in die noordwestelike deel van die studiegebied. Die beskrywing van die RKBL is soos volg (UNESCO 2024): Die 160 000 ha RKBL ondersteun die semi-nomadiese pastorale leefwyse van die Namavolk, wat seisoenale patrone weerspieël wat moontlik vir tot twee millennia in Suider-Afrika voortgeduur het. Dit is die enigste gebied waar die Nama steeds draagbare rietmat-huise (haru om) bou en sluit seisoenale migrasies en weidingsgronde in, saam met veeposte. Die veewagters versamel medisinale en ander plante en het 'n sterk mondelinge tradisie wat met verskillende plekke en eienskappe van die landskap geassosieer word.

Seereis-erfenissensitiwiteit word oor die algemeen as LAAG beoordeel langs die grootste deel van die kuslyn, met gelokaliseerde MEDIUM sensitiwiteitsones wat geassosieer word met aangetekende en moontlike skeepswrakke. MEDIUM sensitiwiteitsones kom voor waar skeepswrakrekords vermeld word, een voor-1965-wrak en verskeie ander kom ook moontlik naby die kus in die SES-studiegebied, en tussen Port Nolloth en Alexanderbaai, voor.

Lewende erfenis word as HOË sensitiwiteit geïdentifiseer in die gemeenskapsgebiede van Richtersveld, Leliefontein, Steinkopf, Komaggas, Concordia en Pella, waar transhumansietradisies en seisoenale weiding voortduur.

Die streek is van HOË kulturele landskap- en natuurskoon-sensitiwiteit, geanker deur internasionaal en nasionaal belangrike erfenislandskappe en ikoniese natuurskoonroetes. Vanuit 'n kulturele landskap- en estetiese perspektief bestaan die gebied uit vier duidelike fisiografiese komponente, naamlik die kuslyn, die kusvlakte, die granietberge van die Kamiesberg, en die binnelandse vlaktes van Boesmanland. Die Namakwalandse koper-mynlandskap vorm deel van die streeks-kulturele landskap en is van hoë betekenis. Belangrike topografiese kenmerke wat geïdentifiseer is, sluit in die Boegoeberg-Tweeling naby Alexanderbaai, die granietberge rondom Springbok, Okiep en Concordia, Sneeukop wat oor Kamieskroon uitkyk, en Gamsberg naby Aggeneys, wat almal historiese betekenis het. Die Richtersveld Kulturele en Botaniese Landskap Wêrelderfenisgebied (RKBL) (Blok OBM 15) en sy buffergebied, verskeie Nasionale Parke en ander reservate, die kuslyn, die Kamiesberge en die hoof streekroetes (N7, N14, R382) word almal as gebiede van **HOË** sensitiwiteit geïdentifiseer vir hul estetiese waarde. Die N7, N14 en R382 word as natuurskoonroetes geïdentifiseer, aangesien hulle toegang voorsien tot die RKBL, die Richtersveld Nasionale Park, die Oranjerivier en Namibië. Die streek se landskapwaarde word verder versterk gedurende die lenteblomseisoen, wanneer baie kleiner westelike paaie beide plaaslike en internasionale besoekers lok wat die ikoniese Namakwalandse blomuitstallings kom beleef.



Figuur OBM 4: Sensitiwiteit van die omgewing oor die Namakwa-streek studiegebied (WP2) vir die onderskeie spesialis-temas – (a) biodiversiteit en bewaringsbeplanning, (b) waterhulpbronne en akwatiese ekologie, (c) kumulatiewe biodiversiteit, (d) voëls, (e) vlermuise, en (f) erfenishulpbronne. Fyner skaal sensitwiteitsanalise en -kartering vir die voorgestelde hawe en SES is voltooi onder WP1 van die SOA.

2.1.4 Sosio-ekonomie (Atkinson et al., 2026)

Die Namakwa-streek bied 'n hoogs sensitiewe ontvangende sosio-ekonomiese omgewing, gekenmerk deur 'n droë klimaat, hoë ekologiese en kulturele waarde, verspreide landelike nedersettings en 'n struktureel kwesbare sosio-ekonomiese profiel. Die distrik het een van Suid-Afrika se grootste geografiese omvang, maar is ylste bevolk, met baie lae nedersettingsdigtheid (~1 persoon/km²), lang reistye en klein, geïsoleerde dorpe waarvan die ekonomie histories op mynbou, pastoralisme en, toenemend, toerisme staatgemaak het. Hierdie omstandighede skep 'n omgewing met beperkte institusionele en ekonomiese vermoë om vinnige, grootskaalse industriële ontwikkeling te absorbeer en daarby aan te pas.

Uit 'n sosio-ekonomiese perspektief ervaar die streek steeds hoë werkloosheid, lae huishoudelike inkomste en aanhoudende jeugwerkloosheid, tesame met langdurige uit-migrasie van geskoolde en ekonomies aktiewe inwoners. Alhoewel armoedetoestande oor tyd verbeter het, bly 'n beduidende deel van huishoudings behoeftig en afhanklik van maatskaplike toelaes en informele inkomstebronne. Bevolkingsverandering het gepaard gegaan met toenemende verstedeliking, waar landelike nedersettings afneem en bevolking en diensvraag konsentreer in die Springbok-, Okiep- en Nababeep-groep, met Port Nolloth as 'n belangrike sekondêre nodus. Langtermyn-groeitendense is ook sigbaar in Springbok, Port Nolloth, Pofadder en Garies, wat lei tot groeiende administratiewe en diensdruk in hierdie dorpe ondanks beperkte infrastruktuurkapasiteit.

Basiese munisipale toestande weerspieël beduidende infrastruktuur- en bestuursdruk. Watertoevoerstelsels is onbetroubaar en duur om te bedryf; sanitasie-agterstande duur voort; padinfrastruktuur versleg; en munisipale kapasiteit vir finansiële bestuur, ruimtelike beplanning, grondgebruikbestuur en rampgereedheid bly beperk. Die Richtersveld Plaaslike Munisipaliteit, waar die voorgestelde hawe en GH_2-verwante ontwikkeling gekonsentreer sou wees, staar verskeie beperkings in die gesig, insluitend uitdagings met watervoorsiening, 'n behuisingsagterstand van ongeveer 160 eenhede, tekorte aan tegniese personeel, en herhalende ouditeurs- en finansiële bestuurskwessies. Hierdie institusionele swakhede verhoog die sensitiwiteit vir vinnige bevolkings-inmigrasie en groeiende diensvraag beduidend.

Blok OBM 16: Die Nalatingskap van Mynbou, Werksgeleenthede en Sensitiwiteit in die Namakwa Streek

Mynbou het die sosio-ekonomiese trajek van die Namakwa-streek diep gevorm en 'n komplekse nalatenskap gelaat wat steeds gemeenskapswelstand, grondgebruik en plaaslike ekonomiese veerkragtigheid beïnvloed. Die agteruitgang en sluiting van groot diamantbedrywighede by Alexanderbaai en Kleinzee het bygedra tot langdurige werkloosheid, dorpsverval en munisipale bestuursuitdagings, met onwettige mynbou wat as 'n gepaardgaande risikofaktor in die betrokke gebiede ontstaan het.

Oor tyd het die inkrimping van mynbou die streeks-werksmagpatrone hervorm, met die ekonomiese struktuur wat wegbeweeg het van ontginning en meer gerig is op staatsdienste, handel/spyseniering/akkommodasie (insluitend toerisme) en landbou. Die streek se arbeidsmark bly egter beperk deur lae inkomste, beperkte tegniese vaardighede en langdurige uit-migrasie van mense in werkende ouderdom wat geleenthede in stede soek. Mynbougeskiedenis kan langdurige afhanklikhede skep wat moeilik is om na nuwe beleggingsbane te heroriënteer, en afhanklikheid van smal kommoditeitsprofiele kan plaaslike ekonomieë blootstel aan ekonomiese siklusse en eksterne "skokke", met potensieel ernstige nadraai-impakte op werkgeleenthede.
Die voorgestelde Boegoebaai-hawe, SES en GH_2-program word beskou as een met die potensiaal om aansienlike konstruksiefase-indiensneming te genereer, maar die streek bly sensitief vir vinnige ekonomiese verandering. Sonder deeglike beplanning en bestuur kan in-migrasie wat met konstruksie-aktiwiteite verband hou en ongelyke verspreiding van voordele sosiale druk verhoog, ongelykheid vererger en addisionele spanning op plaaslike dienste en instellings plaas.

Grondeienaarskap in die gebied, veral in die Boegoebergbaai/Richtersveld-gebied, vorm 'n verdere kritieke sensitiwiteit. Grond wat met die voorgestelde Boegoebaai-ontwikkeling geassosieer word, val onder die eienaarskap van die "Richtersveld Communal Property Association (CPA)" ná die 2007-herstelingskikking (Blok OBM 17).

Bestuur binne die CPA is fragiel, gekenmerk deur interne twis, administratiewe uitdagings en geskille oor leierskap, besluitneming en die verdeling van voordele. Hierdie uitdagings het op tye die uitkomste van strategiese ontwikkelingsinisiatiewe beperk en vertroue binne die gemeenskap ondermyn. Gegewe die CPA se wetlike gesag oor toegang tot grond en goedkeurings, hou onopgeloste bestuurskwessies 'n wesenlike risiko vir toekomstige ontwikkeling in. Sonder geteikende kapasiteitsbou, verbeterde deursigtigheid en geloofwaardige "Free, Prior and Informed Consent (FPIC)"-belynde betrokkenheidsprosesse, kan CPA-verwante bestuursbeperkings groot beleggings vertraag of kompliseer en sosiale spanning vererger.

Blok OBM 17: Die Richtersveld-grondherstelingskikking

Die Richtersveld-gemeenskap het in 1998 'n grondherstelingsaanspraak ingedien teen die diamantmynmaatskappy Alexkor, insluitend eise vir vergoeding vir diamante wat sedert die 1920's ontgin is. Die eis het uitgeloop op Suid-Afrika se grootste grondherstelingskikking, wat in 2007 deur die Grondeisehof bevestig is. Die skikking het die teruggawe van ongeveer 194 600 ha grond behels, insluitend sowat 84 000 ha diamantdraende kusgrond, landbougebiede en die dorp Alexanderbaai, aan die Richtersveld-gemeenskap. Die grond word gesamentlik gehou deur die Richtersveld "Communal Property Association (CPA)", wat as die wettige bewaarder van die herstelingsgrond dien.

Toerisme is die sterkste groeisektor in die Namakwa-streek, maar is hoogs sensitief vir verkeer, geraas, stof, swaar vragvervoer, industriële uitsigimpakte en veranderinge aan die streek se kenmerkende aantrekkingskrag, naamlik 'n afgeleë en platteland gevoel. Die streek word toenemend erken vir sy ekologiese, geologiese en kulturele erfeniswaardes, wat tot 'n groeiende toerisme-aantrekkingskrag bydra. Swak bestuurde logistiek, nedersettingsuitbreiding en vervoerkorridors hou daarom 'n beduidende risiko in vir een van die streek se mees veerkragtige ekonomiese sektor.

Landbou lewer proporsioneel 'n groter bydrae tot die Namakwa-distrik se ekonomie as op nasionale vlak[16], ten spyte van ernstige klimaatbeperkings. Veeboerdery bly 'n belangrike bestaansaktiwiteit met sterk kulturele en erfenisbetekenis vir landelike gemeenskappe, terwyl intensiewe besproeiing langs die Oranjerivier hoëwaarde-uitvoergewasse ondersteun, insluitend tafeldruiwe, sitrusvrugte, rosyne, dadels en pekanneute. Hierdie landboustelsels is egter sensitief vir wateronsekerheid, grondagteruitgang en stof, asook logistieke impakte, wat die streek se algehele sosio-ekonomiese kwesbaarheid verder versterk.

2.1.5 Infrastruktuur en beplanning (Maritz et al., 2026)

Die Namakwa-streek se beplanningsomgewing is beperk, met min geregistreerde beplanners, beperkte geografiese informasiestelsel (GIS) vermoë, en beplanningsdokumente wat dikwels ingevolge statutêre nakoming opgestel word, maar uiteenlopende vlakke van praktiese, innoverende of konteks-spesifieke leiding toon. Alhoewel die meeste munisipaliteite oor die vereiste statutêre beplanningsinstrumente beskik (insluitend "IDPs", "SDFs" en grondgebruikskemas), is kapasiteit om hierdie instrumente proaktief te implementeer, op te dateer en belyn te hou, beperk. Dit lei grotendeels tot 'n reaktiewe beplanningsomgewing.

Nedersettingspatrone word gevorm deur die streek se droogte, beperkte waterhulpbronne en ekonomiese geleenthede, wat lei tot klein, verspreide nedersettings met nederige groei (tipies onder 2% per jaar). Port Nolloth is die enigste nedersetting binne die Richtersveld-munisipaliteit wat meer as 5 000 inwoners huisves, terwyl groepe rondom Springbok en Steinkopf die ander relatief groter nedersettings

[16] 'n Bydrae van ongeveer 10% van die Bruto Distriksproduk vergeleke met net onder 3% van Suid-Afrika se Bruto Produk. In die Richtersveld Plaaslike Munisipaliteit maak landbou ongeveer 6% van die plaaslike ekonomie uit, gelykstaande aan ongeveer R96.8 miljard in 2023-pryse.

verteenwoordig. Informele nedersettings kom voor, veral aan die randgebiede van dorpe, gedryf deur behuisingsagterstande, stadige stedelike uitbreiding en beperkte beskikbaarheid van gediensde erwe.

Die streek, veral sy nedersettings, staar tans verskeie infrastruktuuruitdagings in die gesig. Munisipale water- en sanitasie-stelsels is hoogs gespanne, met kritieke "Blue Drop"-tellings (onder 31% vir drie van die studiegebied se plaaslike munisipaliteite, met die uitsondering van Nama Khoi op ~36%), verouderde pypleidings, onbetroubare voorsiening en beperkte bergingskapasiteit (Blok OBM 18). Hierdie bly funksioneel hoofsaaklik omdat huidige aanvraag laag is, en hulle binne effektiewe kapasiteitsgrense bedryf word.

Die padnetwerk verteenwoordig 'n kritieke lewenslyn in hierdie ylbevolkte streek. Verskeie munisipale paaie benodig wesenlike herstelwerk om aan aanvaarbare standaarde te voldoen. Die R382 (tussen Steinkopf, Port Nolloth en Alexanderbaai) het sy ontwerp-leeftyd bereik of oorskry en benodig opgradering, insluitend oor die Anenousbergpas. Grondpaaie wat kleiner nedersettings bedien, is dikwels in swak toestand en hoogs kwesbaar vir weerverwante skade.

Blok OBM 18: Wat is die "Blue Drop" Sertifiseringsprogram

Teen 2008 het dit duidelik geword dat baie munisipaliteite nie hul drinkwaterstelsels doeltreffend bestuur, instandhou en bedryf het nie, wat gelei het tot swak watergehalte en sporadiese uitbrake van watergehalte-verwante siektes. Bydraende faktore het beperkte bestuurs- en tegniese vaardighede, verouderde en vervalle infrastruktuur, vinnige behuisingsontwikkelings wat nie met infrastruktuurplanne in lyn was nie, en onvoldoende begrip van watersuiveringsprosesse ingesluit. Om hierdie uitdagings aan te spreek, het die Departement van Water en Sanitasie die "Blue Drop"-sertifiseringsprogram ingestel, wat munisipale watervoorsieningstelsels jaarliks oudit, insluitend rouwaterpompstasies en suiweringsfasiliteite, en hul werkverrigting beoordeel. Die resultate word gebruik om dienslewering te vergelyk, munisipaliteite wat risiko loop te identifiseer, en regulatoriese en ondersteuningsintervensies te rig, veral vir stelsels wat onder 30% punte behaal, om nakoming te verbeter en veilige drinkwater te verseker.

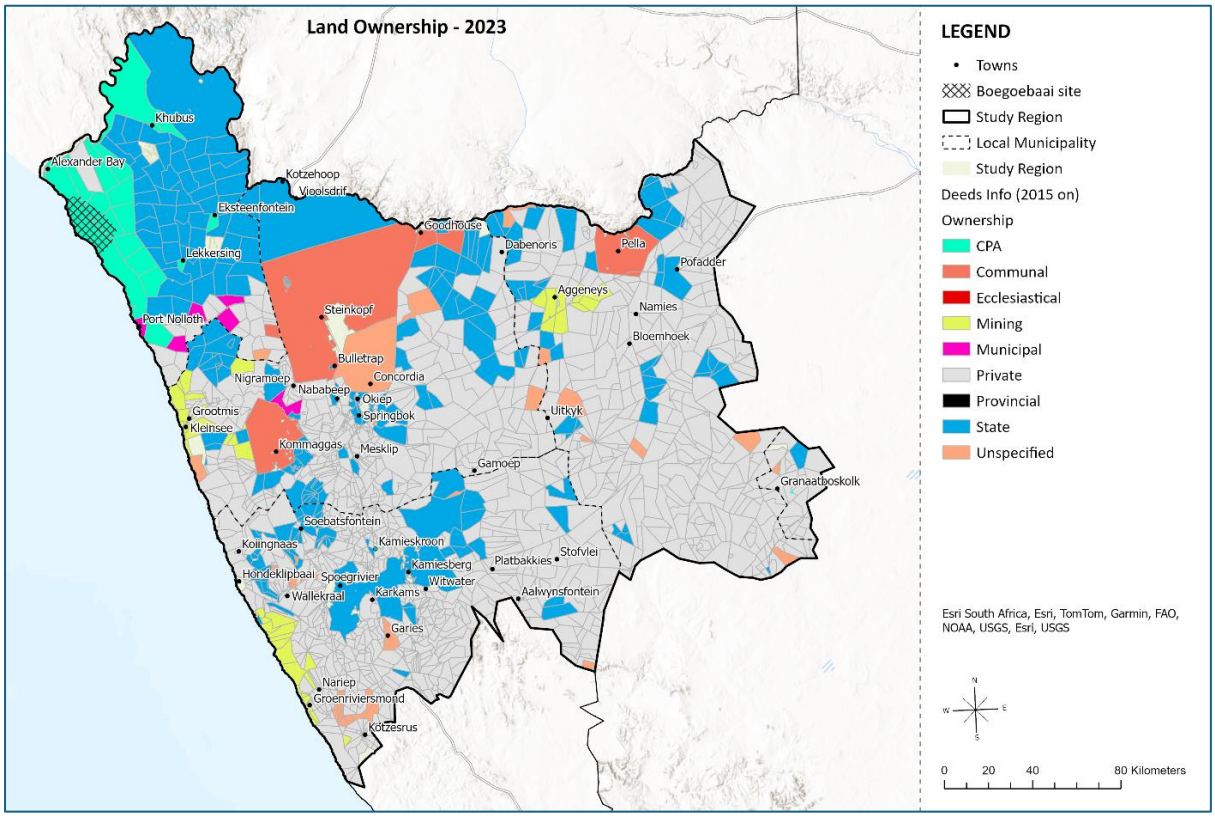
Daar is geen bestaande spoorlyn-infrastruktuur en geen gevestigde gas- of oliepyp-infrastruktuur in die streek nie, wat lei tot 'n inherente afhanklikheid van padvervoer vir vrag en grootmaatmateriaal. Elektrisiteitstoevoer word verdeel tussen Eskom en plaaslike munisipaliteite, met baie munisipaliteite wat op of bo hul *Notified Maximum Demand*-drumpels funksioneer. Elektrisiteitstoevoer word verder beperk deur 'n beperkte kraglynnetwerk, wat die onttrekking van krag bemoeilik, insluitend nuwe hernubare-energie-opwekking. Inligtings- en kommunikasietegnologie ("Information and Communcation Technology (ICT)") dekking is ook beperk buite groter nedersettings, insluitend die voorgestelde hawe- en SES. Hierdi eICT-beperkings beïnvloed nie net huishoudelike konnektiwiteit nie, maar ook munisipale koördinering, regulatoriese toesig, infrastruktuurmonitering en noodreaksie-vermoë.

Om grond of serwitute vir streeksinfrastruktuur (insluitend paaie, transmissielyne, pypleidings of toekomstige spoorwegkorridors) te verkry is administratief kompleks en vereis gekoördineerde betrokkenheid tussen verskeie grondeienaars, instellings en die regering. Die suidelike deel van die streek word gekenmerk deur 'n groter mate van privaat grondbesit, terwyl die breër Richtersveld-gebied hoofsaaklik uit staatsgrond (58%) en CPA-grond (28%) bestaan, met 'n kleiner privaatbesitkomponent (12%) (Figuur OBM 5). Grondbesit is gefragmenteerd, veral in dieRichtersveld, waar CPA-, staats-, privaat- en mynbouverwante besit oor uitgestrekte gebiede ineengeskakel is. Die Richtersveld CPA beheer die grond rondom Boegoebergbaai maar staar interne bestuursgeskille in die gesig, terwyl die munisipaliteit histories huiwerig was om volle diensverantwoordelikheid vir Alexanderbaai te aanvaar weens verouderde bates en nakomingsuitdagings binne die erfenis-infrastruktuurnetwerk.

Munisipale finansiële kapasiteit verteenwoordig 'n addisionele basislyn-sensitiwiteit. Eie-inkomstebronne is swak oor die hele streek, met munisipaliteite wat sterk afhanklik is van interdistrik- en interregeringsoordragte om infrastruktuur en dienslewering te befonds. Onderspandering en oordragte van kapitaalbegrotings weerspieël institusionele en tegniese beperkings eerder as 'n afwesigheid van infrastruktuurbehoefte, wat die vermoë van munisipaliteite beperk om proaktief in grootmaatdienste of voorkomende instandhouding te belê.

Rampbestuur en noodreaksie-kapasiteit is beperk, veral in afgeleë nedersettings en langs lang vervoerkorridors. Lang reaksietye, beperkte personeel en -kommunikasiesisteme verhoog die sensitiwiteit vir padongelukke, konstruksie-aktiwiteite en die vervoer of hantering van gevaarlike materiaal.

Gesamentlik weerspieël die infrastruktuur- en beplanningsbasislyn 'n stelsel wat hoofsaaklik funksioneel bly omdat ontwikkelingsaanvraag histories laag was. Beplanning-, infrastruktuur- en diensleweringstelsels funksioneer met beperkte institusionele kapasiteit en beperkte infrastruktuurstelsels, insluitend verouderende infrastruktuur, finansiële beperkings en tekorte aan geskoolde personeel. Gelyktydige streeks-katalitiese projekte word verwag om kumulatiewe druk op reeds beperkte beplannings-, infrastruktuur- en institusionele stelsels te plaas. **Sonder vroeë, gekoördineerde en voldoende befondsde intervensie, dui toestande op 'n hoogs sensitiewe ontvangende omgewing waarin selfs matige toename in ontwikkelingsintensiteit kan lei tot bo-normale infrastruktuur-, bestuurs- en diensleweringsrisiko's**



Figuur OBM 5: Grondbesit in die streek gebaseer op die 2023 Richtersveld-grondoudit en die Departement van Landelike Ontwikkeling en Grondhervorming se grondbesit-inligting (Bron: Maritz, 2023).

2.2 Moontlike impakte (positief en negatief)

Hierdie afdeling som die potensiële negatiewe en positiewe impakte wat verband hou met die drie ontwikkelingscenario's [basislyn (Sc0), klein GH_2-ontwikkeling (Sc1) en groot GH_2-ontwikkeling (Sc2)], in verhouding tot die voorgestelde Boegoebaai-hawe, SES en GH_2-ontwikkelingsinfrastruktuurkomponente, op. Die basislynsenario neem aan dat die beplande GH_2-ekonomie nie materialiseer nie en dat huidige sosiale, ekologiese, klimatologiese en ontwikkelingsneigings voortduur.

Ekologiese en erfenisverwante impakte word aangebied in Ekologiese- en erfenis impakte

Tabel OBM 3 (negatiewe impakte) en Tabel OBM 4 (positiewe impakte) in Afdeling 2.2.1, wat 'n gekonsolideerde, scenariogebaseerde vergelyking bied tesame met aanbevole bestuursaksies. Sosio-ekonomiese impakte, asook infrastruktuur- en beplanningsoorwegings, wat van kruisende en stelselvlak-aard is, word onderskeidelik opgesom in Afdelings 2.2.2 en 2.2.3.

Hierdie geïntegreerde oorsig van spesialisbevindinge is daarop gemik om strategiese beplanning en bestuur in te lig, daaropvolgende projekvlak-OIS'e te ondersteun, die identifikasie van are en strategieë te rig op die versterking van positiewe uitkomstes en nadelige effekte te vermy of te versag, en om kennisleemtes uit te lig wat verdere fyngeskaalde spesialisondersoek vereis.

2.2.1 Ekologiese- en erfenis impakte

Tabel OBM 3: Saamvattende opsomming van moontlike negatiewe impakte op ekologie en erfenis, en aanbevole bestuursaksies vir die Boegoebaai-hawe, SES en GH_2-ontwikkelingscenario's.

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (versagting)
TERRESTRIëLE EKOLOGIE	**Geïntgreerde ekologie**			

	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie --
	• **Verwoestyning en verdorring,** gedryf deur klimaatsverandering en onvolhoubare grondgebruik, wat lei tot:
	  ○ Die **suidwaartse uitbreiding van die Namibwoestyn** (bioomverskuiwing),
	  ○ **Afname in weiveldproduktiwiteit en agteruitgaande ekosisteme**, met die Richtersveld die ergste geraak.
	  ○ **Toenemende plantegroeiverlies en gronderosie**, wat lei tot afnemende grondstabiliteit, habitatagteruitgang en verminderde neskonstruksiemateriaal vir fauna.
	• **Afnemende plant-en dier bevolkings** van seldsame en endemiese spesies.
	• **Habitatfragmentasie en beskermingsgapings wat voortduur** namate grondgebruikverandering en beperkte dekking van beskermde gebiede ekologiese konnektiwiteit verswak, wat reeds bedreigde ekosisteme blootstel aan voortdurende agteruitgang.
	• **Aanhoudende oorbeweiding,** veral op gemeenskapsgrond, wat plantegroeistruktuur vereenvoudig en klimaatsgedrewe ekosisteemagteruitgang vererger, terwyl **indringerplante habitatte verder homogeniseer** en inheemse biodiversiteit uitkompeteer.
		Boonop impaktendense onder Sc0 --
		• **Gelokaliseerde habitatverlies**, gekonsentreer waar GH_2-infrastruktuur oor **MEDIUM–HOË** sensitiwiteitsgebiede oorvleuel.
		• **Direkte verlies van spesies van bewaringsbelang** binne die geraakte ontwikkelingsvoetspore.
		• **Toenemende fragmentasie** as gevolg van nuwe paaie, pypleidings, transmissielyne en ander lineêre infrastruktuur.
		• **Kumulatiewe ekosisteemagteruitgang** waar GH_2-fasiliteite klimaatsgedrewe verbruining en weidingsdruk vererger.
			Boonop impaktendense onder Sc0 --
			• **Grootskaalse, hoë-intensiteit habitatverlies** wat **HOË** en **BAIE HOË** sensitiwiteitsones direk raak.
			• **Groot impakte op biodiversiteitspatrone:** verlies aan endemiese spesies, SCC-populasies en hele plaaslike sentrums van endemisme.
			• **Ernstige fragmentasie** van korridors, ekologiese prosesroetes, seisoenale bewegingspaaie en klimaats-vlughawe-skakels**.**
			• Toenemende druk op **reeds gedegradeerde ekosisteme**, wat klimaatsgedrewe verbruining vererger en bedreigde plantegroeitipes nader aan ineenstorting stoot.
				• **Bou voort aan 'n streeksbiodiversiteit-inligtingsbasis** om proaktiewe beplanning te ondersteun.
				• **Verbeter bestuur van vee** om klimaatsversterkte agteruitgang te verminder.
				• **Versterk teen-stropery-, moniterings- en herstelprogramme**.
				• **Vul streekskaal-sensitiwiteitskartering aan** met gedetailleerde, fyngeskaalde ekologiese opnames van voorgestelde ontwikkelingsgebiede voordat infrastruktuuruitleg en ontwerp begin, om te verseker dat sensitiwe habitats en biodiversiteitskenmerke vermy.
				• **Ontwikkelingstipe-, terrein-, ekosisteem- of spesie-spesifieke mitigasie-maatreëls** om versteuring te verminder, die oprigting van ondeurdringbare bewegingshindernisse te voorkom en toevallige sterftes van individue te elimineer.
				• **Vermy van ontwikkeling in sensitiewe landskappe of habitats** in die projekbeplanningsfase.
				  ○ **Vermy HOË/BAIE HOË sensitiwiteit** in terreinbepaling; in Medium-gebiede moet fyngeskaalde ekologiese kartering voor ontwerp toegepas word om sensitiewe kenmerke te vermy.
				• **Pas die volle versagtingshiërargie toe**; oorweeg kompensasie ("biodiversity offsets") slegs wanneer vermyding- en versagtingsopsies uitgeput is. Belyn waar moontlik die implementering van biodiversiteitskompensasies met die strategie vir die uitbreiding van beskermde gebiede.
				• Waar vermyding nie moontlik is nie, **beskerm streeksbiodiversiteit deur biodiversiteitskompensasies** te gebruik om die omvang van geraakte ekosisteme binne formele beskermde gebiede te vergroot.
				• **Brei die implementering van die streek se netwerk van beskermde- en "stewardship"-gebiede uit** (d.w.s. afkondiging van beskermde gebiede, ens.) wat kernbiodiversiteitsgebiede bewaar wat verbind word via 'n streeks-ekologiese korridornetwerk binne 'n natuurskoon en natuurlike landskap (behou die natuurlike plekssin).
				• **Herstel versteurde grond**, veral rondom lineêre infrastruktuur.
				• **Beperk lineêre voetspore,** belyn met bestaande serwitute, en herstel/kompenseer knelpunte in korridors ná konstruksie.
				• **Gebruik kumulatiewe-impakassessering en koppel projekte aan weiveldverbeteringsooreenkomste** in die omliggende landskap.

	Voëls			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Stygende temperature kan veroorsaak dat voëls in droë streke hul fisiologiese drempels oorskry**, wat oorlewingspotensiaal, broedsukses en kuikenoorlewing en uitvlieging verminder. • Verdere **afnames in reënval en hoër verdamping kan voedselproduktiwiteit en beskikbaarheid (insekte, sade, nektar, vrugte) verminder,** wat tot nesmislukkings, verhongerrisiko en vertraagde of mislukte broei lei. • Verwoestyning, verlies aan plantegroei en gronderosie kan **neskonstruksiemateriaal verwyder, blootstelling aan stof/hitte verhoog en avifaunale oorvloed/diversiteit verminde**r (veral in die Richtersveld).	*Boonop impaktendense onder Sc0 --* • **Versteuringsgedrewe verplasing vanaf konstruksie/bedrywighede** (hawe/SES, wind/sonplase, paaie, pypleidings, kraglyne, maste). • **Verplasing as gevolg van verlies/fragmentasie/transformasie van habitatte d**eur GH_2- en hernubare energie-voetspore en lineêre korridors. • **Botsing-verwante sterftes (turbines, kraglyne, torings) vir prioriteit-SCC (roofvoëls, korhane, lewerikke, pelikane).** • **Skokrisiko** op 'n uitgebreide netwerk van kraglyne en substasies.	*Boonop impaktendense onder Sc0 --* • **Ernstige versteuringsverwante verplasing** in **BAIE HOË** sensitiwiteitsgebiede. • **Ernstige habitatverlies/fragmentasie,** insluitend SCC-kerngebiede en KBA's. • **Ernstige botsingsrisiko vir EN/CR-spesies** (bv. Ludwig se korhaan, aasvoëls, arende) teen turbines/kraglyne. • **Hoë skokrisiko** weens grootskaalse uitbreiding van die elektrisiteitsnetwerk**.** • **Kumulatiewe impakte wat die grense van bevolkingslewensvatbaarheid vir verskeie SCC nader,** met residuele risiko wat beduidend bly selfs na versagting.	• **Brei beskermde gebiede en "stewardship"-inisiatiewe uit** in prioriteit-habitatte; behou mikrohabitatte. • **Herstel gedegradeerde habitat** om habitatstruktuur te hebou en verwoestyningseffekte te verminder. • **Verbeter weiveldbestuur**, insluitend droogteresponsiewe ontkoping om veldineenstorting te voorkom. • **Beheer indringerplante en beskerm/herstel vleilande**, panne en seepstelsels om drink- en voedingsplekke te beveilig. • **Vermy HOË/BAIE HOË sensitiwiteit** by terreinbepaling en belyn infrastruktuurligte met lae-risiko korridors. • **Voëlveilige ontwerp en bedrywighede**: afwykers, roofvoëlveilige paalontwerpe, lae-impak beligting, anti-sitrustoestelle. • **Windplaas stilstand-op-aanvraag** ("shutdown-on-demand") en seisoenale beperking; vooraf-konstruksie-opnames en mikro-plasing

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (versagting)
	• Toenemende oorbeweiding, vererger deur klimaatsveranderingstresfaktore, **vereenvoudig plantegroeistruktuur, verminder beskikbare voedsel- en neskonstruksiemateriaal vir voëls,** en vererger **klimaatverwante afnames in voëlverskeidenheid** en -aantalle. • Verskuiwende bioomgrense, gedryf deur klimaatsverandering en antropogeniese druk, kan lei tot **habitatkrimping en fragmentasie** binne die Sukkulente-Karoo, wat vermindering individue en diversiteit, bevolkingsfragmentasie, verspreidingsverskuiwings, gemeenskapsherstrukturering en moontlike verlies van endemiese en habitats-spesialis-spesies voëls veroorsaak. • Toenemende frekwensie van warm, droë periodes verhoog **veldbrandrisiko wat nes- en voedselhabitats kan vernietig, wat voedsel- en watertekorte** vir plaaslike voëllewe vererger. • **Verdroging van vleilande, panne en seepstelsels verminder drink- en voedingsgeleenthede, wat dehidrasie**, verlate neste, mislukte broei en verspreidingskrimping veroorsaak. • Toenemende bedekking **deur indringerplante kan habitats homogeniseer en natuurlike plantegroei verdring**, wat moontlik algemene spesies bevoordeel terwyl dit **geskikte habitat, skuiling en voortbestaan van verspreidingsbeperkte en spesialisvoëls verminder,** met moontlike plaaslike uitwissing in indringer-oortrekte gebiede.			om neste/roetes/vlugkorridors te vermy. • **"GenEst"[17]-gebaseerde monitering** voor en ná konstruksie, stel "Thresholds of Potential Concern (TPC)" en pas aanpasbare reaksies toe; habitatherstel en handhawing van hidrologie. • **Gevorderde botsing-voorkoming** (beperkingsregimes, hoë-prestasie afwykers) en roofvoëlveilige elektriese ontwerpe. • **TPC-gebaseerde aanpasbare bestuur** met verpligte regstellende optrede wanneer drumpels oorskry word.
	Vlermuise			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Afnemende natuurlike voedsel as gevolg van verwoestyning, oorbeweiding, gronderosie en waterskaarste,** wat lei tot verminderde insekte-prooi en gedegradeerde jaghabitatte. • **Ontoeganklike oopwaterbronne**, aangesien warmer, droër toestande en afname in grondwateraanvulling oppervlakwater verminder wat noodsaaklik is vir drink en insekbeskikbaarheid. • **Afnemende insekbeskikbaarheid** weens warmer, meer droë toestande en veranderde habitatstruktuur. • **Ligbesoedeling** neem toe, wat ligverdraagsame algemene spesies bevoordeel terwyl dit fotofobiese en spesialis-vlermuissoorte afskrik en spesiesamestelling verander. • **Uitbreiding van windenergie (wat selfs onder die basislyn plaasvind weens Springbok REDZ) kan botsings- en barotrauma-risiko v**erhoog indien dit nie bestuur word nie. • **Landbouveranderinge kan beperkte, gelokaliseerde voedselsoekgeleenthede vir vlermuise skep** deur besproeide landerye en vee-aktiwiteit, terwyl afnemende chemiese plaagdodergebruik vlermuise kan bevoordeel deur toksienblootstelling te verminder; hierdie voordele is egter ruimtelik beperk en versag nie die breër klimaat- en watergedrewe habitatbeperkings nie. • **Uitbreiding van beskermde gebiede kan help om natuurlike voedselsoek-habitatte vir vlermuise en insek-prooiverskeidenheid te bewaar**, wat vlermuise gedeeltelik kan buffer teen breër klimaat- en landdegradasiedruk. • Bogenoemde drywers interaksies skep verwagting dat die	*Boonop impaktendense onder Sc0 --* • **Vernietiging of versteuring van vlermuisrusplekke** (natuurlik en kunsmatig) as gevolg van die konstruksie van turbines, PV-velde, paaie, substasies en GH_2-infrastruktuur. • **Verlies en fragmentasie van voedselsoek-habitatte,** beide permanent (uitkap) en tydelik (konstruksieversteuring). • **Hoë botsings- en barotrauma-sterfterisiko,** veral in **BAIE HOË** en **HOË** sensitiwiteitsgebiede; spesies met die grootste risiko sluit in *Tadarida aegyptiaca*, *Sauromys petrophilus*, *Miniopterus natalensis*. • **Aantrekking tot turbines weens insekte,** aangetrokke is to beligting of laedruklugvakte, wat bo**tsingsblootstellin**g verhoog. • **Vrugtevlermuise se bewegingsroetes** (nie goed verstaan) kan turbines kruis, wat sterfterisiko verhoog, veral naby dadelplase en rivierkorridors.	*Boonop impaktendense onder Sc0 --* • **Ernstige vernietiging/versteuring van vlermuisrusplekke,** met onomkeerbare verlies van makro-nesmaakplekke moontlik. • **Grootskaalse verlies van voedselsoek-habitatte,** wat potensieel kritieke habitatte kan raak wat hoë vlermuisdiversiteit ondersteun. • **BAIE HOË sterfterisiko,** met moontlike ineenstorting van plaaslike vlermuispopulasies indien dit nie bestuur word nie. • **Hoë risiko vir grotbewonende spesies,** waar turbine-impakte energietoevoer na grotekosisteme kan beïnvloed deur vermindering in guano. • **Kumulatiewe, streekwye verplasing van sensitiewe spesies;** moontlike plaaslike uitwissing van algemene spesies.	• **Vermy alle BAIE HOË sensitiwiteitsones en pas buffers toe vir nesmaakplekke (500 m–20 km, afhangend van koloniegrootte).** • **Pas terreinspesifieke sensitiwiteitskartering toe en 12 maande vooraf-konstruksie monitering (insluitend reënseisoen).** • **Gebiede wat tydens konstruksie versteur word, moet ná voltooiing gerehabiliteer word met toepaslike ekologiese hersteltegnieke**. • **Implementeer beperking (verhoogde aanskakelspoed van windturbines) wanneer vlermuisaktiwiteit hoog is.** • **Beperk beligting en vermy die skep van kunsmatige waterbronne** naby turbines. • **Die ontwerp en konstruksie van nuwe geboue en infrastruktuur moet voorkom dat kunsmatige nesmaakplekke ontstaan**. • **Verbied windplaasontwikkeling binne groot buffers rondom bevestigde en moontlike nesmaakplekke** (tot 20–50 km). • **Indien onbekende vlermuisroesplekke tydens die konstruksiefase teëgekom word, moet die betrokke Omgewingsnakomingsbeampte (ECO) dadelik in kennis gestel word en 'n vlermuisspesialis geraadpleeg word** vir die toepaslike aksie. • **Voer operasionele sterftemonitering uit en bestuur windturbines aanpasbaar.** • **Langtermyn operasionele monitering,** insluitend vrugtevlermuis-monitering naby landbou-korridors.

[17] "Generalized Estimator of Mortality" is 'n gratis, oopbron-statistiese model en sagteware-instrument, meestal bekend as "GenEst", wat gebruik word om die totale aantal wildsterftes (veral voëls) in 'n spesifieke gebied akkuraat te beraam, veral by fasiliteite soos wind- of sonplase wanneer alle sterftes nie direk waargeneem word nie en waar die waarskynlikheid van karkas ontdekking minder as een is (https://www.usgs.gov/software/genest-a-generalized-estimator-mortality).

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (versagting)
	struktuur van viermuisgemeenskappe sal verander, met aanpasbare algemene spesies wat plaaslik volhard of toeneem, terwyl spesialis- en waterafhanklike spesies afneem.			
	Terrestriële fauna			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Habitatverlies en fragmentasie weens bestaande grondgebruike** (mynbou, oorbeweiding, paaie, kraglyne, nedersettings) ontwrig bewegingskorridors, tonnelnetwerke en verspreidingspaaie – die ergste vir duin-/kusspesialiste en fossoriale soogdiere/reptiele (bv. goue molle, duinmolrot, skilpaaie, sandakkedisse) • **Versteuring (geraas, beligting, menslike aktiwiteit) verhoog verplasings- en padslagrisiko,** veral vir naglewende mesokarnivore (bv. bakoorjakkals, Kaapse jakkals) en stadigbewegende reptiele (adders, skilpaaie). • **Agteruitgang van ekosisteemprosesse** (bestuiwing, grondingenieurswese, amfibie-pulsbroei) deur oorbeweiding, grondverdigting, hidrologiese verandering en kumulatiewe lineêre infrastruktuur. • **Meer intense klimaatsverandering (hitte, droogte)** stoot amfibieë oor hul hidro-ekologiese drempels (verkorte hidroperioodes), versteur reptiele se temperatuurafhanklike geslagsbepaling, en verminder beskikbare weiding vir herbivore/insektivore.	*Boonop impaktendense onder Sc0 –* • **Die konstruksie-/bedryfsvoetspoor veroorsaak habitatverlies/fragmentasie en versteuring oor MEDIUM–HOË sensitiwiteitsvlaktes en in HOË/BAIE HOË areas** indien swak geplaas, wat verplasing verhoog vir tonnelafhanklike gildes en rots-spesialiste (gordelakkedisse, padlopers). • **Prosesvlak-impakte**: veranderde grondtemperatuur/struktuur (PV-platforms, paaie, harde oppervlaktes) en heinings ontwrig grondingenieurs (termiete, miere, knaagdiere) en amfibie-pulsbroeiers wat aan tydelike poele gebonde is.	*Boonop impaktendense onder Sc0 –* • **Skaalgedrewe, kumulatiewe habitatverlies en fragmentasie met kritieke gevolge in BAIE HOË/HOË senstiwiteit areas** (kusduin-SCC-spesies, korsmosvelde, koppiekomplekse); hoë waarskynlikheid van onomkeerbare verliese en plaaslike uitwissing indien vermyding nie bereik word nie. • **Prosesversteuring op landskapskaal:** ineenstortingsrisiko's vir grondingenieurs, bestuiwingsnetwerke en amfibie-broeidinamika; wydverspreide heinings/paaie verhoog versperringseffekte en padslag.	• **Vermy en buffer alle BAIE HOË sensitiwiteit areas** (kusduinveld, korsmosvelde, SCC-neste-/tonnelkomplekse, rots-inselberge). • **Spesie-spesifieke opnames en ontwerp om finale infrastruktuur-uitlegte te bepaal** (goue molle, duinmolrot, padloper-skilpaaie, reënpaddas). • **Lei lineêre infrastruktuur via kortste pad; gebruik bestaande serwitute waar moontlik;** sluit fauna-onderpaaie/duikweë onder paaie in, saam met "fauna-versperrings"/leidingversperrings; kraai-bestande substasie-/lynontwerpe naby skilpad-habitatte om predasie te verminder; verpligte omgewings- en padslagmonitering met aanpasbare bestuur. • **Beskerm hidrologie**: hou tydelike panne/sandriviere funksioneel (terugstelsones, kruisingontwerp, geen invulling van panne); grondherstel ná werke. • **Vermyding op landskapskaal: sluit alle BAIE HOË en die meerderheid HOË sensitiwiteitsgebiede uit;** stel ontwikkelingsperke om te voorkom dat lewensvatbaarheiddrempels vir SCC oorskry word. • **Scenario 2 (groot GH_2) kan hoë residuele impakte tot gevolg hê wat biodiversiteitskompensasies ("biodiversity offsets") kan vereis.** • **Verpligte kumulatiewe impakassessering, aanpasbare bestuur toelaag in goedkeurings, en monitering buite die voetspoor** (fauna-beweging, padslae, amfibie-broeisukses, grondprosesaanwysers).
WATER RESOURCES AND AQUATIC ECOLOGY	**Grondwater**			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Afnemende grondwaterbeskikbaarheid gedryf deur warmer en droër klimaatstoestande**, insluitend afnemende "MAP" [18],verhoogde "MAPE" [19], lang periodes sonder reënval en verminderde aanvulling, veral in alluviale akwiwerstelsels. • **Agteruitgang in grondwatergehalte** as gevolg van stygende soutgehalte deur mariene aerosoolneerslag en uitloging van soute uit heuweltjies tydens swaar reënvalgebeurtenisse, vererger deur besoedeling vanaf wanfunksionerende afvalwaterbehandelingsaanlegte. • **Toenemende grondwateronttrekking** as gevolg van bevolkingsgroei plaas addisionele druk op grondwater wat reeds gespanne is en dalende watervlakke ervaar	*Boonop impaktendense onder Sc0 –* • **Beduidende addisionele druk op grondwaterbronne** veroorsaak deur verhoogde bevolkingsinmigrasie en watervraag vanaf GH_2-bedrywighede in dorpe soos Alexanderbaai en Port Nolloth. • **Verhoogde besoedelingsrisiko's** wat ontstaan deur hoërisiko GH_2-infrastruktuur soos chemiese stoorfasiliteite, pypleidings en waterstofproduksiestelsels. • **Afnemende grondwatersekerheid** in prioriteit-GRU's waar voorsiening reeds onvoldoende is om bestaande vraag te dek.	*Boonop impaktendense onder Sc0 –* • **Ernstige uitputting van grondwater** gedryf deur grootskaalse GH_2-ontwikkeling, met watervraag wat die voorsieningskapasiteit van grondwater in verskeie hoë-sensitiwiteitseenhede oorskry. • **Verhoogde risiko's van** grondwaterbesoedeling veroorsaak deur die uitgebreide industriële voetspoor en die verhoogde moontlikheid van mors en effluentlekkasie. • **Groter waarskynlikheid van langtermyn of onomkeerbare versouting van grondwater** as gevolg van verminderde aanvulling, hoër verdamping en verhoogde onttrekking.	• **Vermy hoë-risiko aktiwiteite (chemiese berging, pypleidings, GH_2-verwerkingsinfrastruktuur) in gebiede met HOË of BAIE HOË grondwatersensitiwiteit**, insluitend SWSA's en prioriteit-GRU's. • **Belê in munisipale waterinfrastruktuur**, insluitend opknapping van grootmaatvoorsieningstelsels en grondwaterretikulasienetwerke. • **Implementeer grondwater- en seewaterontsouting om watervoorsiening aan te vul** waar grondwater nie aan die vraag kan voldoen nie. • **Verbeter boorgatbestuur** deur gespesialiseerde opleiding (bv. aanspreek van yster-biofouling). • **Stel bestuurde grondwateraanvullingskemas in werking** om langtermynversouting te verminder en grondwateropbrengs te stabiliseer. • **Versterk regulatoriese beskerming vir grondwatergehalte en handhaaf beperkings in sensitiewe gebiede.**
	Oppervlak water			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Afnemende beskikbaarheid** van oppervlakwater veroorsaak deur verminderde reënval, verminderde afloop en verhoogde evapotranspirasie, wat lei tot lang periodes sonder vloei in strome en riviere. • **Toenemende kwesbaarheid van dorpe en landbou** as gevolg van verouderde, onderpresterende Oranjerivier-onttrekkings- en retikulasiesisteme.	*Boonop impaktendense onder Sc0 –* • **Toenemende druk op oppervlakwaterstelsels** veroorsaak deur 'n stygende bevolking en GH_2-verwante watervraag wat bestaande onttrekkings- en retikulasiekapasiteit oorskry. • **Hoër risiko vir watertekorte** weens afhanklikheid van reeds gespanne Oranjerivier-grootmaatwaterskemas.	*Boonop impaktendense onder Sc0 –* • **Ernstige skaarsheid van oppervlakwater** as gevolg van grootskaalse GH_2-uitbreiding, waar watervraag die beskikbare voorsiening ver oorskry, veral gedurende lang droë periodes**.** • **Toenemende stelselrisiko van mislukking in oppervlakwater-voorsieninginfrastruktuur** as gevolg van oorweldigende vraag tydens intense klimaatstoestande.	• **Ontwikkel en optimaliseer nuwe of uitgebreide Oranjerivier-onttrekkingskemas** wat in lyn is met ekologiese vloei-vereistes. • **Implementeer en befonds voldoende ontsouting** vir beide seewater en sout grondwater om beperkte beskikbaarheid van oppervlakwater aan te vul. • **Verbeter werking, instandhouding en betroubaarheid van onttrekking-, behandelings-, retikulasie- en bergingsinfrastruktuur.** • **Voorkom besoedeling by wateronttrekkingswerke**, veral waar ondergrondse filtrering gebruik word.
	Akwatiese ekosisteme en riviermondings			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie --	*Boonop impaktendense onder Sc0 –*	*Boonop impaktendense onder Sc0 –*	• **Vermy alle ontwikkelig in BAIE HOOG sensitiewe akwatiese en riviremond areas,** inlsuitedn CR/EN vleilande, NFEPA riviere en funksionele sones vir riviermondings.

[18] Gemiddelde jaarlikse reënval "(Mean Annual Precipitation (MAP)") is voorspel om tussen 10-20 % in meest plekke te daal, en 0-10% in ander areas.
[19] Gemiddelde jaarlikse evapotranspirasie ("Mean Annual Potential Evapotranspiration (MAPE)") sal met 6-10% styg.

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (versagting)
	• **Biodiversiteitsverlies in tydelike panne** veroorsaak deur verkorte hidroperiodes wat onverhoed dat ongewerwelde en plantgemeenskappe hul lewensiklusse voltooi. • **Afnemende oewerplantegroei** gedryf deur verminderde beskikbaarheid van vlak grondwater, wat riviere meer vatbaar maak vir erosie tydens sporadiese vloedgebeurtenisse. • **Agteruitgang van waterlope veroorsaak deur voedingstowferryking en besoedeling** vanaf wanfunksionerende afvalwaterbehandelingsaanlegte, tesame met toenemende inval van indringerplante. • **Voortgesette agteruitgang in riviermond toestand**, **veral in die Oranjerivier-estuarium,** gedryf deur verminderde vloedfrekwensie, verhoogde soutgehalte en voedingstowferryking vanaf wanfunksionerende afvalwaterbehandelingsaanlegte.	• **Toenemende erosie en sedimentversteuring in riviere en vleilande veroorsaak deur gekonsentreerde stormwaterinvloei** vanaf verhardede GH_2-infrastruktuur soos paaie, turbine fondasies en sonpaneelvelde. • **Fragmentering van akwatiese en riviermond habitatte** as gevolg van nuwe paaie, kraglyne en GH_2-infrastruktuur wat natuurlike hidrologiese en ekologiese konnektiwiteit onderbreek. • **Toenemende voedingstowfbesoedeling** veroorsaak deur hoër afloopvolumes vaanuit groeiende formele en informele nedersettings. • **Stygende menslike druk deur visvang, weiding, versteuring en ontspanningsaktiwiteite op riviermond stelsels**, geassosieer met bevolkingsgroei.	• **Wydverspreide en moontlik onomkeerbare agteruitgang van CR en EN akwatiese ekosisteme** veroorsaak deur uitgebreide landskapfragmentasie en hidrologiese verandering. • **Beduidende agteruitgang in watergehalte** weens verhoogde afloop wat verband hou met groot bevolkingsgroei en uitbreiding van die stedelike voetspoor. • **Toenemende hipersoutheid en verminderde deurbrake in riviermonde**, wat viswerwing beperk en die ekologiese funksionering in droë Weskus-stelsels verder verswak.	• **Pas ekosisteembuffers toe** (20 m vir kunsmatige panne/damme; 50 m vir natuurlike panne, vleilande en riviere; 100 m vir NFEPA-riviere). • **Verseker dat padkruisings en stormwaterstelsels natuurlike hidrologiese roetes behou** en gekonsentreerde vloei en erosie voorkom. • **Opgradeer afvalwaterbehandelingsaanlegte** voor bevolkings- of nedersettinguitbreiding om voedingstofbesoedeling en kontaminasie te voorkom. • **Implementeer Oranjerivier-riviermond-herstelaksies** om rivier-mond-funksionering te ondersteun. • **Gebruik biodiversiteitskompensasie-bankdienste** waar onvermýbare impakte plaasvind, veral onder grootskaalse GH_2-ontwikkeling.
ERFENIS	**Paleontologie**			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Verwoestyning en toenemende mynbou kan fossielryke lae blootlê en 'n risiko vir fossielverlies skep**, veral waar kusvlaksedimente versteur word.	*Boonop impaktendense onder Sc0 –* • **Die meeste ontwikkeling raak oppervlaksedimente met LAE paleontologiese sensitiwiteit, daarom is die impakte oor die algemeen onbeduidend;** uitsonderings kom voor **naby die kus waar begronde mariene formasies met HOË sensitiwiteit deur dieper uitgrawings gekruis kan word**.	*Boonop impaktendense onder Sc0 –* • Impakte is soortgelyk aan Sc1 maar van **hoër intensiteit omdat 'n groter algehele ontwikkelingsvoetspoor die druk op grond verhoog en vermydingsopsies verminder, met die kusvlakte die kwesbaarste indien diep uitgrawings HOË-sensitiwiteitseenhede kruis.**	• **Elke projek moet tydens die OIS-fase deur 'n paleontoloog geëvalueer word** om die behoefte aan 'n paleontologiese spesialisstudie te bepaal, veral langs die kus. • Geen vaste areas waar ontwikkeling verbied moet word oor die voorkspoms van fossiele word op streekskaal geïdentifiseer nie; **beheer impakte deur geval-spesifieke beoordeling en bestuur.**
	Terrestriële argeologie			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Argeologiese hulpbronne word bedreig weens 'n toename in landbou-ontwikkeling langs die Oranjerivier en diamantmynbou langs die kus**. • **Hernude koperontginning in Okiep kan die historiese Koper-mynlandskap beïnvloed.** • **Moontlike kleinskaal-mynlisensies, olie- en gasverkenning, en verdere prospektering/mynbou (mangaan, yster en graniet) kan erfenishulpbronne** beïnvloed. • **Voortgesette ontwikkeling van hernubare energie in die REDZ, nuwe paaie en die industriële korridor langs die N14 kan argeologiese hulpbronne** beïnvloed.	*Boonop impaktendense onder Sc0 –* • **Gebiedsbreë impakte op oppervlak erfenisbronne is moontlik maar oor die algemeen nie hoogs beduidend nie, behalwe langs die kus waar terreine van hoër betekenis meer gekonsentreerd is.** • Binnelandse terreine sal meer verspreid wees, met **geleentheid om hulle tydens ontwikkeling te vermy.**	*Boonop impaktendense onder Sc0 –* • **Impakte soortgelyk aan Sc1 maar met hoër intensiteit weens die groter ontwikkelingsvoetspoor, wat lei tot verhoogde druk op land en 'n verminderde moontlikheid om impakte te vermy**, veral langs die kuslyn. • **Uitgebreide behoefte vir ontwikkelingsgrond verhoog die moontlikheid van impakte** op gemeenskapsgebiede.	• **Doen argeologiese spesialisstudies in alle OIS'e en gedetailleerde opnames** van elke projekvoetspoor. • **Monitor konstruksie in kusduingebiede** waar begrawe skulphope kan voorkom. • Kusimpakte kan nie almal versag word nie; argeoloë moet fokusareas vir veldopnames bepaal om die argeologie binne elke ontwikkelingsvoetspoor die beste te karakteriseer. • Oorweeg en identifseer vir beskerming enige erfenishulpbron-digte kusgebiede tydens OIS'e.
	Seevaart erfenis			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Moontlike see-mynbou en gasverkenning kan onbekende wrakke raak of vernietiging**.	*Boonop impaktendense onder Sc0 –* • **Impakte is onwaarskynlik om beduidend toe te neem weens die oor die algemeen lae moontlikheid dat wrakke gevind sal word;** daar is egter altyd 'n kans vir impakte.	*Boonop impaktendense onder Sc0 –* • Soos met Sc1, bly **impakte oor die algemeen onwaarskynlik, maar 'n groter ontwikkeling voetspoor verhoog die kans om sensitiewe lokaliteite naby histories aangetekende seevaart erfenishulpbronne te kruis.**	• 'n **Seevaart Erfenis-spesialisstudie word vereis vir ontwikkelinge wat die mariene omgewing raak** (bv. ondersee-pypleidings). • **Veldwerkvereistes moet bepaal word op grond van die ontwikkelingsvoorstel**, met die meeste onderwater-veldwerk wat tydens die vooraf-konstruksie- of mikroplasingfase uitgevoer word
	Grafte			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Impakte is onvoorspelbaar** aangesien grafte oor die algemeen heeltemal ongemerk is; **impakte vind sporadies plaas en kan ernstig wees as nie betyds identifiseer en verag word nie**.	*Boonop impaktendense onder Sc0 –* • **Impakte is onvoorspelbaar;** verskeie grafte kan beïnvloed word, of nie, afhangend van die presiese ligging.	*Boonop impaktendense onder Sc0 –* • Met **groter ontwikkelingvoetspore neem die kans om grafte teë te kom toe,** wat die moontlikheid vir beduidende tot ernstige negatiewe uitkomste verhoog indien dit nie vroeg effektief bestuur word nie.	• **Oorweeg grafte saam met argeologie in enige OIS**. • **Vroeë konsultasie met die Noord-Kaap Erfenishulpbronowerheid en verteenwoordigers van plaaslike gemeenskappe** om te bepaal of herbegrawing oorweeg moet word, en om geskikte liggings te identifiseer. • **Opgraving moet slegs plaasvind wanneer geen ander versagtingsopsies moontlik is nie.** • **Wanneer grafte naby ontwikkeling(e) behou word, moet hulle omhein word** om hul langtermynbeskerming te verseker.
	Geskiedenis en Geboude Strukture			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie --	*Boonop impaktendense onder Sc0 –*	*Boonop impaktendense onder Sc0 –*	• **Alle historiese en geboude strukture moet tydens OIS'e geëvalueer word;** restourasie kan aanbeveel word om beskerming en kulturele betekenis te versterk.

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (versagting)
	• **Geleidelike toename in mynbou en infrastruktuurontwikkeling kan historiese plekke, strukture en geboue ouer as 60 jaar beskadig of vernietig**.	• **Beduidende impakte is onwaarskynlik weens die relatief klein ontwikkelingsvoetspore**. • 'n Moontlike bedreiging kan **die onsensitiewe "restourasie" van historiese strukture wees, of sloping** in dorpe waar nuwe residensiële gebiede benodig word (Steinkopf, Okiep, Springbok).	• Impakte soortgelyk aan Sc1 maar met hoër intensiteit weens die groter ontwikkelingsvoetspoor, **wat lei tot toenemende kumulatiewe risiko's vir historiese stof en konteks waar vermyding beperk is.**	• **Plaasopstalle moet vermy word, met 'n buffer groot genoeg om te voorkom dat die strukture "onbewoonbaar"** raak weens die nabyheid van ongewensde ontwikkeling.
	Lewende Erfenis			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Kleinveeboere sal waarskynlik aanhou met tradisionele weidingspraktyke** ondanks swak omgewingstoestande en oorbeweiding. • **Infrastruktuur en mynbou in gemeenskaplike weidingsterreine kan tradisionele grondgebruikspraktyke verder bedreig.**	*Boonop impaktendense onder Sc0 –* • **Gemeenskapsgebiede van Steinkopf, Concordia en die Richtersveld is moontlik mees bedreig** aangesien hulle naby moontlike ontwikkelingsentrums geleë is.	*Boonop impaktendense onder Sc0 –* • **Met aansienlik groter grondvereistes neem die moontlikheid toe dat gemeenskapsgebiede gebruik word, wat risiko's vir transhumante praktyke en lewende erfenis verhoog**; tog kan finansiële voordele aan geraakte gemeenskappe toeval indien dit behoorlik beding word.	• **Plaaslike herdersgemeenskappe moet gekonsulteer word** om hul reaksie op die verlies van weigrond vas te stel, en om redes vir die keuse van weidingsgebiede te verstaan, die waarde van weiveld in terme van seisoenale weidingsvereistes, alternatiewe opsies en hoe die plaaslike omgewing en kultuur integraal in hul wêreldbeskouing is.
	Kulturele landskappe			
	Indien die hawe, SES en GH2 ontwikkeling nie voortgaan nie -- • **Bevolkingsgroei en gepaardgaande ontwikkeling sal geleidelik historiese en kulturele landskappe verander** (veral rondom Springbok/Okiep en Aggeneys), in kontras met seisoenale toerisme wat staatmaak op natuurlike estetiese en erfenisbewaring.	*Boonop impaktendense onder Sc0 –* • **Die klein algehele ontwikkelingsvoetspoor behoort nie beduidende landskapimpakte te hê nie**, tensy projekte naby prominente, esteties sensitiewe kenmerke soos die RKBL-Wêrelderfenisgebied (en buffer), Nasionale Parke/reservate, die Kamiesberg en die kuslyn geplaas word.	*Boonop impaktendense onder Sc0 –* • Soortgelyk aan Sc1, **maar meer intens, aangesien 'n groter ontwikkelingsvoetspoor die druk naby hoë-sensitiwiteit natuurskoongebiede verhoog** en opsies vir vermyding verminder.	• **Konsulteer met SANParke, UNESCO, SAHRA en plaaslike toerisme-operateurs rakende ontwikkeling naby die RKBL-Erfenisgebied of sy buffer, of naby natuurskoonroetes (N7, N14, R382), Nasionale Parke/reservate en ander ikoniese landskappe.** • **Die hele RkBL en sy buffer moet as 'n Geen-Gaan-gebied beskou word.** • **Sluit 'n Visuele Impakstudie in elke OIS in waar landskapeffekte 'n bekommernis is**; berei terreinspesifieke bestuursplanne voor wanneer erfenisterreine hergebruik of bewaar word in noue nabyheid aan ontwikkeling.

Tabel OBM 4: Saamvattende opsomming van moontlike positiewe impakte op ekologie en erfenis, en aanbevole bestuursaksies vir die Boegoebaai-hawe, SES en GH_2-ontwikkelingscenario's.

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (verbetering)
TERRESTIëLE EKOLOGIE	**Geïntigreerde Ekology**			
	• **Geleentheid om ekosisteme te stabiliseer** indien verbeterde bestuur van beskermde gebiede, weidingsbestuur en herstelintervensies geïmplementeer word. • Die huidige basislyn bied meer **ruimtelike buigsaamheid vir langtermynbewaringsbeplanning.**	• **Geleenhteid vir strategiese biodiversiteitskompensasies wat die netwerk van beskermde gebiede uitbrei** of hoëwaarde-prioriteitslandskappe beveilig. • **Moontlike ontwikkeling van grootskaalse biodiversiteitsekonomie-inisiatiewe** wat gekoppel is aan biodiversiteitskompensasies en -bewaring.	• **Uitbreiding van beskermde areas,** gefokus op bestaande biodiversiteitsprioriteite te gebruik.	• Waar residuele impakte oorbly ná vermyding/versagting, **implementeer soort-vir-soort biodiversiteitskompensasies** in gekarteerde prioriteitsgebiede binne dieselfde beplanningsdomein.
	Voëls			
	• **Uitbreiding van beskermde gebiede** skep 'n buffer teen klimaats- en grondgebruikbedreigings en beskerm broei-/voeding-/nes-habitatte en mikrohabitatte vir seldsame spesies.	• **Vroeë, geteikende vermyding en versagting** deur sensitiwiteitskaarte en tegnologie-spesifieke standaarde. • **Biodiversiteitskompensasies kan hoëwaarde-habitat verseker** indien dit korrek toegepas word (dieselfde beplanningsdomein; soort-vir-soort).	• **Moontlikheid vir groot, programmatiese biodiversiteitskompensasie** om korridors, refugia en hoëwaarde-habitatte te beveilig. • **Geleentheid vir streeksmonitering-/ bestuur-/ finansierings-platforms** te vestig vir voortdurende bewaring.	• **Uitbreiding van beskermde gebiede in prioriteit-habitatte;** behou mikrohabitatte. • **Landskapskaal-vermyding van alle BAIE HOË sensitiwiteitsgebiede;** stel ontwikkelingsperke om kumulatiewe risiko te beperk.
	Vlermuise			
	• Toename in kunsmatige nesplekke (geboue, myne, Namakwa-SES-gekoppelde nedersettingsgroei) kan **nuwe nesgeleenthede** vir verskeie vlermuisspesies skep • Landbou-besproeiingsgebiede kan plaaslik **insekgetalle verhoog en aanvullende voedselsoek-habitat bied.** • Veeboerdery (waar dit voortduur) kan **insekte** wat met mis geassosieer word lok, wat voedselsoekende vlermuise bevoordeel. • Beskermde gebiede **bewaar natuurlike**	• **Uitgebreide kunsmatige nesgeleenthede** vanaf GH_2-verwante infrastruktuur (indien onbedoeld geskep). • **Geleenthede vir navorsing en monitering:** vlermuis-OIS-monitering en beperkingstoetse genereer nuwe streekskennis. • **Verbeterings in streeksbeplanning: sensitiwiteitskaarte** maak dit moontlik om GH_2-projekte weg te stuur van Baie Hoë vlermuis-sensitiwiteitsones.	• **Grootskaalse strategiese navorsings- en moniteringprogramme word haalbaar** (migrasieroetes, spesiegedrag, risikoversagting). • **Geleentheid om streeks-korridors** te beskerm deur ruimtelike beplanning.	• **Navorsingsprogramme om migrasieroetes van grotbewonende vlermuise te karteer.**

	Basislyn scenario (Sc0)	Klein GH_2 ontwikkeling (Sc1)	Groot GH_2 ontwikkeling (Sc2)	Beginsels/aksies vir bestuur (verbetering)
	voedselsoek-habitatte en insekdiversiteit, wat vlermuisdiversiteit ondersteun. • **Verminderde gif-gebruik** (neig na organiese boerdery) verminder die risiko van toksienopbou vir vlermuise.			
	Terrestriële fauna			
	• **Beskermde gebiede en ongeskonde koppies/duinriwwe buffer steeds sleutel-SCC** (bv. De Winton se goue mol, Namakwa-duinmolrot, Gespikkelde padloper) waar habitatte ongeskonde bly; hierdie gebiede anker BAIE HOË/HOË sensitiwiteit.	• **Terreinvlak-SCC-opnames maak mikro-vermyding en geteikende ontwerp** moontlik.	• **Geleentheid om programmatiese, streekwye kompensasies, korridorbeskerming en langtermynmoniteringsplatforms te vestig,** alhoewel dit nie permanente verliese waar vermyding misluk, kanselleer nie.	• **Vermy en buffer alle BAIE HOË sensitiwiteitskenmerke (**kusduinveld, korsmosvelde, SCC-nes-/tonnelkomplekse, rotsinselberge). • **Programmatiese biodivesriteitskompensasies** (soort-vir-soort; tydsgebonde; onafhanklik geverifieer) wat korridors, kusduin-SCC-habitatte, korsmosvelde en rotsinselberge prioritiseer; integreer dit met die uitbreiding van beskermde gebiede.
WATERBRONNE EN AKWATIESE EKOLOGIE	**Grond- en oppervlak water, akwatiese ekosisteme en riviermondings**			
	• **Geen word in die basislyn verwag nie**; geen bykomende waterbronne sal beskikbaar word sonder ingryping nie**.**	• **Ontsoutingsaanlegte kan nuwe varswaterbronne voorsien wat druk op grondwater en oppervlakwater verminder,** mits dit verantwoordelik en doeltreffend ontwikkel en geïmplementeer word. • **Opgegradeerde afvalwaterbehandilingsaanlegte verbeter afloopgehalte en verminder voedingstowfbesoedeling,** wat riviere en riviermonde stroomaf bevoordeel, mits natuurlike tydelike stelsels nie in seisoenale of permanente stelsels omskep word deur effluentuitvloeie nie. • Ekonomiese groei wat met GH_2 geassosieer word**, kan munisipaliteite in staat stel om omgewingsbestuur en instandhouding van waternetwerke te versterk**, wat waterhulpbron-veerkragtigheid indirek verbeter.	• Groter skaal voordele soos onder Sc1 besrkyf moontlike positiewe **impakte word groter maar hang af van versagting en gevorderde beplanning.** • **Grootskaalse ontsouting kan varswaterbeskikbaarheid regoor die streek aansienlik verhoog, wat verseker dat menslike én ekologiese behoeftes bevredig word** selfs onder ernstige klimaatstres, en mits natuurlike tydelike stelsels nie omskep word nie. • **Biodiversiteitskompensasie-bankdienste, indien behoorlik geïmplementeer, kan langtermynbewaring van hoëwaarde-akwatiese ekosisteme ondersteun** deur beskerming en herstel op landskapskaal te verseker. • Geïntegreerde infrastruktuur-opgraderings, insluitend watertoevoer, -berging en -behandeling, kan **langtermyn-watersekerheid vir dorpe en ekosisteme verbeter.** ****NB: Hierdie voordele realiseer slegs indien beduidende beleggings en bestuursverbeterings GH_2-uitbreiding vergesel.**	• **Ondersoek die ekologiese, praktiese en finansiële haalbaarheid om behandelde, ontsoute water aan nabygeleë gemeenskappe** te voorsien. • **Belê in watervoorsiening, afvalwaterinfrastruktuur en personeelopleiding.** • **Streng terreinbepaling om sensitiewe gebiede te vermy**. • **Grootskaalse beleggings in ontsouting en bestuurde grondwateraanvulling**. • **Implementeer proaktiewe waterloop- en terrestriële kompensasie-bankprogramme**. • **Handhaaf ekologiese vloei-vereistes vir die Oranjerivier en riviermond.** • Implementeer behoorlike **opgradering, uitbreiding en instandhouding van afvalwaterbehandelingsaanlegte.** • **Verbeterings aan waterbehandelings- en toevoer** (retikulasie-) stelsels.
ERFENIS	**Paleontologie**			
	NVT	**Ontdekking, rekordhouding en wetenskaplike opnames** van fossiele tydens ontwikkeling kan kennis bou en die wetenskap bevoordeel.		
	Terrestriële argeologie			
	NVT	**rekordhouding en opnames** van argeologiese hulpbronne kan wetenskaplike kennis aansienlik bou; verantwoordelike restourasie en hergebruik van historiese strukture wat met ontwikkeling verbind word, kan verwaarlosing en onbruik voorkom; toerismegroei kan bewaring aanspoor.		
	Grafte			
	NVT	**Identifisering en beskerming van voorheen onbekende gemerkte grafte** kan plaasvind waar sistematiese opnames gedoen word, wat erfenisrekords verbeter en kultureel betekenisvolle plekke beskerm..		
	Geskeidenist en geboude strukture			
	NVT	**Verantwoordelike restourasie en hergebruik wat aan ontwikkeling of akkommodasiebehoeftes gekoppel is,** kan historiese strukture stabiliseer en hul kulturele betekenis verhoog; toerismegroei kan bewaring aansienlik versterk.		
	Seevaart erfenis			
	NVT	**Ontdekking en dokumentasie van skeepswrakke** kan seevaart erfeniskennis verryk waar terreine geïdentifiseer en bestuur word.		
	Lewende erfenis			
	NVT	Waar ontwikkeling die fo**rmele erkenning en beskerming van lewende-erfenisterreine en praktyke kataliseer, kan positiewe uitkomste ontstaan**; goed gestruktureerde ooreenkomste in Sc2 kan direkte gemeenskapsvoordele lewer saam met impakbestuur.		
	Kulturele landskap			
	NVT	**Herstelwerk** wat met ontwikkeling gepaard gaan, kan voorheen versteurde gebiede verbeter, en in sommige gevalle kan uitbreidings van beskermde gebiede langtermyn-landskapbewaring versterk.		

2.2.2 Sosio-ekonomiese impakte

2.2.2.1 Moontlike negatiewe impakte

- Druk op plaaslike behuising, dienste en munisipale stelsels.

Die ontwikkeling van die hawe, GH_2-fasiliteite en gepaardgaande infrastruktuur sal waarskynlik in-migrasie aantrek tydens konstruksie en vroeë bedryfsfases. Hierdie verskynsel kan toenemende druk plaas op behuisingsbeskikbaarheid, grootmaatdienste, gesondheidsorg en munisipale administrasie in die Richtersveld en omliggende dorpe. Sonder vroeë ruimtelike beplanning en belegging kan hierdie druk bestaande diensagterstande vererger, bydra tot die groei van informele nedersettings, en fiskale en bestuursuitdagings verdiep in munisipaliteite met beperkte kapasiteit.

Blok OBM 19: "Boomtown"-dinamika en ongelyke ontwikkelingsuitkomste

Groot infrastruktuurprojekte lok dikwels vinnige in-migrasie gedurende die konstruksiefase wanneer werksoekers, kontrakteurs en diensverskaffers die gebied binnegaan. Hierdie verskynsel, algemeen bekend as "boomtown"-dinamika, kan skielike stygings in behuisingsvraag, huur- en voedselpryse, en druk op basiese dienste veroorsaak. Alhoewel konstruksiebedrywighede beduidende korttermyn-indiensneming kan skep, word voordele dikwels ongelyk versprei; persone wat nie toegang tot projekverwante werk het nie, ervaar stygende lewenskoste sonder ooreenstemmende inkomste-winste.

- Stygende lewenskoste en sosiale ongelykheid.

Verbeterde indiensnemingsgeleenthede en hoër lone wat met hawe- en GH_2-verwante aktiwiteite geassosieer word, kan plaaslike ekonomieë stimuleer, maar sal waarskynlik ook voedsel-, huur- en eiendomspryse opstoot. Hierdie dinamika kan arm huishoudings en dié wat nie direk baat by projekverwante werk nie, buitensporig raak, ongelykheid verhoog en moontlik sosiale spanning skep indien inklusiewe toegang tot geleenthede nie verseker word nie.

- Risiko's vir toerisme as gevolg van logistieke en vervoerverwante impakte.

Toenemende vragvervoer, veral indien dit oorwegend deur padgebaseerde erts- en grootmaattoevoer gedryf word, kan die toerisme-aantrekkingskrag van die Namakwa-streek ondermyn deur verkeersvolumes, geraas, stof en landskapversteuring te verhoog. Toerisme is een van die streek se belangrikste groeisektore en is hoogs sensitief vir hierdie veranderinge, wat besoekersveiligheid kan beïnvloed en die ervaringskwaliteite kan verswak wat bewaring- en erfenisgebaseerde toerisme ondersteun.Risks to tourism from logistics and transport impacts.

- Impakte op landbouproduksie en lewensvatbaarheid.

Hawe-verwante erts-hantering, verhoogde swaarvoertuigverkeer en gepaardgaande luggehalte-impakte kan risiko's inhou vir gewaskwaliteit en uitvoerstandaarde, veral vir besproeide landbou. Landbou in die streek word reeds beperk deur droogte en is sensitief vir stof, waterbeskikbaarheid en vervoersekerheid. Swak bestuurde logistiek kan daarom nadraai-effekte hê vir indiensneming en plattelandse bestaansmiddele.

- Institusionele en bestuurskapasiteitsbeperkings

Die skaal en kompleksiteit van die voorgestelde ontwikkelinge sal beduidend veeleisend wees vir munisipale beplanning, finansiële bestuur, rampbestuur en openbare deelnemingsisteme. In munisipaliteite waar kapasiteit reeds beperk is, bestaan die risiko dat ontwikkelingsdruk institusionele gereedheid oortref, wat toesig, aanspreeklikheid en gemeenskapsvertroue kan verswak.

Blok OBM 20: Institusionele kapasiteit as 'n bindende ontwikkelingsbeperking

Institusionele kapasiteit verwys na die vermoë van plaaslike regering om ontwikkeling doeltreffend te beplan, te finansier, te implementeer en te reguleer. Dit sluit personeel, tegniese vaardighede, finansiële bestuur, ruimtelike beplanning, rampgereedheid en openbare deelname in. In klein of landelike munisipaliteite kan kapasiteitsbeperkings die vermoë om op vinnige groei te reageer, beperk — selfs waar ontwikkelingsgeleenthede bestaan.

- Sosiale ontwrigting en samehorigheid risiko's

Vinnige ekonomiese verandering en in-migrasie kan "boomtown"-dinamika laat ontstaan, insluitend verhoogde misdaad, druk op sosiale en gesondheidsdienste, en die afname van sosiale samehorigheid. Hierdie risiko's is meer beduidend indien gemeenskapsbetrokkenheid en sosiale ondersteuningsmeganismes nie proaktief geïmplementeer word nie.

2.2.2.2 Moontlike geleenthede (positiewe impakte)

- Werkskepping en vaardigheidsontwikkeling.

Die konstruksie en werking van die voorgestelde hawe, SES en GH_2-fasiliteite word verwag om indiensnemingsgeleenthede oor 'n reeks vaardigheidsvlakke te skep. Met toepaslike opleiding, vakleerlingskappe en loopbaanontwikkelingspaaie kan hierdie projekte die streek se vaardigheidsbasis versterk, uit-migrasie verminder en langertermyn-werkgeleenthede ná die konstruksiefase ondersteun.

- Streeksvlak ekonomiese groei en diversifisering

Die hawe en gepaardgaande ontwikkelinge kan moontlik 'n nuwe ekonomiese anker vir die Namakwa-streek skep, en verskeie vermenigvuldigingseffekte stimuleer in sektore soos logistiek, vervaardiging, dienste, opleiding en verskafferbedrywe. Met verloop die van tyd kan agglomerasie-effekte langs sleutelvervoerkorridors en rondom streeksentrums soos Springbok bydra tot 'n meer gediversifiseerde en veerkragtige streeksekonomie.

- Infrastruktuurebelegging met gedeelde voordele

Strategiese beleggings in vervoer-, energie-, water- en digitale infrastruktuur, indien geïntegreerd beplan, kan betekenisvolle mede-voordele vir plaaslike gemeenskappe, landbou en toerisme genereer. Voorbeelde sluit in verbeterde konnektiwiteit, uitgebreide toegang tot hernubare energie en ontsoutinginfrastruktuur wat beide industriële en huishoudelike waterbehoeftes ondersteun.

- Geleentheid vir opgradeerde en veerkragtige landbou.

Verbeterde hawe-toegang, beter logistiek en toegang tot hernubare energie kan landboudiversifikasie en verbeterde mededingendheid ondersteun, veral vir uitvoergerigte besproeïngskemas. Korperatiewe maatskaplike beleggings en vennootskappe kan verder klimaatsveilige boerderypraktyke en plaaslike landbou-ontwikkeling ondersteun.

- Toerisme verebetering en diversifisering

Toerisme kan indirek voordeel trek uit verbeterde toegang, opgegradeerde streeks-lughawefasiliteite, verbeterde bestemmingsbemarking en die opkoms van nuwe erfenis- en groen-energie-verwante toerisme-aanbiedinge. Hierdie voordele is meer beduidend indien industriële ontwikkeling ruimtelik geskei word van kern toerisme areas en vragverwante impakte noukeurig bestuur word.

- Institusionele versterking en innovasie in bestuur.

Die skaal en sigbaarheid van die Boegoebaai-GH_2-program bied 'n geleentheid om interregeringskoördinering, munisipale kapasiteit en praktyke vir openbare betrokkenheid te versterk. Benaderings soos iteratiewe probleemoplossing en betekenisvolle gemeenskapsdeelname kan help

verseker dat ontwikkelingsuitkomste meer inklusief, deursigtig en volhoubaar is. Om institusionele kapasiteit te bou sal sterk leierskap en ondersteuning deur nasionale en provinsiale regerings vereis, asook ander belanghebbendes.

2.2.3 Infrastruktuur- en beplannings impakte

2.2.3.1 Ruimtelike ontwikkelings beplanning, grondgebruik bestuur

- **Basislynsenario (geen hawe-, SES- of GH_2-ontwikkeling)**

Munisipale beplanningsisteme in die streek werk reeds onder beduidende kapasiteitsbeperkings, wat hul gereedheid beperk om toekomstige ontwikkelingsdruk te bestuur.

Munisipaliteite het min professionele beplanners, beperkte GIS-vermoë, en maak staat op 'n Dikstrik Munisipaliteit Beplanningstribunaal (Blok OBM 21) wat slegs kwartaalliks vergader om sleutelbeplanningsbesluite te neem, wat tot vertragings kan lei.

Bestaande beplanningsinstrumente ("IDPs", "SDFs" en grondgebruikskemas) funksioneer hoofsaaklik as statutêre nakomingsdokumente en bied beperkte proaktiewe ruimtelike leiding.Gevolglik staar munisipaliteite 'n verhoogde risiko in die gesig vir ad hoc-grondgebruikbesluite en het hulle beperkte vermoë om ruimtelike of infrastruktuurdruk vroegtydig te sien kom.

Blok OBM 21: Wat is 'n Dikstrik Munisipaliteit Beplanningstribunaal en hoekom maak dit saak?

Die Dikstrik Munisipaliteit Beplannings-tribunaal ("District Municipal Planning Tribunal (DMPT)") is die wetlik gemandateerde liggaam wat grondgebruik- en grondontwikkelings-aansoeke beoordeel ingevolge die "Spatial Planning and Land Use Managemetn Act (SPLUMA)". In die Namakwa-streek vergader die DMPT kwartaalliks, wat voldoende is onder lae ontwikkelingsdruk maar 'n kritieke bottelnek word wanneer aansoekvolumes skerp toeneem. Waar munisipale kapasiteit reeds beperk is, bepaal die DMPT se vergaderfrekwensie en beskikbare tegniese ondersteuning direk hoe vinnig groot projekte kan vorder.

- **Sc1 (Klein GH_2 ontwikkeling)**

Die instandstelling van die voorgestelde ontwikkelingsprogram sal waarskynlik beduidende grondgebruikverandering aanwakker, insluitend nuwe behuising, grootmaat-infrastruktuur, hernubare-energie-fasiliteite, konstruksiekampe en padopgraderings, tesame met bevolkingsgroei in dorpe soos Port Nolloth en Alexanderbaai. Dit sal die vraag na grond, gekoördineerde ruimtelike en diensbeplanning, en gekoördineerde besluitneming oor verskeie owerhede heen verhoog, insluitend betrokkenheid oor gemeenskaplike grond in die Richtersveld.

Die skaal en diversiteit van ontwikkeling kan bestaande munisipale beplanningskapasiteit oorskry en risiko's vir aansoek-agterstande en institusionele bottelnekke skep. Versterkte streekskoördinering en bykomende provinsiale en nasionale ondersteuning sal krities wees om die verwagte toename in ontwikkeling oor die volgende 5–10 jaar te bestuur.

- **Sc2 (Groot GH_2 ontwikkeling)**

Die verhoogde skaal van GH_2-produksie en gepaardgaande ontwikkeling sal waarskynlik aansienlik groter druk op munisipale stelsels en prosesse plaas. 'n Hoë volume grondgebruik-, infrastruktuur- en regulatoriese aansoeke oor alle regeringsfere heen kan 'n beduidende las op munisipaliteite met beperkte kapasiteit plaas. Voortgesette implementering van die beplanningsondersteuningsmeganismes wat onder die Klein GH_2-scenario ingestel is, sal noodsaaklik wees om belegging te ondersteun en die verhoogde werklading te bestuur.

Groot infrastruktuurvereistes, insluitend 'n spoorverbinding van Kenhardt na Boegoebaai, binnelandse waterstofpypleidings, en uitgebreide wind- en sonenergie-fasiliteite, sal grondgebruikdruk, serwituutvereistes, konstruksie-impakte en impakte op geraakte grondeienaars intensifiseer. Sorgvuldige ruimtelike beplanning sal ook nodig wees om oor-konsentrasie van belegging in enkele groeidorpe te voorkom, en gebalanseerde belegging en aandag aan die bewaring van Nama- en tradisionele gemeenskappe in afgeleë gebiede te verseker.

2.2.3.2 Ontwikkeling van nedersettings en implikasies vir dienslewering

- **Basislynsenario (geen hawe-, SES- of GH_2-ontwikkeling)**

Geleenthede/Positiewe Impake: **Grootskaalse streeksbeleggings kan beskeie nedersettingsgroei en diensverbeteringe in sleutelstede in die Namakwa-streek stimuleer.** Die Namakwa SES sal waarskynlik vaardige werkers lok en nedersettings soos Aggeneys en Pofadder beïnvloed, terwyl die moontlike Vioolsdriftdam en Namakwa-besproeiingsprojekte nedersettings langs die N7-korridor en die Oranjerivier kan beïnvloed. Geleidelike groei kan ook in Port Nolloth en Alexanderbaai voorkom, terwyl Springbok – as streeksankerdorp – beskeie uitbreiding kan ervaar weens sy reeks dienste en nabyheid aan mynaktiwiteite. Bykomende projekte soos die herlewing van die Port Nolloth-hawe, streeks-son- en windontwikkelings, 'n nuwe streekhospitaal en die opgradering van die Springbok-lughawe kan ook nedersettingspatrone en diensvraag beïnvloed, en beperkte geleenthede vir ekonomiese en infrastruktuurverbetering bied.

Negatiewe Impakte: **Menigte nedersettings in die streek bly kwesbaar weens beperkte munisipale infrastruktuur en min ekonomiese diversifikasie.** Alexanderbaai, in besonder, staar onsekerheid en moontlike afname in die gesig sonder voortgesette finansiële ondersteuning van Alexkor of die staat. Plaaslike diensinfrastruktuur, insluitend watervoorsiening, afvalbestuur en sanitasie, vereis dringende opgraderings om huidige bevolkingsbehoeftes te ondersteun. Sonder belegging en ekonomiese diversifikasie kan dorpe afhanklik bly van bestaande industrieë of staatssteun, wat hul langtermyn-veerkragtigheid beperk.

- **Sc1 (Klein GH_2 ontwikkeling)**

Geleenthede/Positiewe Impake: **Die ontwikkeling van die hawe, SES en gepaardgaande hernubare energieprojekte word verwag om nedersettingsgroei en plaaslike ekonomiese aktiwiteit in nabygeleë dorpe te stimuleer.** Port Nolloth en Alexanderbaai sal waarskynlik beide permanente inwoners en tydelike konstruksiewerkers lok, terwyl Steinkopf en Springbok kan baat by groter vraag na akkommodasie en dienste. Werksmag-vestiging word verwag om groter vraag te skep na huurbehuising, landgoedontwikkeling en kommersiële dienste, wat geleenthede vir eiendomsbeleggings en besigheidsdiversifikasie skep. Aggeneys en Pofadder kan voortgaan om voordeel te trek uit ekonomiese aktiwiteit wat met die Namakwa SES verband hou.

Negatiewe Impakte: **Toenemende ontwikkelingsaktiwiteit sal waarskynlik groeiende druk plaas op behuisingsmarkte en munisipale dienste in nabygeleë nedersettings.** Beperkte op-terrein akkommodasie by die SES en hawegebied beteken dat werkers hoofsaaklik in Alexanderbaai, Port Nolloth en moontlik Springbok sal woon, met pendelpatrone wat nedersettingskeuses beïnvloed. Toenemende vraag na akkommodasie kan lei tot hoër eiendomspryse, die uitbreiding van tydelike behuising of konstruksiekampe, en moontlike groei van informele nedersettings. Munisipaliteite kan toenemende druk ervaar op water, elektrisiteit, sanitasie, afvaldienste en sosiale fasiliteite, terwyl swaarvoertuigverkeer wat met konstruksie en vragvervoer verband hou, veiligheidskwessies kan skep en die toerisme-aantrekkingskrag van Port Nolloth kan verminder.

- **Sc2 (Groot GH_2 ontwikkeling)**

Geleenthede/Positiewe Impake: **Op volle ontwikkelingskaal kan die Boegoebaai-GH_2-program volhoubare streeksbeleggings en meer stabiele nedersettingsgroei dryf.** Volledig operasionele hawefasiliteite en

vervoernetwerke kan beduidende openbare en private beleggings lok, terwyl die bedryfsfase konstruksieverwante druk, soos swaarvoertuigverkeer, verminder. Vestiging van werkers en hul huishoudings sal waarskynlik groter vraag skep na behuising, kommersiële dienste en sosiale infrastruktuur, wat plaaslike ekonomiese diversifikasie kan ondersteun. Voortgesette beleggings in groen-energie-infrastruktuur kan die streek se vaardigheidsontwikkeling en langtermyn-indiensneming versterk, met dorpe soos Steinkopf en Springbok wat moontlik as residensiële area uitbrei.

Negatiewe Impakte: **Aanhoudende bevolkingsgroei en uitbreiding van nedersettings kan volgehoue druk plaas op munisipale infrastruktuur en sosiale dienste.** Groter aanvraag vir water, sanitasie, afvalbestuur en sosiale fasiliteite kan bestaande munisipale kapasiteit oorskry indien opgraderings nie geïmplementeer word nie. Sonder geteikende vaardigheidsontwikkeling en ekonomiese insluiting kan sommige huishoudings afhanklik bly van staatssteun. Onvoldoende behuisingsvoorsiening kan bydra tot die uitbreiding van informele nedersettings, terwyl kleiner en meer afgeleë nedersettings waarskynlik slegs beperkte voordele uit streeksontwikkeling sal ontvang.

2.2.3.3 Konstruksie van grootskaalse ekonomiese infrastruktuurprojekte (spoor, waterstofpypleiding, kraglyne & hernubare energie, hawe en SES)

- **Basislynsenario (geen hawe-, SES- of GH_2-ontwikkeling)**

Onder die basislynsenario realiseer die voorgestelde hawe en SES nie. Infrastruktuurontwikkeling in die streek bly beperk en hoofsaaklik instandhoudingsgedrewe. Bestaande vragvloeie gebruik steeds gevestigde uitvoerkorridors, insluitend spoorverbinde na hawens soos die Hawe van Saldanhabaai, Hawe van Ngqura en Hawe van Lüderitz. Vragbeweging bly afhanklik van die bestaande pad- en spoorstelsels, met geen nuwe spoorverbinding wat na Boegoebaai gebou word nie.

Paaidinfrastruktuur, insluitend die N7, N14 en R382, funksioneer steeds teen relatief lae vragvolumes. Alhoewel SANRAL seksies soos die R382 in sy instandhoudingsprogram opgeneem het, beperk wyer befondsingsbeperkings opgraderings — veral vir munisipale grondpaaie wat kleiner nedersettings bedien. Gevolglik bly infrastruktuurtoestande grootliks onveranderd, met voortgesette agteruitgang in sommige gebiede weens finansiële beperkings.

Geen nuwe spoorlyn word na Boegoebaai gebou nie, en met betrekking tot die waterstofekonomie neem die basislynsenario aan dat Suid-Afrika se GH_2-oorgang onafhanklik van Boegoebaai vorder, met ander spilpunte (d.i. Lüderitz en Saldanha) wat voortgaan om te ontwikkel. 'n Oorgrens-waterstofpypleiding bly konseptueel moontlik, hoewel die haalbaarheid van die ontwerp kan verander indien Boegoebaai nie waterstofvolumes bydra nie. Daarbenewens kan die afwesigheid van Boegoebaai as 'n waterstofspilpunt die voorgestelde oos–wes-pypleiding wesenlik raak, aangesien dit afhanklik sou wees van waterstofproduksie wat aan Boegoebaai gekoppel is.

- **Sc1 (Klein GH_2 ontwikkeling)**

In die kort-tot-medium termyn sal vragvervoer na die hawe hoofsaaklik staatmaak op padgebaseerde vervoer. **Mynboukommoditeite, veral mangaan, word via die N14-, N7- en R382-korridors vervoer. Swaarvoertuigvolumes neem aansienlik toe en kan in die vroeë bedryfsjare meer as 500 vragmotors per dag bereik. Dit plaas merkbare druk op veral die R382, wat sy ontwerplewe bereik het en nie ontwerp is vir volgehoue swaarvragverkeer nie**. Dit sal waarskynlik toerisme en landbou langs daardie roete belemmer, veral oos van Augrabieswaterval. Rekonstruksie, versterking en die toevoeging van klimlêers by Anenouspas word kritieke intervensies.

Konstruksieaktiwiteite wat met die hawe, SES, hernubare-energie-fasiliteite, pypleidings en ondersteunende padopgraderings verband hou, genereer verdere impakte, insluitend:

- Verhoogde risiko van verkeersongelukke en opeenhopings in dorpe soos Springbok, Steinkopf en Port Nolloth.
- Agteruitgang van bestaande padoppervlakke.
- Tydelike ontwrigting weens padwerke.
- Vraag na gruisgate, konstruksiekampe en grootmaatmateriaal.

Spoorinfrastruktuur word nie onmiddellik ontwikkel nie weens hoë kapitaalkoste, en padvrag bly dominant totdat uitvoervolumes ongeveer 10 Mtpa oorskry. Beplanning vir 'n toekomstige spoorverbinding begin gedurende hierdie fase.

Pypleidinfrastruktuur word meer gedefinieer onder hierdie scenario. 'n Noord–suid-waterstofkorridor wat Lüderitz, Boegoebaai en Saldanha verbind, word verder ontwikkel, met haalbaarheidstudies en omgewingsmagtigings wat aan die gang is. **Grondverkryging, serwituutvestiging en roeteringsbesluite bring moontlike grondgebruikkonflikte mee,** hoewel die 2019-Gaspypleiding-SOA-riglyne daarop gemik is om verplasing en ekologiese versteuring te beperk.

Hernubare energie ontwikkeling brei uit tot ongeveer 10 GW om 'n 5 GW-elektroliseerder te ondersteun. Dit vereis groot grondgebiede vir son- en windfasiliteite, waarvan baie buite die onmiddellike Boegoebaai-ontwikkelingsvoetspoor moet wees as gevolg van grondbesit- en ekologiese beperkings. **Toenemende vraag na kraglyne** ontstaan, wat belyning met kraglynontwikkelingsplanne vereis en moontlik nuwe kragnetwerkinfrastruktuur.

- **Sc2 (Groot GH_2 ontwikkeling)**

Die groot GH_2-scenario weerspieël volle industriële volwassenheid en grootskaalse streeks-transformasie. In hierdie stadium is die hawe volledig operasioneel, GH_2-produksie het beduidend uitgebrei, en vragvolumes neem aansienlik toe. **Swaarvoertuigverkeer op die N14, N7 en R382 bly hoog, maar 'n nuwe spoorlyn (geregverdig sodra vragvolumes 10 Mtpa oorskry) word gebou om druk op die padnetwerk te verlig.**

Die voorgestelde 500 km standaardspoorlyn verbind Boegoebaai met die Sishen–Saldanha-korridor, insluitend tonnels, brûe en groot grondbewegings. **Hoewel dit langtermyn-padvragimpakte verminder, bring dit beduidende versteurings tydens die konstruksiefase, vereistes vir grondverkryging en risiko's vir omgewingsmagtiging mee.**

Waterstof-pypleidinfrastruktuur brei verder uit om beide noord–suid en wes–**oos korridors in te sluit, wat Boegoebaai as 'n nasionale en transnasionale energie-spilpunt posisioneer. Die skaal van konstruksie verhoog ruimtelike impakte regoor die provinsie, met moontlike effekte op biodiversiteitsgebiede, grondgebruikpatrone en nedersettings langs die korridors**. Strategiese roetering binne afgekondigde korridors moet geprioritiseer word om ruimtelike weerstand en omgewingsrisiko te verminder.

Vereistes vir hernubare energie skaal dramaties op tot ongeveer 80 GW om 'n 40 GW-elektroliseerder te ondersteun. Dit behels baie groot grond-ontwikkelingsvoetspore vir son- en windinstallasies, wat moontlik oor verskeie provinsies versprei moet word om energie-sekuriteit en netstabiliteit te verseker. Uitbreiding van transmissie-infrastruktuur word krities, met nuwe hoëspanning-lyne wat nodig is om krag na die terrein te vervoer. **Die voldoende beskikbaarheid en tydige uitbreiding van die nasionale elektrisiteitsnetwerk word 'n sleutelrisikofaktor.**

Terwyl hierdie scenario beduidende ekonomiese integrasie en uitvoervermoë vir die Noord-Kaap bied, stel dit ook verhoogde omgewings-, finansiële en beplanningsrisiko's bloot weens die skaal, koste en kompleksiteit van infrastruktuurimplementering.

2.3 Ontleding van Risiko's / Geleenhede

WP2 het 'n gestruktureerde kwalitatiewe raamwerk toegepas om die risiko's (negatiewe impakte / gevolge) en geleenthede (positiewe impakte / voordele) te evalueer wat met 'n streeks-GH_2-ekonomie onder verskillende scenario's geassosieer word (Afdeling 2.2). Risiko of geleentheid is bepaal deur die waarskynlikheid dat 'n gebeurtenis plaasvind te kombineer met die erns van die gevolge of voordele daarvan (sien WP2 Hoofstuk 1).

Gevolg- en voordeel-drempels is vir elke tema (bv. biodiversiteit, waterhulpbronne, sosio-ekonomiese stelsels) gedefinieer met behulp van kategorieë wat wissel van lig tot ernstig, terwyl risiko- en geleentheidsvlakke in voorafbepaalde kategorieë geklassifiseer is van **BAIE LAAG** tot **BAIE HOOG** (Tabel OBM 5).

Tabel OBM 5: Definisies van risiko / geleentheid katergorieë.

RISIKO (-)		GELEENTHEID (+)	
BAIE LAAG ("VERY LOW")	Byna onopsigtelike negatiewe impak.	Byna onopsigtelike positiewe impak.	**BAIE LAAG ("VERY LOW")**
LAAG ("LOW")	Ligte negatiewe impak, beperkte omvang en kort duur, goed binne toleransie.	Ligte positiewe impak, baie gelokaliseer, ver onder verwagtinge.	**LAAG ("LOW")**
MATIG ("MODERATE")	Beduidende impak, maar minder as groot; binne toleransie en onder die limiete van aanvaarbare verandering.	Beduidende positiewe impak, maar meestal korttermyn en ruimtelik beperk.	**MATIG ("MODERATE")**
HOOG ("HIGH")	Groot ongewensde gevolg, wat die toleransie en limiete van aanvaarbare verandering nader.	Hoogs wenslike impak, groot medium- tot langtermyn positiewe impakte oor 'n wye reeks belanghebbendes op plaaslike of streekskaal.	**HOOG ("HIGH")**
BAIE HOOG ("VERY HIGH")	Uitermate negatiewe impak, aanhoudend/lankdurend, buite toleransie en limiete van aanvaarbare verandering.	Hoogs wenslik, omvangryke langtermyn positiewe impakte oor 'n wye reeks belanghebbendes op plaaslike, streeks-, nasionale en/of internasionale skaal.	**BAIE HOOG ("VERY HIGH")**

Elke impak is beoordeel oor drie scenario's [basislyn (Sc0), klein GH_2-ontwikkeling (Sc1) en groot GH_2-ontwikkeling (Sc2)] en vir verskillende ontvangende omgewings, beide voor en ná bestuursintervensies. Resultate word aangebied in gestruktureerde uitsette vir risiko's (negatief) en vir geleenthede (positief).

Tabel SPM 6 en Tabel SPM 7 bied onderskeidelik gekonsolideerde opsommings van die risiko- en geleentheidsbeoordelings vir al die temas wat in die WP2-SOA geëvalueer. Elke ry verteenwoordig 'n enkele impak onder een van die drie ontwikkelingscenario's (Sc0: Basislyn, Sc1: Klein GH_2, Sc2: Groot GH_2), met gemiddelde tellings wat beide sonder en met die toepassing van bestuursmaatreëls op 'n vyfpunt-ordinale skaal (1 = Baie Laag tot 5 = Baie Hoog) aangedui word. Die gemiddelde telling word bereken deur die individuele risiko- of geleentheidsgraderings wat aan elke ruimtelike ontvangende omgewing vir daardie impak-scenario-kombinasie toegeken is. Die selkleur weerspieël die kategorie van die gemiddelde telling volgens die voorafbepaalde risiko- en geleentheidskategorieë soos uiteengesit in Tabel SPM 5. Dit is belangrik om daarop te let dat hierdie tabelle 'n vereenvoudigde opsomming is wat bedoel is om vergelykings tussen tema's en scenario's op 'n oogopslag moontlik te maak. Die gemiddelde telling vat die

volledige verspreiding van graderings oor ontvangende omgewings saam, en individuele omgewings met hoë of baie hoë sensitiwiteit kan aansienlik hoër graderings hê as wat die gemiddelde aandui. Vir die volledige impak-vir-impak- en omgewing-vir-omgewing-beoordeling — insluitend gevolge- en waarskynlikheidsgraderings, versagtingsmaatreëls en bepalings van residuele risiko — raadpleeg die volledige tema-spesifieke assesserings waaruit hierdie tabelle afgelei is (Bylaag SPM.1.).

Oor die meeste temas heen is gevind dat risiko's HOOG tot BAIE HOOG is sonder versagting, veral in gebiede van HOË of BAIE HOË sensitiwiteit en onder die groter GH_2-ontwikkelingscenario's. Implementering van toepaslike beplanning, ontwerp en versagtingsmaatreëls kan baie risiko's verminder tot MATIG, LAAG of BAIE LAAG, hoewel residuele risiko's steeds in sensitiewe omgewings voorkom. Op soortgelyke wyse neem geleenthede gewoonlik toe met ontwikkelingskaal en is die mees uitgesproke in sleutel ekonomiese nodusse soos Port Nolloth, Alexanderbaai en die SES-gebied.

Vir ekologie toon beide biodiversiteitspatrone (direkte verlies van habitatte en spesies) en ekologiese prosesse BAIE HOË risiko's sonder versagting oor die meeste sensitiwiteitsklasse. Selfs onder kleiner GH_2-scenario's bly impakte HOOG in landskappe van hoër ekologiese waarde. Met versagting verminder risiko's oor die algemeen tot **MATIG of LAAG**, veral in gebiede van laer sensitiwiteit. Hierdie bevindinge beklemtoon die belang van vemyding van sensitiewe ekosisteme ekologiese patrone en om konnektiwiteit te handhaaf waar moontlik.

Vir voëls sluit sleutelrisiko's verplasing en versteuring in wat deur infrastruktuur en menslike aktiwiteite veroorsaak word, asook botsings- en elektrokusierisiko's wat met windturbines, kraglyne en substasies geassosieer word. Hierdie impakte is dikwels beoordeel as HOOG tot BAIE HOOG sonder versagting, veral in hoogs sensitiewe omgewings. Met versagtingsmaatreëls — soos sorgvuldige plasing van turbines, voëlveilige kraglynontwerp en monitering — kan risiko's verminder word tot **MATIG of LAAG**, hoewel hoogs sensitiewe gebiede steeds onaanvaarbare residuele impakte kan ervaar ondanks versagting.

Vir vlermuise hou risiko's hoofsaaklik verband met vernietiging of versteuring van nesplekke, verlies of fragmentasie van voedselsoek-habitatte, en vlermuis-sterftes weens botsings of barotrauma veroorsaak deur windturbines tydens voedselsoek en migrasie. Sonder versagting wissel hierdie impakte van MATIG tot BAIE HOOG, afhangend van landskapsensitiwiteit en ontwikkelingskaal. Versagtingsmaatreëls kan risiko's verminder tot **LAAG of BAIE LAAG** in laer sensitiwiteitsgebiede, en tot **LAAG of MATIG** in mediumsensitiwiteitsgebiede — deur onder meer roesplekke te vermy en operasionele beheermaatreëls te implementeer. In gebiede van HOË en BAIE HOË sensitiwiteit kan impakte **egter MATIG tot HOOG of BAIE HOOG** bly selfs ná versagting, veral waar belangrike nes-habitatte voorkom.

Impakte op terrestriële fauna hou verband met habitatverlies en fragmentasie, versteuring van ekologiese korridors en migrasieroetes, en verhoogde sterfterisiko's wat met paaie, heinings en infrastruktuur gepaard gaan. In hoogsensitiewe landskappe word hierdie impakte as **BAIE HOOG** beoordeel sonder versagting, maar hulle kan verminder word tot **MATIG of LAAG** waar doeltreffende versagting en ruimtelike beplanning — soos wildkorridors, buffergebiede en fauna-vriendelike infrastruktuur — geïmplementeer word.

Vir waterhulpbronne wissel risiko's oor grondwater en oppervlakwaterstelsels binne die streek. Grondwaterbeskikbaarheid en -sekuriteit toon oor die algemeen **LAE tot MATIGE** risiko's, terwyl grondwatergehalte **MATIGE** risiko's kan ervaar waar ontwikkeling sensitiewe hidrogeologiese omgewings kruis. **Oppervlakwaterbronne en binnelandse akwatiese ekosisteme, insluitend riviere, vleilande en tydelike panne, toon MATIGE tot HOOG** risiko's sonder versagting — veral waar infrastruktuur akwatiese stelsels kruis. **Moontlike impakte op riviermonde, insluitend die Oranjerivier-riviermond en geassosieerde mikro-riviermonde, word ook as MATIG tot HOOG** aangedui sonder versagting, hoewel hierdie risiko's deur toepaslike bestuur verminder kan word. **Geleenthede wat verband hou met grondwatersekuriteit en oppervlakwaterbronne word oor die algemeen as LAAG tot MATIG** beoordeel met bestuur, veral in hoër sensitiwiteitsgebiede waar verbeterde waterinfrastruktuur en bestuursisteme nodig kan wees om ontwikkeling te ondersteun.

Vir erfenishulpbronne toon argeologiese hulpbronne BAIE HOË risiko's sonder versagting, wat die hoë digtheid van argeologiese materiaal in die streek weerspieël. **Paleontologiese hulpbronne toon MATIGE tot HOOG risiko's**, terwyl risiko's vir die geboude omgewing en kulturele landskappe wissel van **MATIG tot BAIE HOOG**, afhangend van sensitiwiteit. Met versagting word hierdie risiko's oor die algemeen verminder tot **MATIG of LAAG**. Geleenthede word oor die algemeen as **LAAG tot MATIG** beoordeel. Paleontologiese en argeologiese hulpbronne toon **LAE** geleenthede, hoofsaaklik geassosieer met verbeterde dokumentasie, navorsing en erfenisbestuur wat uit ontwikkelingstudies voortspruit. Binne die **geboude omgewing en lewende erfenis neem geleenthede toe tot MATIG of HOOG met bestuur**, veral waar beleggings in erfenisbewaring, toerisme-infrastruktuur en kulturele erkenning streeksontwikkeling vergesel. **Kulturele landskappe kan MATIGE tot HOË** geleenthede ervaar, veral waar ontwikkeling erfenis-sensitiewe toerisme en landskapinterpretasie-inisiatiewe stimuleer.

Vir infrastruktuur- en beplanningsdomein word risiko's wat verband hou met ontwikkelingsbeplanningsdruk, padkorridors, spoorwegkorridors en energieprojek-korridors/-terreine konsekwent as BAIE HOOG beoordeel sonder versagting, weens die skaal van infrastruktuur wat benodig word. Met doeltreffende strategiese ruimtelike beplanning, konsolidering van korridors en goeie infrastruktuurbestuur kan hierdie risiko's verminder word tot **MATIG of LAAG**. **Ontwikkeling van nedersettingsinfrastruktuur toon MATIGE tot HOË geleenthede,** veral in nuwe ontwikkelingsgroeiknope soos die Steinkopf–Springbok-korridor en nedersettings naby die voorgestelde ontwikkelingsones. Beleggings in behuising, dienste en ondersteunende infrastruktuur kan die streek se ontwikkelingskapasiteit versterk en lewensomstandighede in sleutel-nedersettings verbeter.

Sosio-ekonomies bied GH_2-ontwikkeling beide risiko's en geleenthede. Bevolkingsverskuiwings, druk op behuising en munisipale dienste, en druk op gesondheidsdienste toon LAE tot MATIGE risiko's, hoewel groter scenario's **HOË druk** kan veroorsaak in sleutelknoppe soos Port Nolloth en Alexanderbaai waar bevolkingstoestroming en konstruksie-aktiwiteit na verwagting sal konsentreer. Toerisme-ontwikkeling bied groot geleenthede en risiko's; terwyl nuwe infrastruktuur en verhoogde streeksigbaarheid toerisme-ontwikkeling kan ondersteun, insluitend spoorgebaseerde toerismepotensiaal, toon dit **MATIGE** tot **HOË** geleenthede, veral in die Port Nolloth-Alexanderbaai-gebied en die Springbok-streek, kan swaar vragmotorvervoer, industrialisering en verlies van die streek se afgeleë karakter toerisme negatief beïnvloed indien dit nie versigtig bestuur word nie. Uitvoerlandbou, insluitend die potensiële gebruik van spoorlogistiek en verbeterde infrastruktuur, toon beduidende **HOË** tot BAIE **HOË** geleenthede, veral waar verbeterde logistiek, hawetoegang en streekskonnektiwiteitsondersteuning ondersteun, veral waar verbeterde streekskonnektiwiteit landbouwaardekettings ondersteun wat gekoppel is aan die Oranjerivier-besproeiingsgebiede, hoewel risiko's soos stofbesoedeling van uitvoergewasse bestuur moet word. Werkskepping verteenwoordig een van die belangrikste geleenthede wat met GH_2-ontwikkeling verband hou.

Werkskepping verteenwoordig een van die mees betekenisvolle geleenthede wat met GH_2-ontwikkeling geassosieer word. Indiensnemingsgeleenthede word beoordeel as HOOG tot BAIE HOOG, veral in die groter GH_2-scenario's en in sleutel-ontwikkelingsknope. Hierdie geleenthede spruit uit konstruksie-aktiwiteite, energieopwekkingsinfrastruktuur, hawe-ontwikkeling, logistiek en gepaardgaande diensbedrywe. Bykomende sosio-ekonomiese voordele sluit in verbeterde streeks-breëband-uitrol, waar **ontwikkelinggedrewe beleggings MATIGE tot HOË geleenthede** kan skep vir verbeterde digitale konnektiwiteit regoor die streek, veral in landelike nedersettings en ontwikkelingskorridors.

Tabel OBM 6: Risiko – gekonsolideerde opsomming van die risiko-beoordelings wat oor al die geëvalueerde temas uitgevoer is. Elke ry toon die gemiddelde risikogradering vir 'n spesifieke impak onder een van die drie assesseringscenario's (Sc0: Basislyn, Sc1: Klein GH_2, Sc2: Groot GH_2), bereken as die gemiddelde punt oor alle geassesseerde ruimtelike ontvangende omgewings, voor en ná die toepassing van bestuursmaatreëls.

KLEURSKEMA: RISIKO

BAIE LAAG | **LAAG** | **MATIG** | **HOOG** | **BAIE HOOG**

Tema	Impak	Scenario	Gemiddelde risiko — sonder bestuur		Gemiddelde risiko — met bestuur
Terrestriële Ekologie	Biodiversiteitspatrone	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Ekologiese prosesse	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Vlermuise	Vernietiging/versteuring van vlermuisrusplekke	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Verlies van vlermuis-voedingshabitat	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Vlermuissterftes	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

Tema	Impak	Scenario	Gemiddelde risiko — sonder bestuur		Gemiddelde risiko — met bestuur
Waterhulpbronne en Akwatiese Ekologie	Beskikbaarheid en sekuriteit van grondwater	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Grondwaterkwaliteit	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Beskikbaarheid, kwaliteit en sekuriteit van oppervlakwaterhulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Binnelandse akwatiese ekosisteme (riviere, vleilande en panne)	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Agteruitgang van estuariums (insluitend die Oranjeriviermonding) en mikro-uitlate	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Avifauna (Voëllewe)	Verplasing as gevolg van versteuring soos geraas, beligting en menslike aktiwiteit	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Verplasing as gevolg van habitatverlies/-fragmentasie/-transformasie	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Besering of sterftes as gevolg van botsings met windturbines, sonpanele, kraglyne en maste/torings	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Besering of sterftes as gevolg van elektrokusie op kraglyne en substasie-infrastruktuu	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

Tema	Impak	Scenario	Gemiddelde risiko — sonder bestuur		Gemiddelde risiko — met bestuur
Fauna	Verplasing as gevolg van habitatverlies en -fragmentasie	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Verplasing as gevolg van versteuring soos geraas, beligting en menslike aktiwiteit	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Veranderinge in ekologiese funksionering en prosesse	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Erfenis	Paleontologiese hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Argeologiese hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Maritieme hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Grafte	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Geboude omgewing	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Lewende erfenis	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Kultuur en landskappe	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

Tema	Impak	Scenario	Gemiddelde risiko — sonder bestuur		Gemiddelde risiko — met bestuur
Infrastruktuur en Beplanning	Ontwikkelingsbeplanningsdruk	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Ontwikkeling en bestuur van nedersettingsinfrastruktuur	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Konstruksie van infrastruktuurprojekte	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Sosio-ekonomie	Bevolkingsverskuiwings	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Druk op behuising en munisipale dienste	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Druk op gesondheidsdienste	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Sosiale probleme as gevolg van "boomtown"-toestande	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Toerisme	S1: Klein GH2		→	
		S2: Groot GH2		→	
	Landbou	S1: Klein GH2		→	
		S2: Groot GH2		→	
	Munisipale kapasiteit – tegnies	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Munisipale kapasiteit – politieke betrokkenheid en fasilitering	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

Tabel OBM 7: Geleenthede – gekonsolideerde opsomming van die geleentheidsbeoordelings wat oor al die geëvalueerde temas uitgevoer is. Elke ry toon die gemiddelde risikogradering vir 'n spesifieke impak onder een van die drie assesseringscenario's (Sc0: Basislyn, Sc1: Klein GH_2, Sc2: Groot GH_2), bereken as die gemiddelde punt oor alle geassesseerde ruimtelike ontvangende omgewings, voor en ná die toepassing van bestuursmaatreëls.

KLEURSKEMA: GELEENTHEDE

BAIE LAAG	LAAG	MATIG	HOOG	BAIE HOOG

Tema	Impak	Scenario	Gemiddelde geleentheid — sonder bestuur		Gemiddelde geleentheid — met bestuur
Waterhulpbronne en Akwatiese Ekologie	Beskikbaarheid en sekuriteit van grondwater	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Beskikbaarheid, kwaliteit en sekuriteit van oppervlakwaterhulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Erfenis	Paleontologiese hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Argeologiese hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Maritieme hulpbronne	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Grafte	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

Tema	Impak	Scenario	Gemiddelde geleentheid — sonder bestuur		Gemiddelde geleentheid — met bestuur
Erfenis (vervolg)	Geboude omgewing	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Lewende erfenis	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Kultuur en landskappe	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
Infrastructure and Planning	Ontwikkeling van nedersettingsinfrastruktuur	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Werkskepping	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Vaardigheidsontwikkeling	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	
	Streekswye breëbandinfrastruktuur (internet)	S0: Basislyn		→	
		S1: Klein GH2		→	
		S2: Groot GH2		→	

3. STRATEGIESE AANBEVELINGS VIR BEPLANNING EN BESTUUR

Gegewe die skaal, ruimtelike ontwikkelingsvoetspoor en transformerende potentsiaal van die voorgestelde Boegoebaai-hawe, SES en gepaardgaande GH_2-program, is strategiese beplanning en bestuursbelyning noodsaaklik om te verseker dat ontwikkelingsbesluite robuust, billik en omgewingsverantwoordelik is. Hierdie afdeling som die multidissiplinêre bevindinge van die WP2-SOA in strategiese bestuurs- en streeksbeplanningsaksies om beleidsmakers, beplanners, reguleerders en projekontwikkelaars te lei, op. Bewyse uit WP2 dui daarop dat ontwikkeling in die Namakwa-streek nie primêr beperk word deur 'n tekort aan ruimte of grondbeskikbaarheid nie, maar deur die behoefte aan ingeligte ruimtelike selektiwiteit, institusionele gereedheid en goed deurdagte ontwikkelingsvolgorde. Hoewel groot dele van die streek omgewings- en sosiaal sensitief is — soms uiterst sensitief — bestaan daar wel landskappe van laer sensitiwiteit waar ontwikkeling oorweeg kan word, mits streng vermyding van kritieke gebiede, proaktiewe versagting, ruimtelike ontwerpstandaarde en gekoördineerde bestuursreëlings toegepas word. Daar is verder landskappe in die streek, waarvan die voorgestelde SES een is, waar vorige ekologiese agteruitgang reeds so ver gevorder het dat die "doen-niks" alternatief nie meer lewensvatbaar is vir die beskerming van biodiversiteit nie, en 'n mate van regstellende omgewingsaksie vereis word, hetsy markgedrewe of staatsbefonds. Veral in die konteks van veranderende klimaatspatrone in die streek en verlies aan veerkragtigheid in gebiede wat reeds gedeeltelik of ten volle gedegradeer is.

3.1 Klimaatsverandering, Ekosisteemagteruitgang en Implikasies vir Beplanning

Grondgebruikbeplanning moet verder beweeg as bloot die minimum van impakvermindering deur aktief ekosisteem-veerkragtigheid bevorder. Strategiese beplanningsraamwerke moet klimaatsverandering-skuilplekke en gebiede van bestaande ekologiese agteruitgang eksplisiet in ruimtelike besluitneming integreer, om te verseker dat ontwikkeling weg gestuur word van stelsels wat reeds onder druk is en nie voortdurende agteruitgang vererger nie. Klimaatsverandering is moontlik die mees beduidende langtermynbedreiging vir biodiversiteit in die Namakwa-streek, aangesien dit as 'n alomteenwoordige druk optree wat die impakte van grondgebruikverandering, infrastruktuurontwikkeling en habitatfragmentasie versterk. Analises van plantegroeiproduktiwiteit toon wydverspreide tekens van dalende produktiwiteit en ekologiese stres regoor die streek, met veral uitgesproke neigings in die Richtersveld en aangrensende landskappe. 'n Hoë persentasie van die streek se plantegroeitipe aktiveer die risiko-drempels van die ekosisteem Rooilys, wat verstorings van sleutel ekologiese prosesse weerspieël eerder as slegs historiese habitatverlies. Hierdie patrone dui op afnemende ekosisteem-veerkragtigheid en verminderde vermoë om verdere versteurings te absorbeer.

3.2 Hoogs Sensitiewe Areas wat Vermy moet word

BAIE HOË sensitiwiteitsgebiede regoor die streek bevat onvervangbare biodiversiteitskenmerke, konsentrasies van SCC-spesies en kritieke ekologiese prosesse, en is nie geskik vir infrastruktuur ontwikkeling nie. Hierdie gebiede onderlê streeks-ekologiese integriteit en is sentraal tot die bereiking van biodiversiteitsbewaringsteikens.

a) **HOË en BAIE HOË biodiversiteit-sensitiwiteitslandskappe:** 'n Groot deel van die streek val binne die Sukkulente Karoo-bioom, 'n wêreldwye biodiversiteitsbrandpunt wat gekenmerk word deur uitsonderlike endemisme en ekologiese uniekheid. Gebiede wat vermy moet word sluit die volgende in (Blok OBM 22):
   - Kernbiodiversiteitsgebiede en beskermde gebiede, insluitend nasionale parke, natuurreservate en formeel geïdentifiseerde uitbreidingsgebiede.
   - Landskappe met konsentrasies van bedreigde of endemiese plantspesies, kwartsveldplekke, gruisvlaktes, suid-gefaseerde hange en bergstelsels.
   - Areas wat geïdentifiseer is as **BAIE HOË kumulatiewe biodiversiteit-sensitiwiteit** waar veelvuldige ekologiese reseptore (plante, fauna, voëls, vlermuise en akwatiese stelsels) oorvleuel.

   Ontwikkeling in hierdie gebiede sal lei tot onomkeerbare biodiversiteitsverlies en sal waarskynlik kompensasieverpligtinge aktiveer op 'n skaal wat ekologies en institusioneel onprakties is.

b) **Voëls- en vlermuis-sensitiewe gebiede**: **BAIE HOË sensitiwiteitsareas vir voëls en vlermuise**, **veral in verband met windenergie-ontwikkeling**. Hierdie sluit die volgende in:
   - Vlugkorridors wat deur groot roofvoëls en korhane gebruik word.
   - Gebiede wat endemiese of bedreigde voëlspesies ondersteun.
   - Groot vlermuis rusplekke, grotte en buffers om dié areas.

   Windplase en hoë infrastruktuur moet hierdie landskappe vermy, en vermyding is verkies oor versgating na konstruksie.

c) **Beskermingsgebiede vir waterhulpbronne**: gegewe die uiterste droogheid van die streek, word grondwaterstelsels, strategiese waterbrongebiede, vleilande en die Oranjerivier-korridor uitgelig as kritieke beperkings. Ontwikkeling moet vermy:
   - **Strategiese Waterbrongebiede ("SWSAs")** rondom Port Nolloth, Kommagas en die Kamiesberg.
   - **Vloedvlaktes, panne en tydelike riviersisteme** (hierdie is hoogs kwesbaar vir versteuring).
   - **Gebiede waar besoedelingsrisiko's reeds gespanne watervoorsieningstelsels kan benadeel.**

   Oor die algemeen verteenwoordig waterskaarste en die uiterste ekologiese sensitiwiteit van die streek se akwatiese stelsels sommige van die belangrikste beperkings op toekomstige ontwikkeling. Volhoubare uitbreiding van hernubare energie- en GH_2-infrastruktuur sal slegs haalbaar wees indien dit gepaard gaan met groot beleggings in ontsouting, waterbehandeling, watertoevoer-opgraderings, en streng vermyding van hoësensitiwiteit-akwatiese gebiede en grondwateraanvullingsgebiede, tesame met 'n skuif na 'n sirkulêre water-ekonomie wat ontwerp is om onbedoelde veranderinge aan natuurlike hidrologiese regimes te voorkom.

d) **Erfenis- en kulturele landskappe**: die Namakwa-streek bevat digte en dikwels ongemerkte erfenishulpbronne, veral langs die kus en binne gemeenskaplike grond. Gebiede wat vermy moet word sluit in:
   - Die **Richtersveld Kulturele en Botaniese Landskap Wêrelderfenisgebied** en sy buffergebiede.
   - **Kusduinstelsels** met hoë digthede van argeologiese materiaal en ongemerkte grafte.
   - **Erkende kulturele landskappe, natuurskoonroetes** en gebiede met hoë plekwaarde.

   Vermyding is veral belangrik omdat baie erfenishulpbronne eers opgespoor word wanneer hulle reeds versteur is, wat bestuur ná impak grootliks oneffektief maak.

Blok OBM 22: Ligging van biodiversiteitskenmerke wat streng vermyding vereis

Onvervangbare en nie-kompenseerbare biodiversiteitskenmerke is nie eweredig versprei nie, maar gekonsentreer in bepaalde dele van die Namakwa-streek, insluitend:
- **Die Richtersveld**, insluitend die Richtersveld Nasionale Park, die Richtersveld Kulturele en Botaniese Landskap Wêrelderfenisgebied, en aangrensende gemeenskapsgrond, wat sentrums van endemisme, klimaats-skuilplekke, bergstelsels en lewende kulturele landskappe bevat.
- **Die Kamiesberg-bergstelsel**, waar kwartsietberge, suid-gefaseerde hange, hoë plato's en reliek-ekosisteme buitengewone vlakke van plantendemisme ondersteun en as sleutel klimaats-skuilplekke optree.
- **Die Boesmanland-Inselbergstreek**, waar geïsoleerde inselberge en gruisvlaktes nou verspreide endemiese spesies huisves wat in afgebakende mikrohabitatte gekonsentreer is.
- **Ongeskonde Sandveld-duinstelsels** langs die Weskus, wat Sandveld-endemiese soogdiere ondersteun soos De Winton se goue mol, Van Zyl se goue mol en die Namakwa-duinmolrot, en wat hoogs kwesbaar is vir versteuring en sandmobilisering.
- **Die Alexanderbaai-korsmosvelde**, geleë in die verre noordwestelike kusgordel, internasionaal erken vir hul ongeëwenaarde diversiteit aan korstmose en uiterste sensitiwiteit.
- **Beskermde area en formeel geïdentifiseerde prioriteitsones vir die uitbreiding van beskermde gebiede**, insluitend landskappe wat benodig word om langtermyn-bewaringsteikens te bereik en ekosisteemverteenwoordiging te handhaaf.

3.3 Teikengebiede vir Ontwikkeling in Lae-sensitiwiteitsones

n Verdedigbare benadering om ontwikkeling moontlik te maak terwyl ekologiese stelsels, erfenis en sosiale stelsels beskerm word, is om infrastruktuur en grondintensiewe aktiwiteite te konsentreer in landskappe wat reeds getransformeer, gedegradeer of relatief laer in sensitiwiteit is (Blok OBM 23), en om uitbreiding in ongeskonde, hoëwaarde-stelsels te vermy. Op streekskaal is gebiede van relatief laer sensitiwiteit oorweeg. Hierdie gebiede bied geleenthede om bykomende habitatverlies te verminder, fragmentasie te beperk en impakte te bevat binne landskappe wat reeds beduidende historiese versteuring geabsorbeer het. Gebaseer op die WP2-bevindinge kom drie sleutel-liggingsbeginsels na vore om ruimtelike besluitneming te lei:

Blok OBM 23: Waarom 'laer sensitiwiteit' nie 'lae risiko' beteken nie

Lae-sensitiwiteitsgebiede wat in WP2 geïdentifiseer is, bied relatief groter buigsaamheid vir ontwikkeling, maar dit is nie landskappe wat vry is van impakte nie. Selfs in hierdie gebiede kan swak beplande of kumulatiewe ontwikkeling beduidende ekologiese (insluitend voëls, vlermiuse en ander diere), hidrologiese en sosiale gevolge hê. Die aanwysing van laer sensitiwiteit moet daarom verstaan word as 'n vergelykende ruimtelike beplanningssein, nie as 'n deurslaggewende goedkeuring vir ontwikkeling nie. Alle projekte bly onderhewig aan terreinspesifieke assessering, versagting en monitering.

a) **Kussone-landskappe: historiese diamantmynbou langs die Namakwalandse kus het 'n uitgebreide gordel van versteurde grond gelaat, veral tussen Kleinzee en Alexanderbaai.** Hierdie landskappe toon aansienlik veranderde geomorfologie en biodiversiteitstoestande, met voortdurende uitdagings wat verband hou met sandmobilisering en langtermyn-rehabilitasie. Binne hierdie kusmynbougordel bestaan daar relatief groter buigsaamheid vir die plasing van windenergie-infrastruktuur en gepaardgaande fasiliteite, mits:
   - Ontwikkeling beperk word tot reeds versteurde ontwikkelingsvoetspore.
   - Turbinefondasies en toegangsinfrastruktuur ontwerp word om met bestaande ingenieurs-sandstabiliseringsmaatreëls te integreer.
   - Terugstootsones vanaf sensitiewe kuskenmerke, riviermonde en ongeskonde duinstelsels streng afgedwing word.
   - Ontwikkeling avifaunale en vlermuis-bewegingskorridors, sensitiewe erfenishulpbronne en klimaats-skuilplekke vermy; en ruimtelik gekonfigureer word om enige bykomende fragmentasie en ontwrigting van kus-geomorfologiese prosesse te minimaliseer.

Die nabyheid van hierdie gebiede aan

Blok OBM 24: Windturbines en die kustelike mis dinamika

Kustelike mis dinamika is van kritieke belang vir die instandhouding van lewe in droë landskappe soos die Richtersveld, omdat baie uniek aangepaste plante en diere staatmaak op die vog wat deur gereelde mis wat vanaf die koue Atlantiese Oseaan inrol (plaaslik bekend as "Ihuries" of "Malmokkies") voorsien word as 'n primêre waterbron in 'n andersins uiters droë omgewing (SANParks, 2026).

Hoewel mis 'n belangrike ekologiese rol langs die kus speel, veral in droë omgewings, bestaan daar tans 'n gebrek aan wetenskaplike navorsing wat spesifiek ondersoek hoe landgebaseerde kus-windturbines die beweging van mis landinwaarts beïnvloed. Geen studies het tot op hede vasgestel of turbines mis se indringing in droë ekostelsels versteur, vertraag of verbeter nie. Dit verteenwoordig 'n beduidende navorsingsleemte in streke waar misafhanklike biodiversiteit beide uniek en kwesbaar is.

Tog toon bewyse van windplase wat in die see geplaas word ("offshore wind energy") dat turbines misvorming en atmosfeer-gedrag kan beïnvloed, insluitend gevalle waar windplaas-geïnduseerde blokkasie en "wake effects" mispatrone veroorsaak of vorm (Hasager et al., 2023). Hoewel hierdie aflandige bewyse nie direk soortgelyke effekte vir landgebaseerde kus-turbines bevestig nie, dui dit op waarskynlike meganismes waardeur hulle misdinamika naby die kus kan beïnvloed.

Die belangrikheid van mis in droë ekosisteme, gekombineer met aflandige bewyse van turbine-verwante misverandering, beklemtoon die behoefte aan toegewyde navorsing om moontlike impakte van kus-windontwikkeling op landinwaartse misafhanklike biodiversiteit te verstaan.

die voorgestelde Boegoebaai-hawe verminder ook die behoefte aan uitgebreide nuwe oordragkorridors, wat sodoende bykomende en wydverspreide landskapfragmentasie beperk.

Hierdie beginsel vereis dat turbine-plasing, toegangspaaie, harde oppervlaktes en oordraginfrastruktuur beperk word tot bestaande versteuringsgebiede; dat nuwe lineêre infrastruktuur tot die minimum beperk word en saamgeplaas word met bestaande versteurde roetes; en dat ontwikkeling nie sandmobilisering vererger, inmeng met misgedrewe ekologiese prosesse, of indring in aangrensende ongeskonde kusstelsels nie.

b) **Lae-sensitiwiteits-binnevlaktes vir sonplaas-ontwikkeling**: landinwaarts van die kus-eskarp is daar uitgestrekte dele van droë vlaktes met relatief laer biodiversiteitsensitiwiteit, veral waar plantegroeiproduktiwiteit reeds laag is en waar die verteenwoordiging van bedreigde ekosisteme minder gekonsentreer is. Hierdie gebiede is oor die algemeen meer geskik vir grootskaalse PV-installasies, wat 'n laer vertikale ontwikkelingsvoetspoor en verminderde botsingsrisiko het in vergelyking met windenergie. Selfs binne hierdie lae-sensitiwiteitsgebiede moet ontwikkeling egter vermy:
   - Dreineringlyne, panne en tydelike riviersisteme.
   - Gebiede wat met grondwateraanvulling, vleilande of strategiese waterbrongebiede geassosieer word.
   - Bekende erfenislandskappe, insluitend paleontologies sensitiewe formasies en argeologiese terrein-groeperings.
   - Prioriteit-biodiversiteitskenmerke.

   Strategiese beplanning moet daarom sonplaas-ontwikkeling bevorder as gekonsentreerde presinkte binne hierdie binnevlakte, eerder as verspreide individuele projekte, om kumulatiewe grondtransformasie te verminder en monitering en bestuur te vereenvoudig.

   Hierdie beginsel vereis dat sonplase so uitgelê word dat onbeboude korridors en landskapdeurlaatbaarheid behou word, dat deurlopende kombersbedekking van groot gebiede vermy word, en dat gelykmaak, afstroop en verseëling van grond — wat krities is vir ekologiese funksionering in droë gebiede — vermy word. Geskiktheid vir ontwikkeling hang nie net van ligging af nie, maar ook van uitleg en spasiëring, en watervoorsiening en dienste sonder om ekologiese of munisipale veerkragtigheid te benadeel.

c) **Infrastruktuurkorridors en nodale konsolidasie:** 'n Korridor-gebaseerde ontwikkelingsmodel word sterk ondersteun, veral langs die N14 en die voorgestelde SES-logistiekkorridors. Die konsentrasie van pypleidings, kraglyne, paaie en (waar haalbaar) spoorinfrastruktuur binne gedeelde serwitute verminder landskapfragmentasie, beperk herhalende versteuring en verbeter regulatoriese toesig. Hierdie benadering is veral krities gegewe die skaal van lineêre infrastruktuur wat onder die groter GH_2-scenario's benodig word.

   Hierdie beginsel vereis pro-aktiewe sameplasing van lineêre infrastruktuur, vermyding van parallelle of gedupliseerde korridors, en belyning wat die integriteit van ekologiese prosesse prioritiseer bo kortste-roete- of laagste-koste-oorwegings. Konsolidasie is egter nie gepas waar dit impakte sal konsentreer tot bo ekologiese of sosiale drempels, sensitiewe stelsels sal benadeel, of die institusionele kapasiteit vir gekoördineerde beplanning, monitering en aanpasbare bestuur sal oorskry nie.

3.4 Strategiese benadering tot biodiversiteitskompensasies en ekologiese vergoeding op streekskaal (Botha, 2026 en Desmet et al., 2026)

Die Namakwa-streek word gekenmerk deur **buitengewoon hoë biodiversiteitsensitiwiteit op landskapskaal**, gekombineer met wydverspreide bestaande en voorgestelde ontwikkelingsdruk. **Ongeveer 71% van die streeksbeplanningsdomein bevat sensitiewe biodiversiteitskenmerke**, insluitend CBA's, prioriteitsfokusgebiede vir die uitbreiding van beskermde gebiede, onder-beskermde plantegroeitipes en konsentrasies van SCC. As gevolg hiervan is **volledige vermyding van biodiversiteitsimpakte onwaarskynlik**, selfs onder relatief beskeie GH_2-ontwikkelingspaaie.

Die WP2-SOA-biodiversiteitsraamwerk beklemtoon **dat biodiversiteitskompensasies en ekologiese vergoeding** (Blok OBM 25) **nie 'n plaasvervanger is vir vermyding of minimalisering nie**, en nie gebruik kan word om ontwikkeling te regverdig in gebiede waar impakte op Kritieke Habitat of onvervangbare biodiversiteitskenmerke onvermýbaar is nie. Vir ontwikkelinge wat in lyn wil wees met internasionale finansieringsstandaarde en GH_2-mark-vereistes, is bewysbare toepassing van **die versagtingshiërargie nie onderhandelbaar nie, met kompensasies streng geposisioneer as 'n meganisme van laaste uitweg om residuele impakte aan te spreek.**

Blok OBM 25: Kompensasie teenoor ekologiese vergoeding

Biodiversiteitskompensasies beoog om 'n geen-netto-verlies of netto-wins uitkoms vir biodiversiteitskenmerke te behaal, en ekologiese vergoeding kan slegs oorweeg word waar residuele impakte nie volledig gekompenseer kan word nie.
Ekologiese vergoeding dra aansienlik hoër regulatoriese, finansiële en bestuursrisiko's en moet, waar moontlik, deur vroeë ruimtelike beplanning en vermyding voorkom word.

Op streekskaal word biodiversiteits-kompensasie waarskynlik **geaktiveer deur die kumulatiewe ontwikkelingsvoetspoor van GH_2-verwante infrastruktuur, eerder as deur enige enkele aanleg. Selfs relatief beskeie GH_2-ontwikkelingspaaie (bv. onder Sc1) word verwag om omvangryke kumulatiewe grondgebruik te veroorsaak, terwyl groter of versnelde ontwikkelingspaaie die skaal van residuele biodiversiteitsimpakte wesenlik verhoog, veral wanneer lineêre infrastruktuur ingesluit word, uitgesluit indirekte en geïnduseerde effekte.** Lineêre infrastruktuur soos kraglyne, pypleidings, spoorwegkorridors en toegangspaaie versterk beide die ruimtelike omvang en ekologiese betekenis van impakte aansienlik, veral waar dit ekologiese korridors, voëlbewegingsroetes of onder-beskermde plantegroeitipe kruis.

Kompensasies word dus die waarskynlikste benodig waar ontwikkeling onvermýdelik (i) CBA's en ESA's, (ii) habitatte wat SCC-spesies ondersteun, (iii) plantegroeitipe wat swak beskerm word binne die nasionale netwerk van beskermde gebiede, en (iv) landskapskaal-ekologiese prosesse, insluitend konnektiwiteit, beïnvloed. Waar impakte ekosisteem-voortbestaan drempels ondermyn of Kritieke Habitat raak, mag **standaard-biodiversiteitskompensasies onvoldoende of onvanpas wees, en die raamwerk identifiseer die moontlike behoefte aan ekologiese vergoeding, onderhewig aan streng regverdiging en regulatoriese toesig**. Dit verhoog regulatoriese, finansiële en bestuursrisiko's aansienlik.

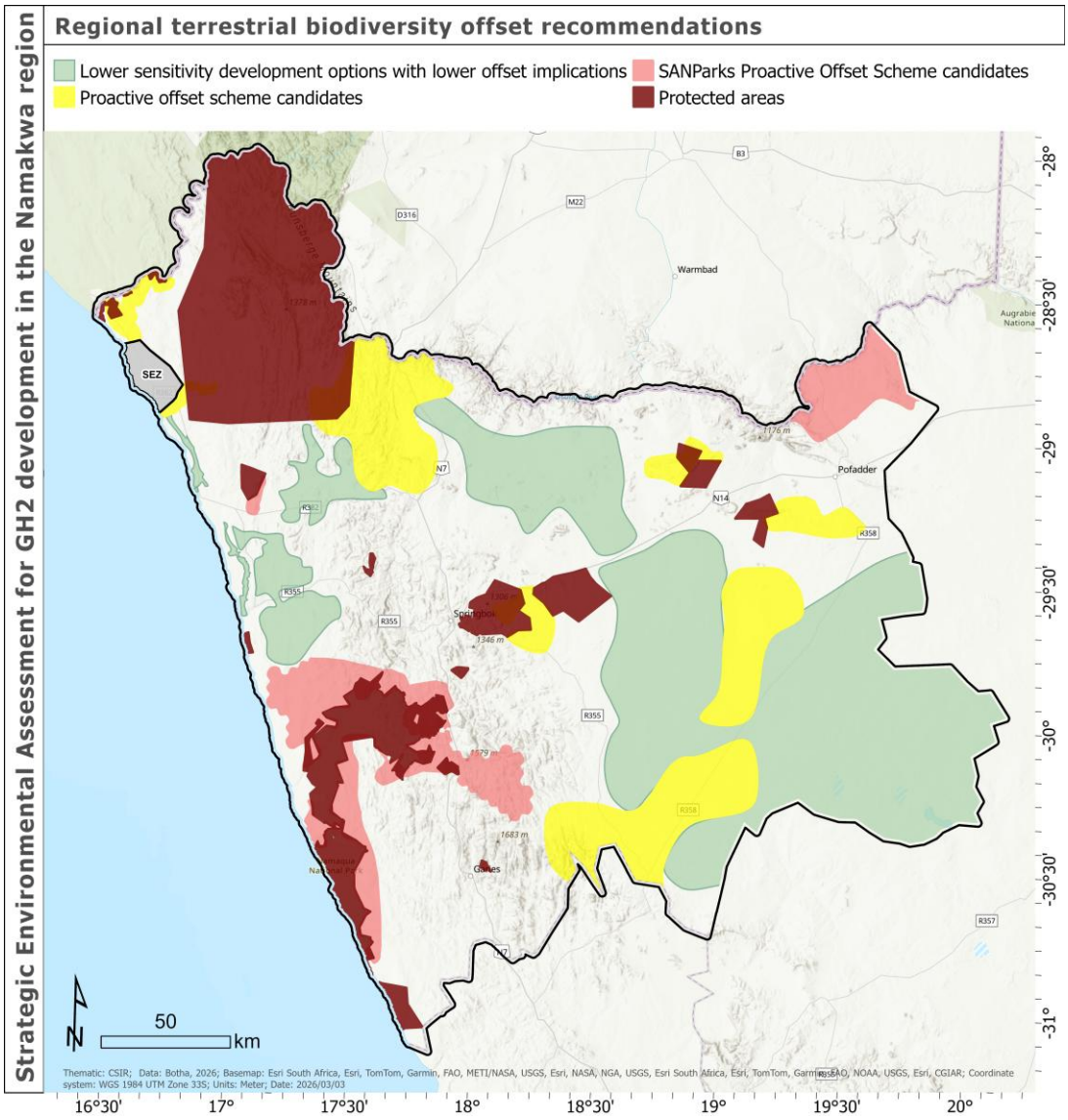
Die WP2-Biodiversiteitskompensasie-Raamwerk dui nie spesifieke kompensasiegebiede aan nie, maar identifiseer **strategiese kompensasie-geleentheidsgebiede op streekskaal**. Hierdie ontvangsgebiede word gedefinieer om beplanning en volgordebesluite te rig, met die erkenning dat kompensasieverpligtinge waarskynlik groot, kumulatief en langtermyn sal wees.

Moontlike kompensasie-ontvangsgebiede (Figuur OBM 6) is hoofsaaklik geleë binne:

- **Beskermde Area-Uitbreidingsprioriteitsgebiede,** veral waar hierdie aan bestaande nasionale of provinsiale beskermde **gebiede grens en tot konsolidasie van die netwerk van beskermde gebiede kan bydra.**
- **Groot, ongeskonde binnelandse landskappe met relatief lae huidige ontwikkelingsdruk en hoë ekologiese integriteit.**
- **Gebiede wat in staat is om aaneenlopende kompensasie-landskappe te ondersteun**, eerder as gefragmenteerde, geïsoleerde erwe.

Gebiede wat aan bestaande of historiese mynbou- en prospekteringsregte onderhewig is, word uitdruklik as swak kandidate vir kompensasies geïdentifiseer, weens die risiko van toekomstige grondgebruikkonflik en die uitdagings om volhoubare, afdwingbare bewaringuitkomste te verseker. Verder word **gedegradeerde of voorheen gemynte kuslandskappe — hoewel geskik vir ontwikkeling — nie as geskikte kompensasie-ontvangsgebiede beskou nie**, aangesien hulle onwaarskynlik verdere biodiversiteitswins sal oplewer.

Die ruimtelike patroon wat in Figuur OBM 6 geïllustreer word, beklemtoon dat kompensasie-ontvangs-geleenthede beperk en hoogs gekonstraineer is, wat die behoefte aan vroeë, gekoördineerde streeksbeplanning versterk. Die kaart is aanduidend en verduidelikend en is bedoel om strategiese besluitneming te informeer, eerder as om goedgekeurde kompensasiegebiede te definieer.



Figuur OBM 6: Aanduidende kompensasie-ontvangsgeleentheidsgebiede vir biodiversiteit en beperkings binne die WP2-beplanningsdomein, met die klem op Prioriteitsgebiede vir Uitbreiding van Beskermde Gebiede, biodiversiteitsprioriteitskenmerke en gebiede wat uitgesluit word weens mynbou- en ontwikkelingsbeperkings. (Botha, 2026)

Die bepaalde skaal van moontlike kompensasieverpligtinge is ongekend in die streekskonteks. Die toepassing van nasionaal-belynde kompensasieverhoudings dui daarop dat grootskaalse GH_2-ontwikkeling die verkryging van **meer as 180 000 ha** kompensasiegrond kan vereis, terwyl selfs kleiner ontwikkelingspaaie **tienduisende hektare** kan benodig. Hierdie groottes maak projek-vir-projek kompensasie onprakties (Blok OBM 26), veral in 'n streek wat gekenmerk word deur gefragmenteerde grondbesit, historiese mynbouregte en beperkte institusionele kapasiteit.

Om dit aan te spreek, word 'n **proaktiewe, saamgevoegde en streeksgeskakelde benadering** tot biodiversiteitskompensasies aanbeveel, insluitend:

- **Vroeë identifikasie van groot, aaneenlopende kompensasie-ontvangsgebied**e.
- **Prioritiseer die uitbreiding van beskermde areas.**
- **Los konflikte met bestaande mynbou- en prospekteringsregte in voornemende kompensasiesones op.**
- **Vestig van volhoubare "stewardship"-, bestuurs- en finansieringsreëlings** om langtermyn-biodiversiteitsuitkomste te verseker.

Kompensasie-oorwegings moet as ontrekkingspunt ingebed word in streeksbeplanning- en bestuursraamwerke, eerder as om dit na afstroomse projekvlak-assesserings uit te stel. Ruimtelike beplanningsinstrumente soos "SDFs", "IDPs", SES-meesterplanne en hernubare-energie-korridors moet uitdruklik:

- **Rig ontwikkeling na reeds gedegradeerde of voorheen gemynte landskappe**, veral langs die kusmynbougordel.
- **Belyn hernubare energie-opwekking, kragnetwerkinfrastruktuur en gepaardgaande korridors met gebiede van laagste biodiversiteitssensitiwiteit. en**
- **Baken waar ontwikkeling onhanteerbare kompensasie- of vergoedingverpligtinge sal aktiveer, af,** wat in effek as strategiese vermydingsones funksioneer.

Grootskaalse kompensasie fundamenteel 'n bestuursuitdaging is. Sonder vroeë ruimtelike rigting, gekoördineerde institusionele reëlings en regulatoriese sekerheid kan kompensasies projekte vertraag, beleggersrisiko verhoog en versuim om bewaringuitkomste te verseker. Proaktiewe streeks-kompensasiebeplanning verminder onsekerheid vir sowel ontwikkelaars as reguleerders, terwyl dit biodiversiteitsuitkomste verbeter. Daar word aanbeveel dat **proaktiewe strategiese en/of gesamentlike kompensasiemeganismes** ondersoek word, moontlik gekoppel aan bestaande beskermde gebiede, om fragmentasie te verminder, doeltreffendheid te verbeter en bewaringseffektiwiteit te verhoog. Sulke meganismes moet addisioneel wees tot, en nie 'n plaasvervanger vir, bestaande openbare bewaringbefondsing nie.

3.4.1 'n Geïntegreerde GH2 Versagting en Biodiversiteit Implementeringsplan

Die biodiversiteitskompensasieraamwerk moet nie as 'n losstaande ingryping geïmplementeer word nie. Biodiversiteitskompensasies, ekosisteemherstel, die ontwikkeling van die biodiversiteitsekonomie, die generering van biodiversiteitskennis, die verfyning van biodiversiteits- ruimtelike beplanningsinstrumente, en die beskerming van die streek se sin van plek ("gevoel") behoort gekoördineer te word deur 'n enkele streekskaalse GH_2 versagtings en Biodiversiteit Implementeringsplan. Hierdie benadering sal die proaktiewe en gekoördineerde implementering van biodiversiteitsverwante anbevelings op 'n streekskaal moontlik maak, eerder as deur gefragmenteerde, projek-vir-projek-inisiatiewe. Die implementeringsplan moet:

- Die streeksvisie vir biodiversiteitsbewaring ondersteun en 'n ruimtelike raamwerk bied wat belyn is met nasionale en provinsiale strategieë vir die uitbreiding van beskermde gebiede, Visie 2040, en ander biodiversiteitsbeplanningsprioriteite.
- Strategiese ontvangsgebiede vir biodiversiteitskompensasie, geleenthede vir ekosisteemherstel, en ander prioriteitsversagtingsintervensies wat met GH_2-ontwikkeling verband hou, identifiseer.
- Die rolle en verantwoordelikhede van sleutel-implementeringsvennote duidelik definieer, insluitend regeringsinstellings, die wetenskaplike gemeenskap, burgerlike organisasies, nie-regeringsorganisasies en ander relevante belanghebbendes.
- 'n Befondsingsmodel vestig wat gekoppel is aan die skaal van die GH_2-belegging om biodiversiteitskompensasie-implementering, ekosisteemherstel, die verkryging en bestuur van bewaringgrond, en inisiatiewe vir die biodiversiteitsekonomie te ondersteun.
- Praktiese maniere identifiseer vir ekonomiese voordeel-trekking wat verband hou met bewaringsbelegging, en die begunstigdes van biodiversiteitsekonomie-inisiatiewe wat aan GH_2-ontwikkeling gekoppel is, duidelik uitwys.
- Meetbare implementeringsteikens vestig wat gekoppel is aan 5-, 10- en 15-jaar-beplanningshorisonne en belyn is met die verwagte tempo en skaal van GH_2-ontwikkeling.

- Voorsiening maak vir periodieke (3–5 jaar intervalle) hersiening van implementeringsvordering en -uitkomstes, ondersteun deur onafhanklike toesig- en verslagdoeningsmeganismes.

3.5 Verbetering van ruimtelike biodiversiteitsbeplanningsinstrumente

Daar is 'n behoefte aan voortgesette belegging in biodiversiteits- ruimtelike beplanning en sensitiwiteitskartering om ingeligte streeksbesluitneming te ondersteun. 'n Prioriteitsaksie is die ontwikkeling van 'n ruimtelike streeks-biodiversiteitsraamwerk wat biodiversiteitsbeplanningsprodukte, prioriteite vir die uitbreiding van beskermde gebiede en spesialis-sensitiwiteitsbeoordelings in 'n omvattende ruimtelike beplanningsinstrument integreer. Die raamwerk moet die ruimtelike bloudruk verskaf vir die uitbreiding van beskermde gebiede, die implementering van biodiversiteitskompensasies, die ontwikkeling van die biodiversiteitsekonomie, en die strategiese belyning van GH_2-verwante infrastruktuur en hernubare energie-ontwikkeling met biodiversiteitsbewaringsdoelwitte. Die raamwerk moet periodiek bygewerk word namate nuwe ekologiese inligting beskikbaar word, insluitend 'n beter begrip van ekologiese korridors, migrasieroetes en ander biodiversiteitskenmerke van streeksbelang.

3.6 Aanbevelings vir infrastruktuur en strategiese beplanning (Maritz et al.,2026)

Infrastruktuurkapasiteit en beplanningsgereedheid is onder die mees betekenisvolle beperkende faktore vir volhoubare ontwikkeling in die Namakwa-streek. **Korridor-geleide infrastruktuurbeplanning moet geprioritiseer word om paaie, spoor, pypleidings en oordraginfrastruktuur in lyn te bring met die beginsels van ruimtelike konsentrasie en om kumulatiewe impakte te verminder.**

Waar grootskaalse vervoer van erts en grootmaatmateriaal beoog word, **is vroeë belegging in spoorinfrastruktuur strategies verkieslik bo langtermyn-afhanklikheid van swaar padvervoer, wat ernstige risiko's vir padtoestand, veiligheid, toerisme en die leefbaarheid van nedersettings inhou. Spoorvervoer veral gegewe die vervoer van mynbou erts, moet verkieslik vroeer oorweeg word, in die klein GH_2 ontwikkelingscenario, om die omvang en risiko verwant aan grootskaalse swaarvoertuig padvervoer te vermy.Waterbeskikbaarheid, behandelingskapasiteit en operasionele bestuur moet erken word as bindende beperkings op ontwikkeling, met ontsouting en aanvullingstelsels wat as streekstelsels beplan en bestuur moet word, eerder as projek-spesifieke toevoegings.**

Infrastruktuurbelegging moet prioriteit gee aan nodale nedersettings soos Port Nolloth, Alexanderbaai en Springbok om verspreide informele groei te voorkom. Die implementering van hierdie aanbevelings verg versterkte beplannings- en regulatoriese kapasiteit op munisipale en distriksvlak, proaktiewe grondtoegang en oplossing van grondbesit, en gekoördineerde interregerings-bestuursreëlings.

3.7 Voorlopige ontwikkelingsbeplanningsriglyne

Basseer op die integrasie van WP2-tematiese assesserings word voorlopige ontwikkelingsbeplanningsriglyne afgelei (Figuur OBM 7). Die ruimtelike riglyne identifiseer nie voorkeur- of goedgekeurde ontwikkelingsgebiede nie, maar onderskei eerder tussen gebiede en ontwikkelingsopsies wat, op 'n voorlopige strategiese vlak, potensieel geleenthede kan bied.

Teoreties is daar genoeg ruimte van laer omgewingsensitiwiteit en laer kompensasie-implikasies in die Namakwa-streek om die hernubare energie-ontwikkeling te ondersteun wat nodig is vir die Boegoebaai-GH_2-ambisie. Ten spyte van die streek se hoë algehele ekologiese sensitiwiteit, bestaan daar relatief lae-sensitiwiteitsterreine oor die binnelandse vlaktes, wat voldoende ruimtelike geleentheid bied om die 52 000–416 000 ha hernubare-energie-ontwikkelingsvoetspore te akkommodeer wat onder die klein en groot GH_2-scenario's vereis word. Die geïdentifiseerde hernubare-energie-ontwikkelingsopsies (Figuur OBM 7). word gekenmerk deur laer konsentrasies van prioriteit-biodiversiteitskenmerke,

verminderde erfnisdigtheid en minder hidrologiese beperkings, wat hulle die mees verdedigbare gebiede maak vir grootskaalse son-PV en gepaardgaande RE-infrastruktuur.

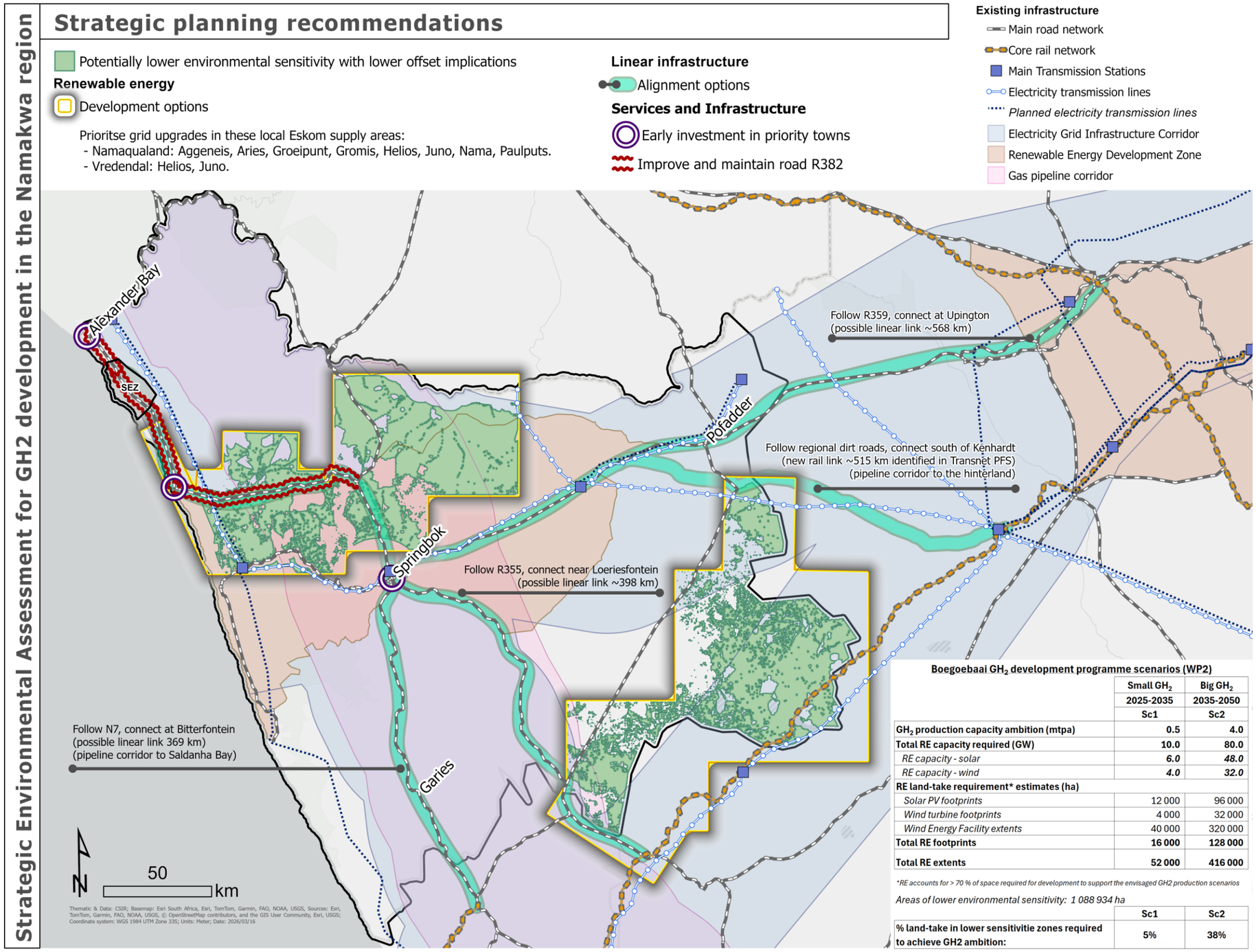
Hoewel hierdie gebiede relatief laer sensitiwiteit op streekskaal toon, moet alle ontwikkeling onderwerp word aan projekvlak-omgewingsassessering en terreinspesifieke veldverifiëring, aangesien hierdie gebiede steeds hoogs sensitiewe sosiale en ekologiese kenmerke bevat. Hierdie gebiede vereis steeds terreinvlakverifiëring, maar die streekskaal-kartering bevestig dat teoretiese grondbeskikbaarheid nie die bindende beperking is nie; eerder is strategiese plasing binne hierdie lae-konfliksones die sleutel om die groenwaterstofvisie te verwesenlik sonder onhanteerbare kompensasie-verpligtinge.

Dit is noodsaaklik om versteurde gebiede en bestaande lineêre korridors vir ontwikkeling te teiken. Nuwe ontwikkelingsvoetspore moet eerstens gerig word na reeds getransformeerde gebiede en gevestigde infrastruktuurserwitute, waar ekologiese en erfenis-sensitiwiteit reeds wesenlik verander is. Sameplasing van nuwe paaie, pypleidings, kraglyne en spoor binne bestaande lineêre korridors soos die R382, N7 en N14 (Figuur OBM 7). kan bykomende fragmentasie minimaliseer en help om kumulatiewe streeksimpakte te beperk. Hierdie benadering verseker dat ontwikkelingsintensivering plaasvind in landskappe wat reeds ekologiese versteuring dra, eerder as om nuwe, parallelle versteuringroetes te skep.

Elektrisiteitsnetwerk en kapasiteitsbeskikbaarheid is een van die mees betekenisvolle beperkende faktore vir die verwesenliking van die Boegoebaai-GH_2-program. Hoewel lae-sensitiwiteitsterreine vir hernubare-energieopwekking beskikbaar is, het die huidige netwerk onvoldoende kapasiteit en is dit ruimtelik beperk om die skaal van krag wat nodig is om 5–40 GW elektrolise te ondersteun, te hanteer. Nuwe en versterkte transmissie-infrastruktuur, veral in die Eskom-versorgingsgebiede van Vredendal en Namakwaland (Eskom, 2023), moet vroeg geprioritiseer word en strategies belyn word binne lae-sensitiwiteitsones en bestaande korridors om hoë-impakgebiede te vermy. Sonder vroeë netwerkuitbreiding loop die streek die risiko van ’n scenario waar hernubare energie potensiaal bestaan, maar nie gekoppel kan word nie, wat GH_2-produksie effektief tot stilstand bring en die lewensvatbaarheid van die SES en hawe-verwante industriële ontwikkeling ondermyn.

Opgradering en instandhouding van sleutelvervoerroetes, veral die R382 wat as primêre vrag- en mobiliteitskakel na die Boegoebaai-kuslyn sou dien, is noodsaaklik. Onder die klein GH_2-scenario kan vragmotorvolumes meer as 500 swaarvoertuie per dag oorskry, wat onvolhoubare druk plaas op ’n roete wat deur verskeie medium- tot hoë-sensitiwiteitsones naby die kus beweeg. Opgradering, herbelaaipadwerk en instandhouding van die R382 — veral by Anenouspas — is ononderhandelbaar, beide om konstruksielogistiek te ondersteun en om nedersettingveiligheid, toerisseroetes en noodreaksie-vermoë te beskerm. Ideaal moet die implementering van ‘n spoorlyn vir die vervoer van mynbou erts reeds vroeër beplan word om die gebruik van grootskaalse vragmotorvervoer te vermy. Die versterking van hierdie korridor voorkom ook die behoefte om nuwe paaie deur ongeskonde duinstelsels te skep, wat infrastruktuurontwikkeling belyn met die laagste-konflik ruimtelike omgewing.

Vroeë katalitiese belegging in ankernedersettings is noodsaaklik om hawe- en SES-ontwikkeling te ondersteun. Port Nolloth, Alexanderbaai en Springbok is kritieke ruimtelike nodusse wat vroeë belegging moet ontvang om in-migrasie, konstruksiefasevereistes en langtermyn operasionele ondersteuning vir die voorgestelde hawe en SES te bestuur. Hierdie dorpe is relatief geïsoleerde nedersettingsnodusse wat omring word deur hoë-sensitiwiteitslandskappe, wat beteken dat uitbreiding na buite beperk is en opgradering binne die dorp noodsaaklik is. Prioriteitsbelegging in watervoorsiening, afvalwaterbehandeling, behuising, paaie, maatskaplike dienste en administratiewe kapasiteit is nodig om onbestuurde groei, uitbreiding van informele nedersettings en plaaslike diensdruk te voorkom. Omdat hierdie nedersettings waarskynlik die grootste deel van Boegoebaai-GH_2-verwante ekonomiese en demografiese druk sal dra, vorm proaktiewe versterking van hul infrastruktuur- en bestuursisteme die grondslag vir ’n sosiaal en omgewingsgewys lewensvatbare ontwikkelingspad.



Boegoebaai GH_2 development programme scenarios (WP2)

	Small GH_2	Big GH_2
	2025-2035	2035-2050
	Sc1	Sc2
GH_2 production capacity ambition (mtpa)	**0.5**	**4.0**
Total RE capacity required (GW)	**10.0**	**80.0**
RE capacity - solar	***6.0***	***48.0***
RE capacity - wind	***4.0***	***32.0***
RE land-take requirement* estimates (ha)		
Solar PV footprints	12 000	96 000
Wind turbine footprints	4 000	32 000
Wind Energy Facility extents	40 000	320 000
Total RE footprints	**16 000**	**128 000**
Total RE extents	**52 000**	**416 000**

**RE accounts for > 70 % of space required for development to support the envisaged GH2 production scenarios*

Areas of lower environmental sensitivity: 1 088 934 ha

	Sc1	Sc2
% land-take in lower sensitivitie zones required to achieve GH2 ambition:	**5%**	**38%**

Figuur OBM 7: Voorlopige streeksontwikkelingsriglyne vir die Boegoebaai-GH_2-ekonomie. Ongeveer 1 miljoen hektaar van relatief laer omgewingsensitiwiteit is geïdentifiseer (liggroen skakering). In beginsel kan hierdie gebied die hernubare energie-insette akkommodeer wat onder die twee scenario's vereis word: ongeveer 10 GW (≈52 000 ha) vir Sc1 en ongeveer 80 GW (≈416 000 ha) vir Sc2. Hoewel hierdie gebiede relatief laer sensitiwiteit op streekskaal toon, moet alle ontwikkeling steeds onderwerp word aan projekvlak-omgewingsassessering en terreinspesifieke veldverifiëring, aangesien hierdie gebiede steeds hoogs sensitiewe sosiale en ekologiese kenmerke bevat. Ondersteunende infrastruktuur sal krities wees vir verantwoordelike streeksontwikkeling, insluitend: (i) uitbreiding en versterking van die elektrisiteitsnetwerk binne die geïdentifiseerde lae-sensitiwiteitsones; (ii) opgradering en instandhouding van sleutelvervoerroetes, veral die R382; en (iii) vroeë katalitiese belegging in ankernedersettings om hawe- en Spesiale Ekonomiese Sone- (SES-) ontwikkeling te ondersteun. Waar haalbaar, moet nuwe lineêre infrastruktuur saamgeplaas word binne bestaande versteuringskorridors om impak te minimaliseer.

3.8 Strategiese sosio-ekonomiese aanbevelings en bestuursbeginsels (Atkinson et al. 2026 and Maritz et al., 2026)

Die bevindinge van die SOA toon dat sosio-ekonomiese risiko's en geleenthede kernbepalers is van die vraag of omgewingsverdedigbare ruimtelike besluite suksesvol geïmplementeer kan word. Die Sosio-ekonomie-Hoofstuk identifiseer ses onderling verbonde strategiese temas wat beplanning, konsultasie en besluitneming vir die Boegoebaai-hawe, SES en die gepaardgaande GH_2-ekonomie eksplisiet moet lei.

Blok OBM 26: Hoekom sosio-ekonomiese risiko deur strategiese beplanning bestuur kan word.

Die sosio-ekonomiese assessering toon dat baie van die mees beduidende risiko's wat met die Boegoebaai-hawe en GH_2-program geassosieer word, nie uit die fisiese ontwikkelingsvoetspoor spruit nie, maar uit die tempo, volgorde en bestuur van verandering. In-migrasie, oorlading van dienste, grontoegangsgespute en onbeantwoorde werkskeppingsverwagtings kan omgewingsbestuur ondermyn, institusionele kapasiteit erodeer en konflik genereer wat projekte vertraag of ontspoor. Die aanspreek van sosio-ekonomiese risiko's op die **strategiese beplanningsvlak** — deur ruimtelike differensiasie van ontvangsgebiede, vroeë konsultasie, realistiese indiensnemingsbeplanning en versterkte bestuur — is daarom noodsaaklik om te verseker dat ontwikkeling sosiaal aanvaarbaar, uitvoerbaar en volhoubaar bly.

1) **Differensiasie van ontvangsgebiede en ruimtelike teikening van impakte**

Die Richtersveld Plaaslike Munisipaliteit word geïdentifiseer as die primêre ontvangende omgewing vir konstruksiefase-impakte, grondtoegangsdruk en sosiale verandering wat met die hawe, SES en lineêre infrastruktuur geassosieer word. Springbok sal waarskynlik funksioneer as die streeks-administratiewe, diens- en ekonomiese spilpunt, met sekondêre kus-nedersettings soos Port Nolloth en Alexanderbaai wat meer gespesialiseerde rolle speel wat aan haweverwante aktiwiteit gekoppel is. **Strategiese beplanning en belegging moet hierdie gedifferensieerde rolle erken en verseker dat impakbestuur, diensvoorsiening en voordeelverdeling ruimtelik geteiken word, eerder as om uniform oor die streek toegepas te word.**

2) **Volgordebepaling van ontwikkeling om in-migrasie en diensdruk te bestuur**

Die sosio-ekonomiese assessering beklemtoon konstruksiefase-in-migrasie as een van die mees betekenisvolle drywers van sosiale risiko. Waar behuising, water, sanitasie, gesondheid, veiligheid en polisiëringsinfrastruktuur agter konstruksie-aktiwiteit aan sloer, is onbestuurde nedersettingsgroei, diensagterstande en sosiale konflik waarskynlik. **Strategiese beplanning moet daarom ontwikkeling sekwenseer sodat grootmaatdienste, behuising en sosiale infrastruktuur voor piek-konstruksiefases op plek is, veral in hoë-druk ontvangsgebiede.**

3) **Konsultasie, legitimiteit en toestemming as strategiese risikobestuursinstrumente**

Nakoming-gebaseerde konsultasie is onvoldoende vir ontwikkeling van hierdie skaal en kompleksiteit. In gebiede wat deur gemeenskaplike grondregte, lewende erfenis en gebruiklike grondgebruik gekenmerk word, moet **konsultasie vroeg begin, deurlopend voortgaan deur beplanning en implementering, en voldoende deursigtig wees om ingeligte deelname te ondersteun. Strategiese betrokkenheidsbenaderings wat met "Free, Prior and Informed Consent (FPIC)"-beginsels belyn** is, is noodsaaklik om legitimiteit te behou, konflik te verminder en vertragings te voorkom wat beide sosiale en omgewingsuitkomste kan ondermyn.

4) **Grondtoegang, grondreg-kompleksiteit en onderhandelingsraamwerke**

Grondtoegang kom na vore as 'n bindende beperking in die Namakwa-streek, gegewe die voorkoms van gemeenskaplike grond, CPA-reëlings, staatsgrond en historiese mynbou-nalatenskappe. **Ad hoc-onderhandelinge per projek verhoog onsekerheid, vertragings en ongelyke uitkomste. Strategiese beplanning moet daarom gesteun word deur duidelike, vooraf onderhandelingsraamwerke wat grondtoegang, vergoeding, voordeel-deling en langtermyn-grondgebruikreëlings konsekwent en deursigtig aanspreek.**

5) Indiensnemingsrealisme en vermyding van "boom-bust"-dinamika

Die sosio-ekonomiese assessering waarsku teen oor-afhanklikheid van konstruksiefase-indiensneming as maatstaf vir langtermyn sosio-ekonomiese voordeel. Alhoewel konstruksie korttermyn-werk kan skep, is operasionele poste beperk en hoogs gespesialiseerd. Strategiese beplanning moet daarom fokus op verwagtingsbestuur, vroeë beleggin in tegniese vaardigheidsontwikkeling (insluitend Tegniese en Beroepsopvoeding en -Opleiding ("Technical and Vocational Education and Training (TVET)") kolleges, ambagsman-opleiding en gespesialiseerde GH_2-verwante vaardighede), plaaslike verkryging en ekonomiese diversifikasie om boom-bust-siklusse en sosio-ekonomiese agteruitgang ná konstruksie te vermy.

6) Institusionele en bestuurskapasiteit as beperkende faktor

Swak institusionele kapasiteit versterk sosio-ekonomiese risiko aansienlik. Munisipaliteite in die streek is reeds onder druk, en selfs die kleiner GH_2-ontwikkelingscenario sal waarskynlik beplannings-, regulatoriese en diensleweringstelsels benou. **Versterking van institusionele kapasiteit, rolverduideliking oor regeringsfere heen en belyning van sosio-ekonomiese beplanning met ruimtelike en infrastruktuur-besluitneming is daarom voorvereistes vir volhoubare uitkomste**. Hierdie institusionele versterking behoort ook rampbestuursvermoë, gereedheid vir gevaarlike materiale, noodreaksiestelsels en koördinering tussen munisipaliteite in te sluit.

Die sosio-ekonomiese beoordeling (Hoofstuk 7 van die SOA WP2) pleit vir samewerkende bestuur ("*collaborative governance"*) oor regeringsfere heen, insluitend openbare en private deelname aan deurlopende beplanning, besluitneming en evaluering.

3.9 Effektiewe konsultasie en onderhandelinge (Atkinson et al., 2026)

Die WP2-sosio-ekonomiese assessering toon dat die **langtermynleefbaarheid en wettigheid van die voorgestelde Boegoebaai-hawe, GH_2- en SES-ontwikkelings krities afhanklik is van billike, goed gestruktureerde en volhoubare konsultasie- en onderhandelingsprosesse.** Gegewe die skaal, duur en transformerende aard van die voorgestelde ontwikkelinge, is konsultasie- en onderhandelingsprosesse wat billik, inklusief en volhoubaar oor tyd is, noodsaaklik. In kontekste waar gemeenskaplike en gerestitueerde grond, inheemse regte en kultureel ingebedde bestaansmiddele ter sprake is, is betekenisvolle betrokkenheid 'n kritieke bepalende faktor vir sosiale legitimiteit en langtermynprojekleefbaarheid.

Gemeenskappe wat direk deur die voorgestelde ontwikkelinge geraak word — veral dié met gemeenskaplike grondregte — moet as regmatige onderhandelingsvennote betrek word. In die Boegoebaai-konteks funksioneer gemeenskapsaanvaarding as 'n sosiale lisensie om te opereer, en onvoldoende of swak gestruktureerde betrokkenheid hou 'n wese-like risiko van geskille, vertragings en verlies aan vertroue in.

Die assessering beklemtoon die belangrikheid van vroeë en doelbewuste ontwerp van betrokkenheid, veral in omgewings waar institusionele spanning bestaan. Dit sluit in: duidelikheid oor verteenwoordigende strukture, mandate, besluitnemingsprosesse, asook aandag aan magasimetrië tussen projekvoorstaanders, staatsinstellings en plaaslike gemeenskappe. **Onafhanklike fasilitering word geïdentifiseer as 'n belangrike ondersteuningsmeganisme om deursigtige dialoog, vertrouebou en konstruktiewe onderhandeling te bevorder.**

Waar voorgestelde besluite langtermyn of onomkeerbare implikasies vir grondgebruik, bestaansmiddele of kulturele erfenis het, beveel die assessering aan dat betrokkenheidsprosesse gelei word deur die beginsels van FPIC (Blok OBM 28).

FPIC word benader as 'n proses-georiënteerde bestuursbenadering wat beklemtoon: vroeë betrokkenheid, toegang tot voldoende en verstaanbare inligting, genoegsame tyd vir interne beraadslaging, en respek vir kollektiewe besluitnemingstelsels — eerder as 'n enkele prosedurele gebeurtenis.

Konsultasieprosesse moet tegnokratiese of eenslag-benaderings vermy, en eerder aanpasbare en iteratiewe betrokkenheidsmetodes gebruik, soos "Problem-Driven Iterative Adaptation (PDIA)"[20], wat toelaat dat dialoog en onderhandeling oor tyd ontwikkel in reaksie op nuwe bekommernisse, veranderende projekparameters en verskuiwende plaaslike prioriteite.

Die **kapasiteit van plaaslike instellings om betekenisvol aan konsultasie- en onderhandelingsprosesse deel te neem word geïdentifiseer as 'n belangrike kontekstuele beperking.** Beperkte munisipale en gemeenskapsinstellingskapasiteit kan voortsetting, geloofwaardigheid en reaksievermoë in betrokkenheidsprosesse ondermyn. Die versterking van institusionele gereedheid en bestuursvermoë is daarom integraal tot die instandhouding van effektiewe betrokkenheid gedurende beplanning, konstruksie en operasionele fases.

Blok OBM 27: "FPIC" Beginsels

- "**Free**" (Vry): Toestemming moet vrywillig wees en sonder dwang.
- "**Prior**" (Vooraf): Betrokkenheid moet plaasvind voor enige projekbesluite of aktiwiteite begin.
- "**Informed**" (Ingeligde): Gemeenskappe moet volledige, toeganklike en kultureel gepaste inligting ontvang.
- "**Consent**" (Toestemming): Gemeenskappe het die reg om goed te keur of te verwerp, en om toestemming terug te trek.

In geheel is **billike konsultasie en onderhandeling die grondslag vir sosiaal-legitieme, veerkragtige en regverdige ontwikkelingsuitkomste in die Boegoebaai-streek, en moet dit strategies ingebed word in daaropvolgende beplannings-, goedkeurings- en implementeringsfases.**

3.10 Ten slotte

Die bevindinge uit die SOA toon dat hoewel GH_2-ontwikkeling wesenlik kan bydra tot Suid-Afrika se energietransisie en streeks-ekonomiese diversifikasie, die ontvangende omgewing gekenmerk word deur hoë ekologiese, kulturele en sosio-ekonomiese sensitiwiteit. Op ekologiese vlak vorm die Namakwa-streek deel van 'n wêreldbelangrike biodiversiteitsbrandpunt wat buitengewone vlakke van plantendemisme, belangrike habitatte vir bedreigde fauna en landskappe wat as klimaatsverandering-skuilplekke funksioneer, bevat. BAIE HOË en HOË sensitiwiteitsgebiede is wydverspreid, veral langs die kusgordel, bergstelsels en sleutel ekologiese korridors. Ontwikkeling in hierdie gebiede dra 'n wesenlike risiko van onomkeerbare biodiversiteitsverlies en moet daarom waar moontlik vermy word. Alhoewel die meeste van die landskap 'n mate van biodiversiteitsbeperking bevat, bevat slegs 'n kleiner deel van die streek oorvleuelende hoogwaarde-biodiversiteitskenmerke. Dit skep geleenthede vir strategiese ruimtelike beplanning wat ontwikkeling rig na gebiede van relatief laer sensitiwiteit, terwyl kritieke ekologiese hulpbronne beskerm word.

Die Namakwa-streek is 'n uiters waterbeperkte landskap met 'n hoë afhanklikheid van grondwater en beperkte oppervlakwater. Verskeie grondwaterhulpbron-eenhede en strategiese waterbrongebiede is reeds onder druk, en munisipale waterinfrastruktuur is kwesbaar. Sonder deeglike beplanning kan die bykomende watervraag wat met GH_2-ontwikkeling verband hou, bestaande waterskaarste en diensleweringsuitdagings vererger, hoewel beduidende geleenthede bestaan vir die skep van nuwe

[20] 'n Benadering tot beleidsontwerp en implementering wat fokus op die oplossing van plaaslik gedefinieerde probleme deur inkrementele leer en aanpassing, eerder as die toepassing van voorafverpakte oplossings. Toegepas op konsultasie- en onderhandelingsprosesse, erken PDIA dat komplekse, betwiste ontwikkelingskontekste (soos grootskaalse infrastruktuur- en groenwaterstofprogramme) nie deur vaste konsultasiesjablone bestuur kan word nie. In plaas daarvan moet betrokkenheidsprosesse ontwikkel oor tyd in reaksie op opkomende sosiale, institusionele en bestuursuitdagings..

waterbronne deur seewaterontsouting. Erfenis- en kulturele landskappe is ook prominente kenmerke van die streek.

Die Richtersveld Kulturele en Botaniese Landskap-Wêrelderfenisgebied, tesame met talle argeologiese hulpbronne, grafte en histories beduidende mynboulandskappe dra tot 'n sterk plekssin en kulturele identiteit by. Hierdie hulpbronne vereis vroeë identifikasie en vermydingsbeplanning om te verseker dat ontwikkeling erfeniswaarde nie ondermyn nie.

Uit 'n sosio-ekonomiese perspektief toon die streek beide hoë kwesbaarheid en beduidende ontwikkelingsgeleenthede. Voortdurende werkloosheid, ekonomiese herstrukturering ná mynbouverval, beperkte munisipale kapasiteit en bestuurskompleksiteite skep 'n sensitiewe ontwikkelingskonteks. Terselfdertyd kan GH_2-verwante infrastruktuurbeleggings indiensneming, infrastruktuurverbeterings en ekonomiese diversifikasie stimuleer. Die verwesenliking van hierdie voordele sal egter sterk afhanklik wees van doeltreffende bestuur, inklusiewe konsultasieprosesse, en sorgvuldige bestuur van in-migrasie, diensvraag en plaaslike verwagtinge.

'n Toekomstige GH_2-ekonomie in die Noord-Kaap word nie deur 'n enkele omgewings- of sosiale faktor beperk nie, maar deur die kumulatiewe interaksie van ekologiese sensitiwiteit, waterskaarste, institusionele kapasiteit en ruimtelike beplanningsvereistes. Die bevindinge beklemtoon die belangrikheid van strategiese beplanning, vroeë omgewings/sosiale sifting, en sterk bestuursraamwerke om te verseker dat toekomstige ontwikkeling voortgaan op 'n wyse wat sosio-ekonomiese voordele maksimeer terwyl die streek se wêreldbelangrike ekologiese en kulturele erfenis beskerm word.

Vir die omvangryke bevindinge van die SOA om doelmatig toegepas te word, moet beleidmakers verskeie instrumente oorweeg waarmee wetenskaplike bevindings die beste kan rigting gee aan beleidsformulering. **In hierdie geval is verskeie beleidsinstrumente wat 'n streeks-GH_2-ekonomie ondersteun, reeds in die Namakwa-streek in plek:**

- Springbok-**REDZ** (Figuur OBM 7) binne die SOA-WP2-studiegebied, sowel as die Upington-REDZ verder noord, is gepubliseer ingevolge Goewermentskennisgewing (GN) 114, gedateer 16 Februarie 2018.
  Voordele vir grootskaalse hernubare-energieontwikkeling (>20 MW) sluit in: BA-proses in plaas van 'n volledige Omvangsbepaling en OIS-proses, en verkorte besluitnemingstyd op OI-aansoeke van 107 dae tot 57 dae.
- **Elektrisiteitsnetwerkinfrastruktuur-korridors** (GN 113, 16 Februarie 2018) (Figuur OBM 7) binne die SOA-WP2-studiegebied.
  Voordele vir hoëspanning-transmissie en verspreidingsinfrastruktuur (>275 kV): BA-proses i.p.v. 'n volledige Omvangsbepaling en OIS; verkorte besluitnemingstyd van 107 dae tot 57 dae op roeterings vooraf onderhandel met grondeienaars; generiese OMPr beskikbaar; geen OI vereis in Medium/Lae-sensitiwiteitsgebiede nie.
- Die Boegoebaai-hawe en Spoorinfrastruktuurprojek: Noord-Kaap en Boegoebaai Groenwaterstof-ontwikkelingsprogram, aangewys as **Strategiese Geïntegreerde Projekte (SIP)** ingevolge die Wet op Infrastruktuurontwikkeling (GN 812, 24 Julie 2020; GN 2835, 6 Desember 2022).
  Voordele sluit in: verkorte permit-besluitneming van 107 dae tot 57 dae.
- **Gaspyplyn-korridors** (Figuur OBM 7) binne die SOA-WP2-studiegebied, gepubliseer onder GN 836 (31 Julie 2020) met prosedures bevestig onder GN 411 (7 Mei 2021). Voordele vir die grootskaalse vervoer van gevaarlike stowwe per pyplyn (bv. waterstof) sluit in: BA-proses i.p.v. vol OIS; verkorte besluitnemingstyd; generiese OMPr beskikbaar.
- **Son-uitsluitingsnorm** (GN 4558, 27 Maart 2024) wat son-PV-ontwikkeling uitsluit van OI-vereistes waar dit in lae/medium-sensitiwiteitsonderdele volgens die nasionale webgebaseerde screen tool geleë is.

Verdere beleidsaksies om die uitkomste van die SOA te operasionaliseer kan insluit, byvoorbeeld:

1. **Mandaat integrasie van SOA-uitsette in statutêre beplanningsinstrumente soos "SDF's", "IDP's", "EMF's" en biodiversiteitsbeplanning**; aanvaarding van 'n

streeks-biodiversiteitskompensasie-/vergoedingmeganisme wat vir 'n "pooled offset bank" voorsiening maak.

2. **Ontwikkeling van Omgewingsbestuursinstrumente** kragtens Artikel 24(2) van NEMA, insluitend:
    a. Minimum Inligtingsvereistes vir GH_2-ontwikkeling in die Namakwa-streek;
    b. Integrasie van die SOA-studiegebied in die Nasionale Webgebaseerde Screening Tool (ST).
3. **Vestiging van 'n multisfeer Boegoebaai-Interregerings-Stuurkomitee om aanbevelings te bestuur, ontwikkelingstempo te koördineer** en hoofaspekte soos grondtoegang, kompensasies en FPIC-betrokkenheid te belyn.
4. **Implementering van 'n formele FPIC- en Gemeenskaps-Onderhandelingsraamwerk** om sosiale lisensie te verseker en vertraagdes te voorkom.
5. **Gebruik van SOA-bevindinge om toekomstige opdaterings aan die nasionale Ekosisteem-Rooilyste te ondersteun**, deur SANBI in samewerking met die SOA-span en eksterne kenners.

Die SOA moet as 'n lewende strategiese beplanningsinstrument beskou word wat langsaan opkomende GH_2-ekonomie ontvou. Om te verseker dat beplanningsleiding aktueel bly en reageer op veranderende omgewings-, sosiale, ekonomiese en ontwikkelingsomstandighede, word dit aanbeveel dat 'n provinsiale- of streekskaalse SOA, wat op kumulatiewe impakte, streeksontwikkelingstendense en strategiese beplanning fokus, elke vyf jaar onderneem word. Gebaseer op die huidige beoordeling, behoort die volgende hersiening of opdatering in 2031 gedoen te word.

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5. BYLAAG OBM.1: VOLLEDIGE TEMA-SPESIFIEKE BEOORDELINGS VAN RISIKO'S EN GELEENTHEDE

Tema-spesifieke risiko-beoordeling van die impakte oor die basislynscenario (Sc0) en twee GH_2-ontwikkelingscenario's (Sc1 en Sc2). Let wel dié tabel verskyn in oorsponklike Engels.

WATER RESOURCES & AQUATIC ECOLOGY

Chapter	Impact		Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
WATER RESOURCES	Groundwater	Groundwater Availability and Security	S0: Baseline	Very high sensitivity	High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		Very High	High
			S0: Baseline	High sensitivity	Moderate	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Moderate	Very Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
		Groundwater Quality	S0: Baseline	Very high sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Moderate
			S0: Baseline	High sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Low	Low
			S2: Big GH2		Low	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Surface Water Resources		S0: Baseline	Very high sensitivity	Very High	Moderate
			S1: Small GH2		Very High	Moderate
			S2: Big GH2		Very High	Moderate
			S0: Baseline	High sensitivity	High	Low
			S1: Small GH2		High	Low
			S2: Big GH2		High	Low
			S0: Baseline	Medium sensitivity	Moderate	Low
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Low	Very Low
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Inland Aquatic Ecosystems (Rivers, Wetlands and Pans)		S0: Baseline	Very high sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate
	Estuaries (including the Orange River Estuary) and Micro-outlets		S0: Baseline	Very high sensitivity	Low to Moderate	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate

AVIFAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to Habitat loss/ fragmentation/ transformation	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Low	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
Injury or mortality due to collisions with wind turbines, solar panels, powerlines and masts/towers	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate

TERRESTRIALECOLOGY

Biodiversity pattern	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
Ecological process	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate

BATS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Destruction/disturbance of bat roosts	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat foraging habitat loss	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat mortalities	S0: Baseline	Very High	High	N/A
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low

FAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to habitat loss & fragmentation	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
Changes to Ecological functioning and processes	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Paleontological Resources	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Archaeological Resources	S0: Baseline	Very high sensitivity	Very High	High
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Very High	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Medium sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Built Environment	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Moderate	Low
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Moderate	High
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Population Shifts	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	SEZ area	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Pressure on housing and municipal services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Low
	S2: Big GH2		Low	Low
Pressure on health services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		Moderate	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Social ills due to boomtown conditions	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Moderate	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low

SOCIO-ECONOMICS *Cont...*

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S1: Small GH2	Port Nolloth, Alexander Bay	Very High	Moderate
	S2: Big GH2		Very High	High
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Springbok area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	SEZ area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Rural settlements	Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Export Agriculture (includes railway as management option)	S1: Small GH2		Very High	Very Low
	S2: Big GH2		Very High	Very Low
Municipal capacity - technical	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Municipal capacity - political engagement and facilitation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Development Planning Pressure	S0: Baseline	Richtersveld (Primary Receiver)	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Kamiesberg, Nama Khoi, Khai-Ma (Rest Of Region)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	District, Province and National (Incl. Agencies: NCEDA, COGSTA)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		High	Moderate
Settlement Infrastructure Development & Management	S0: Baseline	Richtersveld (Alexander Bay And Port Nolloth)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Nama Khoi (Steinkopf and Springbok Settlement Cluster)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Khai-Ma (Poffadder And Aggeneys)	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Construction of Economic Infrastructure Projects	S0: Baseline	Port & SEZ	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Road Corridor (focus on R382)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Low	Low
	S0: Baseline	Pipeline Corridors	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Rail Corridor	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very High	High
	S0: Baseline	Transmission Corridors	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Green Energy Projects/ Corridors/Sites	Moderate	Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate

Tema-spesifieke geleentheidsbeoordeling van die impakte oor die basislynscenario (Sc0) en twee GH_2-ontwikkelingscenario's (Sc1 en Sc2). Let wel dié tabel verskyn in oorsponklike Engels.

WATER RESOURCES AND AQUATIC ECOLOGY

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Groundwater Availability and Security	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
Surface Water Resources	S0: Baseline	Very high sensitivity	N/A	Moderate
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Medium sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	Very Low
	S1: Small GH2		N/A	Very Low
	S2: Big GH2		N/A	Very Low
Inland aquatic ecosystems and Estuaries:	No positive opportunities identified			

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	High
	S0: Baseline	Springbok area	Moderate	High
	S0: Baseline	SEZ area	Low	Low
	S0: Baseline	Rural settlements	Low	Moderate
Export Agriculture (includes railway as management option)	S0: Baseline	Port Nolloth, Alexander Bay, Orange River	Moderate	High
Job creation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Very High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
Regional broadband roll-out	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	Springbok area	Very Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	SEZ area	Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		Very Low	Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Palaeontological Resources	S0: Baseline	Very high sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	High sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	Medium sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
	S0: Baseline	Low sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
Archaeological Resources	S0: Baseline	Very high sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	High sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Medium sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Low sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Settlement Infrastructure Development	S0: Baseline	Port Nolloth and Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Steinkopf and Springbok cluster	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Pofadder and Aggeneys	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Built Environment	S0: Baseline	Very high sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	High sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	Moderate
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

Werkpakket 2:

Strategiese Omgewings Assessering vir die voorgestelde Boegoebaai hawe, Spesiale Ekonomiese Sone en Namakwa-Streek

OPSOMMING VIR BELEIDMAKERS (OBM)

Outeurs, alfabeties en affiliasie:

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Work Package 2:

Strategic Environmental Assessment for the proposed Boegoebaai Port, Special Economic Zone and Namakwa Region

June 2026

SUMMARY FOR POLICYMAKERS

CSIR

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List of acronyms and abbreviations

CBA	Critical Biodiversity Area
CPA	Community Property Association
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EN	Endangered
EWR	Ecological Water Requirement
FPIC	Free, Prior and Informed Consent
GH_2	Green Hydrogen
GW	Gigawatts
Ha	Hectares
IDPs	Integrated Development Plans
KBA	Key Biodiversity Area
NCEDA	Northern Cape Economic Development, Trade and Investment Promotion Agency
NCGHM	Northern Cape Green Hydrogen Masterplan
PDIA	Problem-Driven Iterative Adaptation
PV	Photovoltaic
RQO	Resource Quality Objectives
SANEDI	South African National Energy Development Institute
SCC	Species of Conservation Concern
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SPM	Summary for Policymakers
PtX	Power-to-X
TNPA	Transnet National Ports Authority
TPC	Thresholds of Potential Concern
TVET	*Technical and Vocational Education and Training*
WP1	Work Package 1
WP2	Work Package 2

1. THE ORIGIN, SCOPE, PURPOSE AND METHODS OF THIS ASSESSMENT

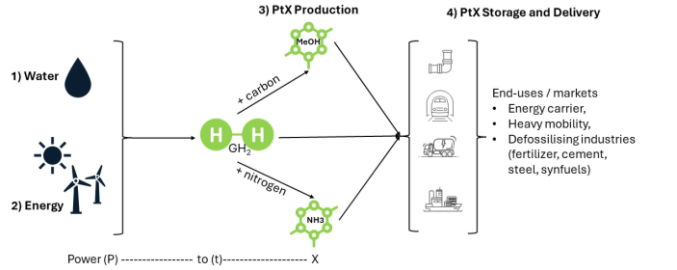
Green[1] hydrogen (GH_2), and its derivative Power-to-X (PtX) products, such as green ammonia and green methanol, could assist South Africa's transition to a low-carbon economy by decarbonising hard-to-abate sectors and catalysing regional development. The Northern Cape Green Hydrogen Masterplan (NCGHM, 2023) proposes that the Northern Cape is well positioned to lead this transition, given its' globally competitive solar and wind resources, large tracts of land, and a 300 km coastline where a deep‑water port at Boegoebaai is being investigated. The province's ambition includes 5 gigawatts (GW) of electrolysers supported by 10 GW of renewables by 2033, scaling to 40 GW of electrolysers by 2050. The realisation of this ambition will require extensive infrastructure development across multiple municipalities and ecosystems, including energy generation sites, transmission corridors, desalination plant/s, and transport networks. These expansive developments could potentially intersect with sensitive ecological systems, heritage landscapes, and socio-economic dynamics across the Namakwa District. For this reason, a Strategic Environmental Assessment (SEA) was initiated through a collaboration between the South African National Energy Development Institute (SANEDI), the Northern Cape Economic Development, Trade and Investment Promotion Agency (NCEDA) and Transnet National Ports Authority (TNPA). The Council for Scientific and Industrial Research (CSIR) was appointed to lead and coordinate an independent SEA process, drawing on established expertise in SEA, renewable energy, port planning and GH_2.

Box SPM 1: What is Green Hydrogen (GH_2) and Power-to-X (PtX) products?

GH_2 is a form of hydrogen fuel produced via electrolysis (i.e., by splitting water into hydrogen and oxygen) using renewable energy sources (e.g., wind/solar). PtX is a broader concept that encompasses various technologies and processes (including GH_2) to convert electrical power, from renewable sources, into different forms of energy carriers, chemicals, or materials. This conversion enables the storage, transportation and use of hydrogen (Power-to-Hydrogen), synthetic fuels (Power-to-Liquid), and even chemicals (Power-to-Chemicals), broadening the scope of renewable energy applications, particularly crucial for industries and sectors where green electrification is challenging, such as heavy- duty transport, maritime shipping, and aviation ('hard-to- abate' sectors).

Infrastructure components and processes required to produce and deliver GH_2 and PtX products to potential end users:

1. **Water** (H_2O) source – desalinated seawater / wastewater produced for the purpose of GH_2/PtX production.
2. **Energy** source – electricity generation through wind / solar PV for the purpose of GH_2/PtX production, battery storage, transmission (Tx).
3. **GH_2/PtX production** – Electrolyser splits $H_2O \rightarrow H_2$ + O to create GH_2. GH_2 can be stored and delivered or further synthesised into green *ammonia* (NH_3) with the addition of nitrogen, or to *methanol* (MeOH) with the addition of sustainably sourced carbon.
4. **GH_2/PtX Storage and Delivery** – storage tanks, trucks, railway, pipeline, and shipping to get the PtX products to market (for export or for use in local industries).



Key components in the GH_2 and PtX development process

[1]. There are many different definitions and perspectives on the concept of "green". Here, we use the term in the narrow sense, meaning a product developed where upstream production facilities are supplied by renewable energy sources.

Box SPM 2: Hydrogen safety risks

Hydrogen can be handled safely, but it requires careful design and management because it is highly flammable, ignites easily, and may burn with a flame that is difficult to see in daylight. Small leaks can spread quickly, accumulate in enclosed spaces, and create fire, explosion or oxygen-displacement risks; some materials may also become brittle in hydrogen service. These risks require project-level hazard assessment, leak detection, ventilation, emergency shutdown systems and disaster-management planning (Leinala, 2024; NFPA, 2026; USDoE, n.d.).

This SEA considers a multi-component, phased programme of large-scale GH_2 and PtX development in the Northern Cape, comprising the proposed Boegoebaai Port, the Boegoebaai Special Economic Zone (SEZ), and regional renewable energy and linear infrastructure. The Boegoebaai Port, in a proposed area of approximately 2 187 hectares (ha), is proposed to be developed in phases.

The short-term phase (**Phase 1A**) includes:

- A two-berth jetty for dry bulk, liquid bulk and multi-purpose cargo, connected to land by an access trestle and sheltered from wave energy by a concrete armoured breakwater.
- Supporting infrastructure includes:
    - closed stockpiles and enclosed warehouses for manganese, lead and zinc;
    - ship loaders, enclosed conveyor systems, and pipelines linking to diesel and ammonia storage tanks;
    - a multi-purpose terminal for containerised and break-bulk cargo, a dig-out Admin Craft Basin, port administration and emergency services buildings;
    - on-site desalination (~1 ML/day) plant, separated stormwater systems, sewer treatment systems;
    - electrical and Information and Communication Technology networks, security systems; and
    - truck staging and access control facilities.

Early operations would rely on the R382 road, serving as the primary route for imports and exports. The projected export volumes by 2033 include ~5 million tonnes per annum (Mtpa) dry bulk (manganese), 1 Mtpa break bulk (lead and zinc), 1.4 Mtpa GH_2 derivatives and various agricultural products (0.2 Mtpa). Diesel imports are expected to reach ~ 1.3 Mtpa.

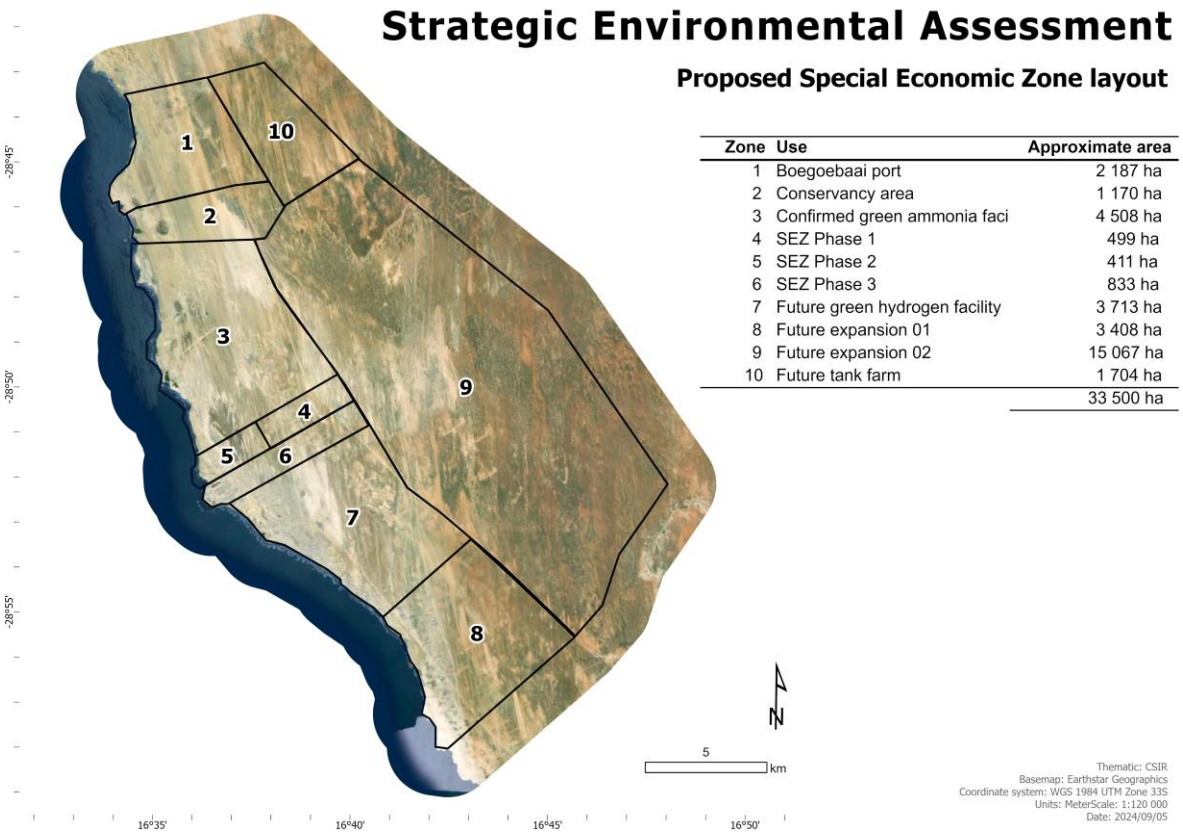
Phase 1B (2035–2050) plans include extending the breakwater, additional liquid bulk and multi-purpose berths, a container terminal, a ship repair yard, expanding stockpiles and enclosed warehouses, and supporting road-over-rail bridges, rail links and tippler facilities. The longer-term vision for the Boegoebaai port (Phase 1B) is designed for flexibility to accommodate future changes in commodities and operations; with continued export of Phase 1A commodities and the potential inclusion of other GH_2 derivatives such as methanol, naphtha and e-kerosene, with total projected export volumes expected to increase to 2.15 Mtpa from 2035 to 2050.

The proposed Boegoebaai SEZ area, encompassing ~33 500 ha (inclusive of the port precinct), plans to

host GH_2/PtX production, manufacturing, logistics and agro-processing. The SEZ area is envisaged to include 10 zones (Figure SPM 1), proposed by policymakers, inclusive of the port area (**Zone 1**) and the conservancy area (**Zone 2**). The **Zone 3** footprint includes the proposed green ammonia facility with ~188 ML/day desalination, electrolysers, ammonia synthesis units, air separation, storage for hydrogen, oxygen and ammonia, and marine discharge of brine from desalinated seawater within acceptable limits. **Zones 4–6** form an Industrial Park including a 2.7 ML/day desalination plant and two SEZ access points. **Zones 7–9** replicate GH_2/ammonia production at future stages, while **Zone 10** provides inland tank-farm storage. Initial SEZ development includes a 5 GW electrolyser build-out by 2030 and related water, storage and pipeline infrastructure.

Box SPM 3: Conservancy Area and Irreplaceable Environmental Features in SEZ

The SEZ area plans to include a conservancy area that has been provisionally delineated based on initial conservation priorities such as the Boegoeberg koppies and seal colony on the Boegoebaai point. WP1 of the SEA provides further recommendations for conservation areas in the proposed SEZ area. A habitat unit known as Swartvygie Heuweltjie Strandveld, located just inland of Boegoebaai, has suffered extensive damage from mining over the past century. The only intact areas are protected by the Buchuberg twins and hardened roads, which prevent sand scour. It is crucial for any port and GH_2 projects to avoid these intact portions and the other priority biodiversity and cultural features, as they cannot be offset. There is also an interesting archaeological site at the proposed development – the Boegoebaai cave/lair.



Zone	Use	Approximate area
1	Boegoebaai port	2 187 ha
2	Conservancy area	1 170 ha
3	Confirmed green ammonia faci	4 508 ha
4	SEZ Phase 1	499 ha
5	SEZ Phase 2	411 ha
6	SEZ Phase 3	833 ha
7	Future green hydrogen facility	3 713 ha
8	Future expansion 01	3 408 ha
9	Future expansion 02	15 067 ha
10	Future tank farm	1 704 ha
		33 500 ha

Figure SPM 1: The port footprint of the proposed Boegoebaai Port and phases of the proposed SEZ (Zones 1 – 10)

Beyond the SEZ, a dispersed renewable energy (RE) network [wind and solar photovoltaic (PV)] would be required to supply electricity to electrolysers, with projects located in reasonable proximity and far from Boegoebaai due to environmental sensitivity and corrosion risks. Electricity will be wheeled via new and existing transmission infrastructure, developed by Independent Power Producers (IPPs) and/or the National Transmission Company of South Africa. Linear infrastructure includes new transmission lines, dedicated hydrogen and ammonia pipelines (Boegoebaai<>Namibia, Boegoebaai<>Saldanha, and

Boegoebaai<>Prieska), a new rail corridor proposed to connect Boegoebaai with Kenhardt, linking into the existing Saldanha–Sishen railway route, and new/upgraded roads to enable efficient transport of GH_2 derivatives, bulk commodities and RE components.

The purpose of the SEA is to guide strategic planning for the proposed infrastructure programme in and around Boegoebaai, as well as the broader Namakwa region of the Northern Cape. Readers must be reminded that the SEA is not a decision-making process in itself, in the same way that, for example, an Environmental Impact Assessment (EIA) is. The purpose of the SEA is to, in a transparent way, guide downstream planning and decision-making processes that may, or may not, occur over many years, if not several decades into the future. Integrating a variety of best practice science-policy processes, SEA should provide an evidence-based, cross-disciplinary perspective on the main opportunities and constraints associated with the proposed port, SEZ and network of regional RE generation facilities (wind and solar PV), electrical grid infrastructure, roads, pipelines and other GH_2 support infrastructure development. Given the multiscale scope of the SEA, its processes and outputs were split between two Work Packages (WPs) (Table SPM 1): WP1 and WP2. Please note that only the findings from Work Package 2 are reported in this Summary for Policymakers (SPM) publication.

Table SPM 1: Summary of the SEA Work Packages across different spatial scales, methods, and data collection practices.

	Work Package 1	Work Package 2
Spatial scale	Local (33 500 ha) covering the extent of the proposed port and SEZ.	Regional (>5 million ha) across four Local Municipalities, including the 33 500 ha extent covered by Work Package 1.
Temporal scale	Introspective, fixed view on currently existing sensitivities in the receiving environments of the proposed port and SEZ.	Expansive, forward looking up to 2050 considering existing land-uses and trends in accumulation to any future regional GH2 infrastructure.
Methods	High resolution determination of receiving environment sensitivity with a view to practicing avoidance (top of the mitigation hierarchy).	Determination of the cumulative social and ecological impacts of a regional expansive GH_2 economy across development scenarios within a structured risk/opportunity framework.
Resolution	Fieldwork, coupled with desktop reviews (peer reviewed and grey literature) and other sources where necessary (e.g., interviews).	Desktop reviews (peer reviewed and grey literature, interviews etc.) and other publicly available data and sources.
Outputs	Local-scale feasibility and planning studies (especially for the new proposed port) and future decision-making processes, like EIAs and other local-scale planning exercises which may occur in the future.	Regional/national planning documents, through processes like Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs) and Environmental Management Frameworks (EMFs), national energy planning and any EIA processes that may be undertaken in the region.

1.1 Work Package 1

For context, WP1 focused on assessing the social and ecological sensitivities of the local-scale receiving environment around the proposed port and SEZ development, covering a spatial scale of approximately 33 500 ha. This was undertaken with the intention of informing local-scale feasibility and planning studies (particularly for the proposed port) and to guide future decision-making processes, including EIAs and other planning processes related to the port and SEZ. The social and ecological themes considered in the WP1 assessment include marine ecology, terrestrial and aquatic ecology, biodiversity offsets, heritage,

sustainable port planning, and fisheries and coastal livelihoods impacts. WP1 SEA outputs were concluded in December 2025, available at: Individual Chapters | CSIR[2].

The WP1 assessment highlighted several important environmental and social constraints within the proposed port and SEZ footprint that are critical for informing strategic planning. These include the sensitivity of coastal and terrestrial ecosystems, the importance of breakwater positioning and port precinct and SEZ layout in avoiding high-value habitats, the need to prioritise already disturbed areas where feasible, and the potential implications for coastal livelihoods such as small-scale fisheries. **These local-scale findings and recommendations (Box SPM 4) should be considered in conjunction with the broader regional findings and recommendations from WP2** when guiding planning and decision-making for port, SEZ and GH_2-related infrastructure development in the Namakwa region.

Box SPM 4: Key recommendations from WP 1

Recommendations - strategic planning:

1. Place the harbour breakwater so as to avoid sensitive Cape fur seal breeding colonies and rocky sea cliffs. The technical feasibility (e.g. regarding sea depth) of the harbour placement should of course be investigated and determined.
2. Place infrastructure in already disturbed areas, and avoid Very High and High sensitive areas – current estimates indicate that there could still be (more than) enough space to place infrastructure in already disturbed areas.
3. Manage shifting / wind-blown sands which present widespread ecological, social and engineering challenges.
4. Consider a strategic biodiversity offset framework, where specific areas, e.g. east of the R382, around the Holgat River and along the Orange River, are set aside as target areas for long-term conservation.
5. Commence environmental monitoring early, before development takes place, to enrich data in this isolated area.
6. Plan for a sustainable port, balancing economic growth, environmental protection and quality, and social development.
7. Establish and implement a comprehensive, transparent and ongoing consultation plan, from the earliest project planning and management phases. Aimed at fair consultation and negotiations (incl. ”Free, Prior & Informed Consent (FPIC)” principles).

Recommendations – impact management

1. Prioritize diligent, proactive and best practice planning and EIA processes.
2. Avoid sensitive ecological and cultural areas, as identified in the SEA, and further confirmed through fine-scale investigation during project-specific EIA.
3. Consult with local communities, including fishers and herders, regarding areas and practices that are important to culture and livelihoods, as well as to establish mechanisms for coexistence.
4. Invest in local skills development.

[2] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/individual-chapters

1.2 Work Package 2

WP2 (the focus of this SPM) provides a more strategic, region-wide assessment of the cumulative social, economic, and ecological implications of an expansive GH_2 economy in the Northern Cape, extending beyond the localised footprint considered in WP1. The spatial scale of WP2 covers parts of the Namakwa District, delineated by the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities.

Box SPM 5: The contents of Work Package 2

WP2 represents a collaborative scientific effort, comprising of seven chapters developed by a team of thirty-four authors, peer-reviewed by thirteen independent experts. The content has also been enriched by contributions from a diversity of stakeholders engaged in the process via a formally constituted Working Group.

The WP2 chapters are as follows:

1. Introduction and context (Mqokeli et al., 2026)
2. Ecology, biodiversity and conservation planning (Desmet and Venter, 2026)
3. Biodiversity offset (Botha, 2026)
4. Water resources and aquatic ecology (Day et al., 2026)
5. Heritage (Orton et al., 2025)
6. Infrastructure and planning (Maritz et al., 2026)
7. Socio-economics (Atkinson et al., 2026)

The regional scope enables the identification and evaluation of systemic risks and opportunities that may not be apparent at the individual project level, providing a robust evidence base to support decision-making across multiple governance and planning frameworks. WP2 aims to guide local and regional planning, through processes like Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs) and Environmental Management Frameworks (EMFs), including any EIA processes that may be undertaken in the region. The strategic issues covered in WP2 include ecology, biodiversity and conservation planning (including biodiversity offsets), water resources and aquatic ecology, heritage, infrastructure and planning, and socio-economic impacts.

1.2.1 Scenarios

A key gap in the current knowledge and decision-making base regarding GH_2 development in the Northern Cape is the absence of an integrated, cumulative, long-term understanding of what a medium- to large-scale GH_2 economy might entail. To address this, the WP2 SEA adopts an interdisciplinary, scenario-based assessment designed to explore both the scale and implications of GH_2 development in the region.

This scenarios assessment serves two main purposes:

1. To provide a concrete representation of what a large Northern Cape GH_2 economy could look like, in terms of the nature, scale, and spatial footprint of infrastructure and development.

2. To estimate the potential cumulative positive and negative impacts of GH_2 development and identify strategies to enhance benefits and mitigate adverse effects.

Two development scenarios are considered in the WP2 assessment, each compared to, and on top, the Scenario 0 dynamic baseline (i.e., where no GH_2 development occurs). The scenarios are summarized further below:

Box SPM 6: Scenario 0 (Dynamic Baseline)

Scenario 0 (Dynamic Baseline) does not represent a static "no development" future. Rather, it represents the environmental and socio-economic conditions expected to occur between 2023 and 2050 in the absence of the proposed Boegoebaai Port, SEZ and regional GH_2 economy. It includes ongoing and anticipated regional development trends such as mining and prospecting activities, renewable energy development within

- **Scenario 0 (Dynamic Baseline, 2023–2050): No GH_2, no port, no SEZ**. Regional change continues via climate variability, ongoing development activities and proposals (Figure SPM 2), land-use pressures, biodiversity loss, water scarcity, municipal capacity and market dynamics. This reference case is used to assess additional effects in Scenarios 1–2.

established Renewable Energy Development Zones (REDZs), associated electricity grid expansion, climate change impacts, demographic change, major development initiatives and other existing development pressures. Consequently, cumulative impacts associated with these activities, including impacts to avifauna arising from renewable energy and grid infrastructure development, form part of the baseline against which the additional impacts of the GH_2 development scenarios (Scenarios 1 and 2) are assessed.

- **Scenario 1 – "Small GH_2" (by 2030)**: **5 GW** electrolysis, **10 GW** renewables (**~60% solar/40% wind**), Phase 1A port functions, SEZ Phase 1 (including green ammonia), first linear pipeline/rail/powerline links.
- **Scenario 2 – "Big GH_2" (by 2050)**: **40 GW** electrolysis, **80 GW** renewables (**~60%/40% solar/wind**), expanded port (Phase 1B elements), SEZ replication zones, extended pipelines/rail/powerlines.

Scenario quantifications include estimated indicative footprints for electrolysers, GH_2/ammonia storage, desalination outputs (e.g., Sc1 ~ 35.7 ML/day for GH_2 production; Sc2 ~ 285.7 ML/day) and brine discharges, plus the lengths/servitudes of roads, rail, pipelines and powerlines.

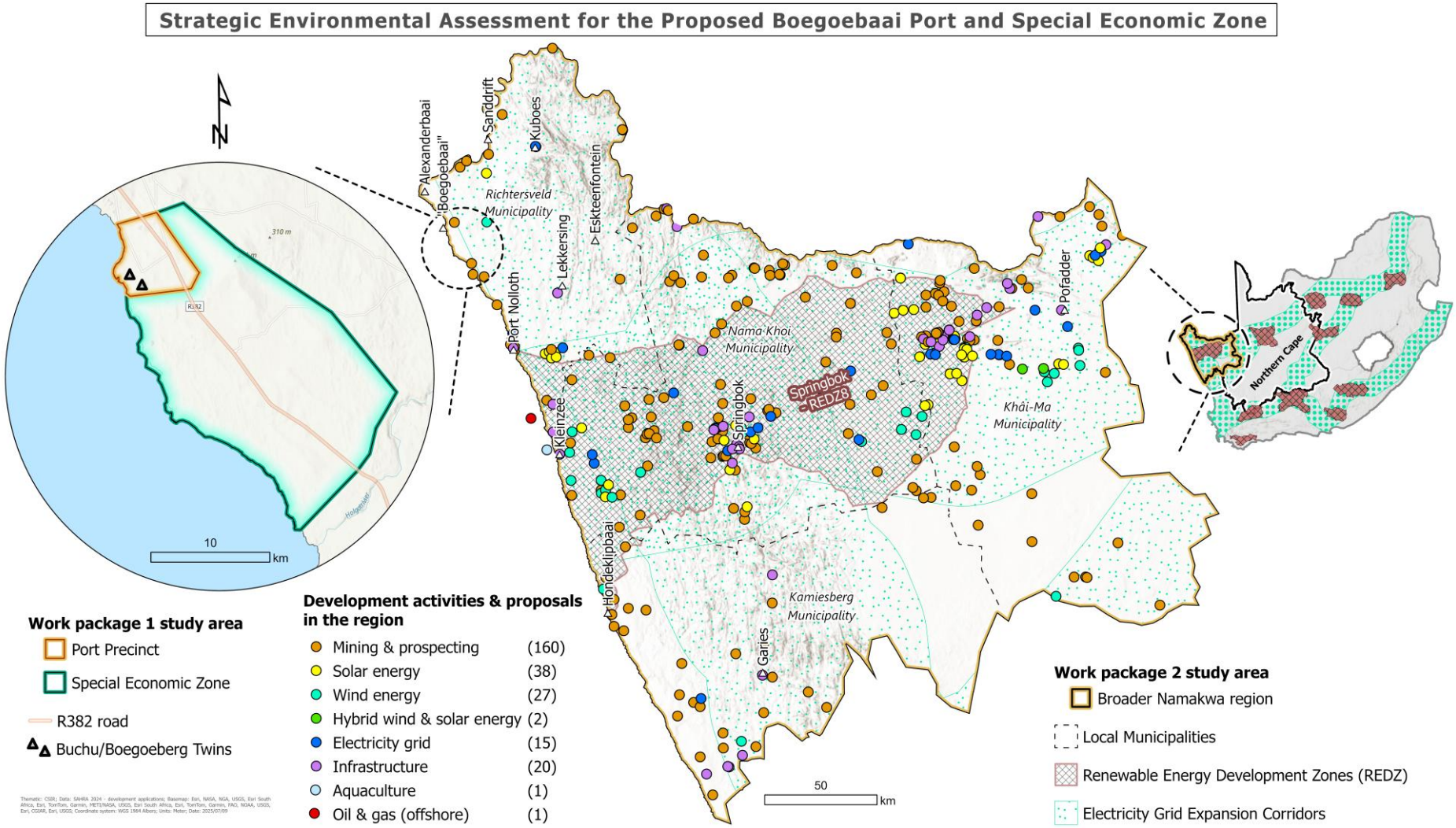


Figure SPM 2: The proposed Boegoebaai port and SEZ (WP1 study area) and Namakwa region study area (WP2 study area) in the Namakwa District of the Northern Cape Province. Economic activities include widespread mining and prospecting. A renewable energy sector is also emerging with established Renewable Energy Development Zones (REDZ) and Electricity Grid Infrastructure (EGI) Corridors. These ongoing and emerging development trends exist and continue regardless of new port, SEZ and GH2 development materialising, and form part of Scenario 0 (Dynamic Baseline, 2023–2050) considered in the WP2 SEA.

1.3 Multi-author Team Model in the SEA

The SEA adopted a multi-author team[3] model to integrate specialist expertise for both Work Packages. The teams developed peer reviewed reports, with the WP1 teams focusing on identifying the key sensitivities and impacts associated with the port and SEZ development, and the Work Package teams undertook a broader, strategic assessment of cumulative risks and opportunities across the region. The writing teams collaborated closely throughout the SEA process to ensure comprehensive coverage of all salient issues across the two WPs. The findings from WP2 are summarised in Section 2 of this SPM, and the content has also been enriched by contributions from a diversity of stakeholders engaged in the process via a formally constituted Working Group (Box SPM 7).

Box SPM 7: The SEA Working Group

To ensure that the SEA process is informed by a broad spectrum of expertise and perspectives, an interdisciplinary Working Group has been established. This multi-sectoral team comprises experts drawn from national, provincial, and local government departments, state agencies, academic and research institutions, non-governmental and community-based organisations, as well as industry and the private sector. The Working Group serves two key functions:

1. Providing expert input throughout the SEA to ensure the assessment is informed by robust and context-specific knowledge; and
2. Acting as an information conduit, enabling two-way communication between members' constituencies and the SEA team, thereby supporting transparency, inclusive engagement, and consistent information sharing across sectors.

1.4 Stakeholder Engagement

Stakeholder engagement is a central component of the SEA for the Boegoebaai Port, SEZ, and regional infrastructure development, and forms a core process element for both WP1 and WP2. It is being implemented through a structured, multi-channel participation programme that has included the dissemination of accessible information via the SEA website[4], local notices and posters, newspaper adverts, radio interviews, and formal Working Group meetings. Public meetings and multiple Working Group sessions have also been held to present and discuss the SEA process and emerging draft findings, including local public sessions across eight locations in the Richtersveld and surrounding areas for WP1, alongside the formal public review of the draft WP1 chapters. A similar approach has been undertaken for Work Package 2, comprising Working Group engagements to present and discuss the draft specialist findings and the currently underway formal public review period for the WP2 chapters (including the content of this SPM and associated chapters) supported by public meetings to be held in the affected municipalities within the Namakwa region.

[3] A multi-author team, in the context of SEA refers to a structured, pluralistic authorship model designed to integrate diverse perspectives and expertise across an assessment process. For the Boegoebaai SEA, multi-author teams were constituted through a consultative process with the Working Group (which included representatives from government, academia, NGOs, and other stakeholders) to nominate researchers who possess the required niche knowledge of this remote region, along with an understanding of strategic infrastructure impacts, academic credibility, and expertise in high-level strategic assessments.

[4] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/strategic-environmental-assessment/boegoebaai-port

2. KEY FINDINGS FROM WORK PACKAGE 2

The following sections synthesise the key findings from the independent, peer reviewed specialist chapters of WP2, highlighting the regional-scale overview, sensitivities of the receiving environment (Table SPM 2Figure SPM 4), risks and opportunities in relation to a potential future GH_2 economy.

Table SPM 2: Calibration of sensitivity categories for receiving environments across the study area.

Category	Description
VERY HIGH	Highly vulnerable to disturbance with little/no capacity for recovery. Includes endangered species, critical habitats, heritage/social resources, or ecosystems with very narrow tolerances for change.
HIGH	Sensitive to ecological and social change but with better recovery potential. Lower concentrations of endangered species, critical habitats, heritage resources, or ecosystems with some tolerance for change.
MODERATE	Some resilience to stress or change. Systems can absorb moderate impacts without long-term harm, or irreversible loss. Includes adaptable species, less valuable social/cultural resources and moderately sensitive habitats.
LOW	Likely already severely degraded by past disturbance, or higher adaptive resilience and low vulnerability. Includes widespread social resources, ecosystems or species with broad ecological niches and high regenerative capacity.

2.1 The Sensitivity of the Receiving Environment

2.1.1 Regional Ecology (after Desmet and Venter, 2026)

The Namakwa region is internationally recognised as a global biodiversity hotspot and represents a priority focus area for biodiversity conservation. It encompasses five of South Africa's biomes (Box SPM 8), dominated by the Succulent Karoo and Nama Karoo, and smaller extents of the Desert, Fynbos and Azonal biomes also present. The central and western parts of the study area form part of the Succulent Karoo biome of the Richtersveld, Namaqualand, the world's most species-rich arid region, with exceptionally high levels of plant endemism and diversity.

Box SPM 8: What Are Biomes?

Biomes are broad ecological units characterised by specific climate conditions, vegetation types, and associated fauna. South Africa comprises of nine major biomes, including Grasslands, Fynbos, Savanna, Nama Karoo, Succulent Karoo, Desert, Albany Thicket, Indian Ocean Coastal Belt, and Forests, and a tenth group of Azonal vegetation (vegetation that crosses climatic and geographic boundaries). Biomes are defined based on the plants and animals that inhabit that area, influenced by factors such as climate (temperature and precipitation), soil type and topography.

Across the Namakwa Region, biodiversity and ecosystems are already under pressure from a combination of drivers, including, but not limited to, widespread livestock grazing, historic and current mining activity, the anticipated growth of mineral sands extraction, and the rapid rollout of solar and wind energy (and associated linear infrastructure) to meet the current and future energy demands. Poaching of biodiversity is considered the most important threat currently facing biodiversity in the region, contributing to real-time population declines in species of conservation concern, including rare and endemic species. These pressures have resulted, or may result, in the degradation and loss of the natural environments, with implications for the region's ability to achieve sustainable development. Assessing the impacts of proposed developments therefore requires an understanding of the current state of biodiversity, the key anthropogenic pressures influencing ecological trends, and the ways in which new developments may interact with or exacerbate these pressures.

Overlaying these pressures is climate change, which emerges as the most significant (short-, medium- and long-term) threat to biodiversity in the region. Long-term vegetation productivity trend analyses show widespread "browning" of vegetation across much of the region, particularly in the Richtersveld. Based on these trends, approximately 62-65% of the 71 vegetation types in the region now qualify as threatened ecosystems under Red List of Ecosystems criteria, underscoring the urgency of proactive conservation planning (Box SPM 9).

Box SPM 9: Climate Change, Grazing Pressure and Vegetation Resilience in Namaqualand

Vegetation trends across Namaqualand show clear climate-driven declines, especially in the northwest, but different ecosystems respond differently depending on their underlying ecological characteristics. The vegetation analysis also reveals that land use, particularly livestock grazing, strongly intensifies these climate impacts, while lightly grazed protected areas remain more stable. Managing grazing pressure is therefore considered one of the most effective climate-adaptation actions available, and expanding well-managed protected areas will be essential for strengthening ecosystem resilience across the region.

Fewer than one-third (28%) of the region's ecosystems are considered well protected, while two-thirds (66%) are poorly or not protected at all. At the same time, more than 70% of the region has already been identified in protected area expansion strategies, reflecting its national significance for achieving South Africa's 30×30 conservation targets[5]. This further highlights the need for any large-scale development in the region, including GH_2-related infrastructure, to be carefully aligned with biodiversity priorities to avoid undermining long-term conservation objectives.

The avifaunal (birds) assessment identifies extensive VERY HIGH and HIGH avifaunal sensitivity zones across the Namakwa Region, particularly in relation to wind farm related impacts. These risk patterns are driven by (i) irreplaceable habitats in and around Key Biodiversity Areas (KBAs) (Box SPM 10) and protected areas, and (ii) the presence of 44 priority[6] bird species, including threatened, endemic and range-restricted species. Avifaunal sensitivity classifications **(LOW, MEDIUM, HIGH, VERY HIGH)** across the region are informed by a combination of conservation weighting (i.e., Red List Status, endemism, range size), habitat suitability, and susceptibility to four primary avifaunal impact pathways relevant to a GH_2-related development footprints: disturbance-driven displacement, habitat loss/fragmentation, collisions with wind turbines and powerlines, and electrocutions on electrical infrastructure.

Box SPM 10: What Are Key Biodiversity Areas (KBAs)?

KBAs are 'sites that contribute significantly to the global persistence of biodiversity', which means they are the most important places in the world for species and their habitats – whether these be in terrestrial, freshwater, estuarine, or marine ecosystems. Sites qualify as global KBAs if they meet the specific standardised criteria and quantitative thresholds focused on one or more of five trigger aspects: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability through quantitative analysis. The Namakwa Region includes 15 KBAs (see Figure 3 of Chapter 2a – Avifauna).

[5] South Africa's 30×30 conservation target commits the country to effectively protecting at least 30% of its terrestrial, inland water, and coastal and marine areas by 2030, aligning with the Global Biodiversity Framework.

[6] Priority species were defined as species that are particularly sensitive to displacement due to disturbance and/or habitat loss, as well as risk of collisions and electrocutions; endemic and near-endemic species; all SCC; waterbirds; raptors; and range restricted species.

For bats, sensitivity zones are based on the relative importance of landscapes for bat roosting, foraging and conservation value. **VERY HIGH** sensitivity areas are effectively "no-go" at the strategic level, particularly for wind energy development, and are attributed primarily to open water sources and perennial rivers, wetlands, the coastline, protected areas and known bat roosts, all of which are important for bat activity by providing moisture, water, insect or fruit sources. Roosts are particularly important due the potential for large-scale impacts on bat populations. **HIGH** sensitivity zones are associated with limestone geology because of its potential to contain undiscovered cave systems (high roosting potential), and less substantial aquatic features. **MEDIUM** sensitivity is linked to non-perennial watercourses where seasonal moisture can elevate insect abundance and attract foraging bats. **LOW** sensitivity covers the remaining areas lacking these key features (i.e., with limited roosting and foraging potential), and is generally more compatible with development, subject to site confirmation at EIA stage. Two additional zones, namely Roost Investigation and Roost Caution zones (**Figure SPM 7e**), are identified around known bat roosts, representing areas that may be used extensively by bats and therefore require careful consideration, and where field verification becomes critical.

Box SPM 11: Importance of Bats in Ecosystems

Bats are an important component of biodiversity and provide key ecosystem services. Most South African bats are insectivorous and consume large quantities of insects, contributing to natural pest control. Other species play roles in pollination and seed dispersal, supporting vegetation regeneration and ecosystem functioning. Bats are also regarded as keystone species in cave ecosystems, where their guano supports specialised cave-dwelling organisms. In addition, bats can serve as ecological indicators of ecosystem health. However, bat populations are vulnerable to disturbance, habitat loss, and infrastructure such as wind turbines, and their low reproductive rates limit their ability to recover from large-scale impacts.

The faunal assessment maps the Namakwa Region into VERY HIGH, HIGH and MEDIUM sensitivity (with a gradient from coast to inland) based on the intersection of exceptional endemism, highly specialised habitat requirements, and intensifying development pressures typical of the Succulent Karoo biodiversity hotspot. **VERY HIGH** sensitivity is concentrated along the coastal dune belt and lower Orange River corridor, reflecting core habitats for narrowly endemic and Red-Listed fauna, particularly dune-dependent mammals and fossorial amphibians, including De Winton's Golden Mole (CR), Grant's Golden Mole (VU), Namaqua Dune Mole-rat (uplisted to EN), Desert Rain Frog (VU) and the micro-endemic Branch's Rain Frog[7]. Development in these areas is regarded as having a high probability of irreversible biodiversity loss and should be treated as "no-go/strict avoidance" zones unless exceptional justification exists. **HIGH** sensitivity extends inland across Namaqualand Hardeveld, succulent shrublands and rocky inselbergs where irreplaceable microhabitats (koppies/outcrops) and key ecological processes occur, driven by species such as the Speckled Padloper (EN), range-restricted girdled lizards, and amphibians associated with ephemeral pools and drainage lines, alongside pollination and soil-engineering processes. **MEDIUM** sensitivity covers broader inland plains that still support significant faunal diversity but are dominated by more disturbance-tolerant species assemblages; development may be feasible here subject to careful siting, maintenance of corridors, and project-level verification.

[7] Known only from red sands near the Holgat River. Although the precise range remains unconfirmed, the species is strongly associated with the northern coastal duneveld also classified as Very High Sensitivity.

The integrated biodiversity sensitivity analysis (Box SPM 12)**, drawing on existing biodiversity planning informants and specific biodiversity sensitivities developed as part of the SEA, identifies extensive areas of HIGH to VERY HIGH sensitivity across the Namakwa region. VERY HIGH** sensitivity areas comprise protected areas and other irreplaceable biodiversity features that underpin biodiversity pattern, ecological processes and climate-refugia functions. These landscapes support rare, endemic, and threatened species, and have no ecologically equivalent alternatives. Development in these areas would pose significant and often irreversible risks or impacts to biodiversity, with limited scope for effective mitigation or offsetting. Accordingly, it is strongly recommended that these areas should be avoided and kept intact as anchors for connectivity and climate resilience.

Box SPM 12: How the Integrated Biodiversity Sensitivity Analysis Was Produced

The WP2 regional biodiversity sensitivity analysis integrates six biodiversity informant groups onto a four-categories sensitivity scale (LOW, MEDIUM, HIGH, VERY HIGH). These informants include: (1) biodiversity planning datasets [Critical Biodiversity Area (CBA) maps, expert-mapped priority areas, ecological corridors, and plant species locality records]; (2) protected area expansion priorities; and WP2 SEA specialist sensitivity layers for (3) birds, (4) bats, (5) terrestrial fauna, and (6) aquatic ecosystems. Each layer was standardised to the same sensitivity classes and combined using two approaches:

- a **maximum-of-inputs** approach reflecting the highest sensitivity score present at a site; and
- a **cumulation-of-inputs** synthesis reflecting how many inputs identify a location as sensitive, producing a more finely resolved map of cumulative biodiversity sensitivity.

The resulting integrated map provides a strategic, regional-scale screening tool to highlight where biodiversity constraints are likely and where planning flexibility is greater. It does not replace site-level specialist studies or project-specific EIAs.

HIGH sensitivity areas are essential to meeting conservation targets and maintaining key ecological processes across the landscape. Development in these areas is generally undesirable and should be avoided wherever feasible. Where impacts are demonstrably unavoidable, following the full application of the mitigation hierarchy, only strictly controlled, like-for-like biodiversity offsets may be considered. Such offsets should be directed to ecologically equivalent sites within the same planning domain, with the explicit recognition that certain biodiversity features are not fully offsetable and that residual ecological risk may remain significant. **MEDIUM** sensitivity areas support ecological functionality and local-scale connectivity, including seasonal movement pathways and ecological buffer zones that help maintain the resilience of adjacent **HIGH** and **VERY HIGH** sensitivity landscapes. While these landscapes may accommodate some development, impacts remain possible and development proposals must be carefully sited and designed to maintain ecological flows, movement routes and key microhabitats, applying robust baseline screening, the mitigation hierarchy and best-practice construction and operational controls. **LOW** sensitivity areas occur predominantly in more homogeneous parts of the landscape where biodiversity features are less concentrated, ecosystem threat status is lower, and fewer spatial priorities overlap. These areas often include more resilient vegetation types or previously disturbed land, presenting comparatively lower conservation constraints and are therefore the preferred focus for directing new infrastructure, subject to confirmatory screening and good practice.

Overall, the integrated maximum inputs sensitivity analysis shows that at least 70% of the Namakwa Region is characterised by HIGH to VERY HIGH biodiversity sensitivity. This reflects its status as a global biodiversity hotspot, where ecologically important features are widespread and rarely absent. At the same time, the cumulative-inputs view reveals that only about 11.5% of the region is Very High sensitivity for three or more biodiversity inputs, indicating limited spatial overlap among taxa and ecological drivers. This means that while most of the landscape contains some form of biodiversity constraint, only a relatively small proportion contains multiple, co-occurring high-value sensitivities. From a development-planning perspective, this distinction is important, as areas classified as **VERY HIGH** for only one input may offer comparatively greater flexibility, subject to site-level assessment, than areas where several biodiversity priorities converge, and where the scope for acceptable impact or effective mitigation is substantially lower.

2.1.2 Water Resources and Aquatic Ecology (after Day et al., 2026)

The Namakwa Region is an extremely water-limited landscape, defined by Hyper-Arid or Arid conditions, very low rainfall (60-215 mm/annum), high evaporation rates and a high dependence on groundwater. Surface water resources are very limited and mostly comprise ephemeral streams and sporadic runoff events, with the Orange River being the only perennial surface water source in the area. Other rivers are seasonal to ephemeral[8], and although wetlands and pans occur in places, surface water remains spatially and temporally sparse.

Box SPM 13: Strategic Water Source Areas (SWSAs)

Strategic Water Source Areas (SWSAs) are defined as areas of land that either: (1) supply a disproportionately large quantity of mean annual surface water runoff in relation to their size and are therefore, considered nationally important; or (2) have high groundwater recharge and where groundwater forms a nationally important resource; or (3) areas that meet both criteria (1) and (2). SWSA aquifers sustain baseflow, contribute to runoff and, especially, contribute to dry season flows.

Groundwater recharge is generally low and water quality is relatively poor[9]. Groundwater occurs in sandy/alluvial aquifers, weathered zones (regolith), and fractured crystalline bedrock, which are hydraulically interconnected. However, the granite and gneissic bedrock has low primary porosity, with groundwater stored and transmitted mainly through fractures, resulting in generally low and variable hydraulic conductivities. Given the high reliance of communities on groundwater, several Groundwater Resource Units (GRUs)[10] have been identified as intermediate and high priority, and three identified Strategic Water Source Areas (Box SPM 13) (**Port Nolloth**, **Kommagas** and **Kamiesberg**) have been further classified as areas of **VERY HIGH** sensitivity (Figure SPM 3).

[8] Ephemeral rivers flow only after rainfall events and remain dry for most of the year, making them highly sensitive to disturbance and changes in hydrology.
[9] Groundwater recharge is generally 0.1–10 mm/a; electrical conductivity ranges from 70 to >1 000 mS/m.
[10] Most of the GRUs have been delineated in the Lower Orange WMA. A GRU, classified as a groundwater body that has been delineated or grouped into a single significant water resource, is based on one or more characteristics that are similar across that unit.

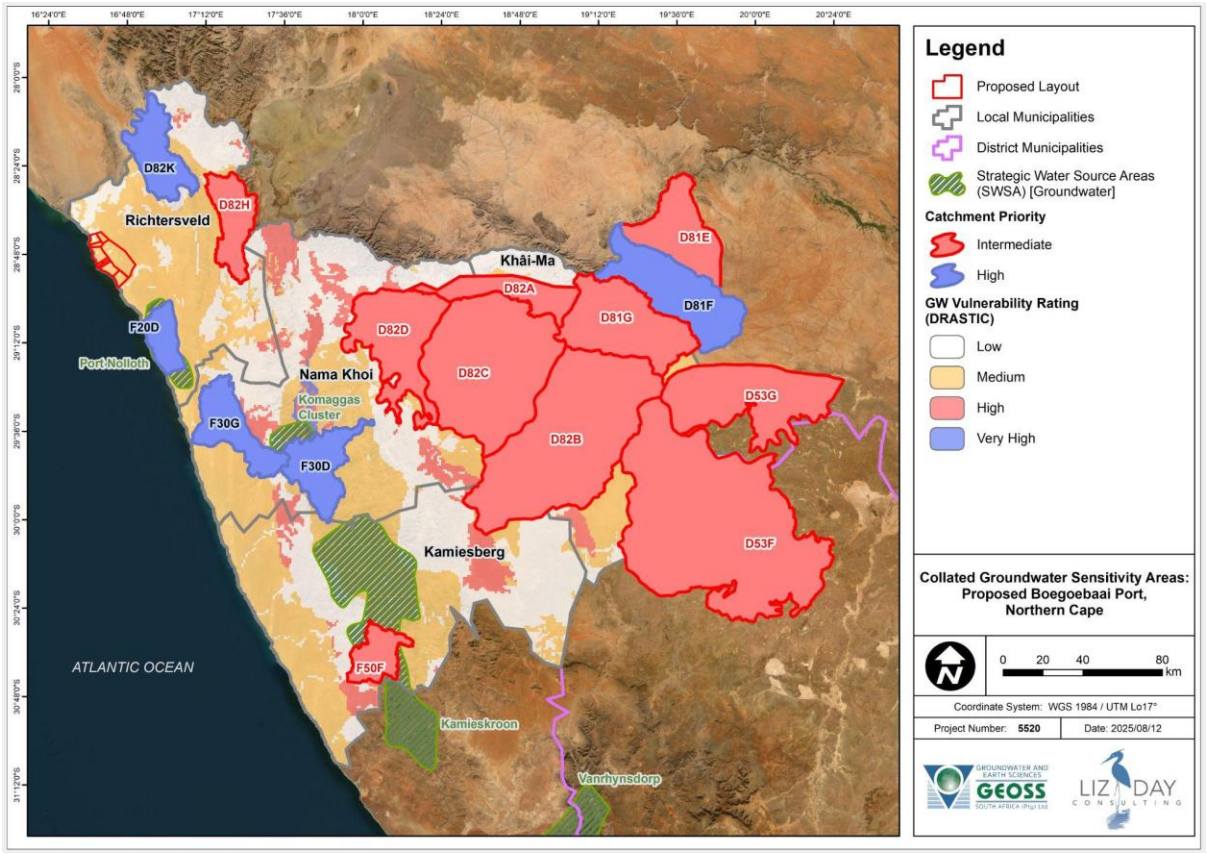


Figure SPM 3: Intermediate and high priority Groundwater Resource Units (GRUs) in the greater Namakwa Region, Northern Cape

Surface water resources in the interior are limited, with runoff occurring less than 10% of the time with long dry periods between events. The Orange River system yields less than its design demand, and approximately 18% of the study area is likely to change from Arid to Hyper-Arid in the near future[11]. Proposed new and expanded abstraction and reticulation systems are considered **EXTREMELY sensitive** to poor management and maintenance, as they represent the only viable water supply for much of the region. In addition, the very low frequency of runoff events and the long dry periods render rivers and floodplains highly sensitive, with limited ability to recover from disturbance for several decades, if at all.

Aquatic ecosystems in the region, including ephemeral rivers, pans, seasonal and perennial wetlands, are of high ecological importance but extremely sensitive to changes in hydroperiod, physical disturbance, water quality degradation, and fragmentation. Many of these inland aquatic ecosystems are classified as **Critically Endangered**[12] or **Endangered**[13], and even subtle changes in hydrology (such as shorter inundation periods or nutrient enrichment from malfunctioning WWTWs) could cause irreversible ecological loss, especially for the specialised invertebrate communities adapted to transient water conditions. Wetlands are limited, although some areas such as Kamiesberg area contain important seasonal and perennial wetlands. Pans are the most common aquatic ecosystem type, with many of these pans classified as **Critically Endangered** or **Endangered** depending on their bioregion.

The Orange River Estuary, an internationally recognised Ramsar site, is the largest and most ecologically important estuary in the region. In addition, the study area includes four smaller Cool Temperate Arid Predominantly Closed (CTAPC) estuaries, the Buffels, Swartlintjies, Spoeg and Groen estuaries. Most rivers are in **good ecological condition** [Present Ecological State (PES) Categories B/C][14] except the Kwaganap, Bitter and parts of the Groen River. The Orange River Estuary and the four CTAPC estuaries in the study area are all rated as **Endangered** systems, of **high conservation priority**.

[11] Approximately 18% of the study area is projected to shift from Arid to Hyper-Arid conditions.
[12] Ecosystem at **extremely high** risk of extinction or collapse.
[13] Ecosystem at **very high** risk of collapse.
[14] Rivers in good ecological condition.

From a water demand perspective, and the potential for pollution of existing water supplies, existing water and wastewater treatment works (WWTW) and distribution infrastructure are noted as generally underperforming and in need of urgent upgrades. The Department of Water and Sanitation (DWS) information indicates that the District Municipality is already under significant water supply pressure, and any additional demand could significantly worsen pressures on water services.

Across groundwater, surface water, and aquatic ecosystems, the sensitivity mapping reveals extensive areas of **VERY HIGH** and **HIGH** Sensitivity, where development could lead to irreversible degradation.

2.1.3 Heritage Resources (after Orton et al., 2026)

Palaeontological[15] **sensitivity** is **ZERO** or **LOW** for most of the area, with **MODERATE** sensitivity in the east and **HIGH** sensitivity in the mountains northwest of Springbok and in the southeast part of the study area. In general, the surficial sediments of the coastal plain are of **LOW** sensitivity with more highly significant deposits present at depth close to the coast and below 100 m above sea level.

Box SPM 14: Heritage Resources Legislative Context

The National Heritage Resources Act (NHRA) (Act 25 of 1999) protects a wide range of heritage resources, including archaeological and palaeontological material, graves, cultural landscapes, and living heritage - requiring their consideration in all development planning. Under Section 38 of the NHRA, most GH_2-related infrastructure will trigger a Heritage Impact Assessment, as linear developments longer than 300 m and disturbances exceeding 5,000 m^2 fall within statutory thresholds. This means early heritage screening, avoidance planning, and engagement with heritage authorities are essential for compliant and responsible development in the region.

The region contains archaeological resources spanning Early, Middle and Later Stone Ages, with the coastline identified as an area of HIGH archaeological sensitivity due to the high density of sites. Terrestrial archaeological resources include Early Stone Age (ESA) material beneath the surface aeolian sands along the coastal plain and among the gravels of Bushmanland; Middle Stone Age (MSA) material recorded both along the coastline and in rare inland rock shelters such as Spitzkloof and in the basal layers of Wolfkraal cave and Keurbos Cave in the Kamiesberg; and abundant Later Stone Age (LSA) sites, occurring both along the coast and inland around deflation hollows in dunefields, rocky hills and pans in Bushmanland. Rock paintings are rare; with geometric rock engravings occurring along the Orange River. Historical archaeological remains, including those relating to the Anglo-Boer War, are found around old farmhouses, permanent or temporary settlement, copper mining areas, and prospecting locations.

Pre-colonial graves, while rare and highly localised, are automatically of VERY HIGH heritage sensitivity when encountered. Pre-colonial graves may be encountered across the study area and are more commonly associated with coastal dune contexts and areas of historically higher population density. Several graves are present in the region, including three known graves at the western foot of Boegoeberg South (refer to WP1). Most pre-colonial graves are unmarked and cannot be identified until disturbed, although rare stone-packed graves occur and are likely to represent very late/historical graves. While graves have high local cultural significance (Grade IIIA) and are automatically of **VERY HIGH** sensitivity when encountered, recorded occurrences in Namaqualand and Bushmanland are rare, highly localised, and generally unmarked, making spatial sensitivity mapping impractical.

Maritime heritage sensitivity is assessed as generally LOW along most of the coastline, with localised MEDIUM sensitivity zones associated with recorded and potential shipwrecks. MEDIUM sensitivity zones occur at locations referenced in shipwreck records, where one pre-1965 wreck is highly likely and several others may also be present offshore near the proposed SEZ study area between Port Nolloth and Alexander Bay.

[15] Palaeontological refers to fossilised remains of ancient plants, animals and other organisms preserved in the geological record. These remains are considered heritage resources under the NHRA due to their scientific, cultural, and historical significance.

Living heritage is identified as HIGH sensitivity in the communal areas of Richtersveld, Leliefontein, Steinkopf, Komaggas, Concordia and Pella, where transhumance traditions and seasonal grazing continue.

The region has HIGH cultural landscape and scenic sensitivity , anchored by internationally and nationally significant heritage landscapes and iconic scenic routes. From a cultural landscape and/or sense of place perspective, the area consists of four distinct physiographic components, namely the coastline, coastal plain, granite mountains of the Kamiesberg, and the inland plains of Bushmanland. The Namaqualand Copper Mining Landscape forms part of the regional cultural landscape, with high significance. Important topographic features identified are the Boegoeberg Twins near Alexander Bay, the granite mountains around Springbok, Okiep and Concordia, Sneeukop overlooking Kamieskroon and Gamsberg near Aggeneys, which all have historical significance. The Richtersveld Cultural and Botanical Landscape (RCBL) World Heritage Site (WHS) (Box SPM 15) and its buffer zone, several National Parks and other reserves, the coastline, the Kamiesberg mountains, and the main regional routes (N7, N14, R382) are all identified as areas of **HIGH** sensitivity for their aesthetic value. The N7, N14 and R382 are identified as scenic routes as they provide access to the RCBL WHS, the Richtersveld National Park, the Orange River and Namibia. The region's landscape value is further enhanced during the spring flowering season, when many smaller western roads attract both local and international visitors seeking the iconic Namaqualand flower displays.

Box SPM 15: Significance of the Richtersveld Cultural and Botanical Landscape (RCBL)

The most significant aspect of the cultural landscape in the Namakwa Region is the **RCBL World Heritage Site**, located in the north-western part of the study area. The description of the RCBL is as follows (UNESCO 2024):
The 160,000 ha Richtersveld Cultural and Botanical Landscape sustains the semi-nomadic pastoral livelihood of the Nama people, reflecting seasonal patterns that may have persisted for as much as two millennia in southern Africa. It is the only area where the Nama still construct portable rush-mat houses (haru om) and includes seasonal migrations and grazing grounds, together with stock posts. The pastoralists collect medicinal and other plants and have a strong oral tradition associated with different places and attributes of the landscape.

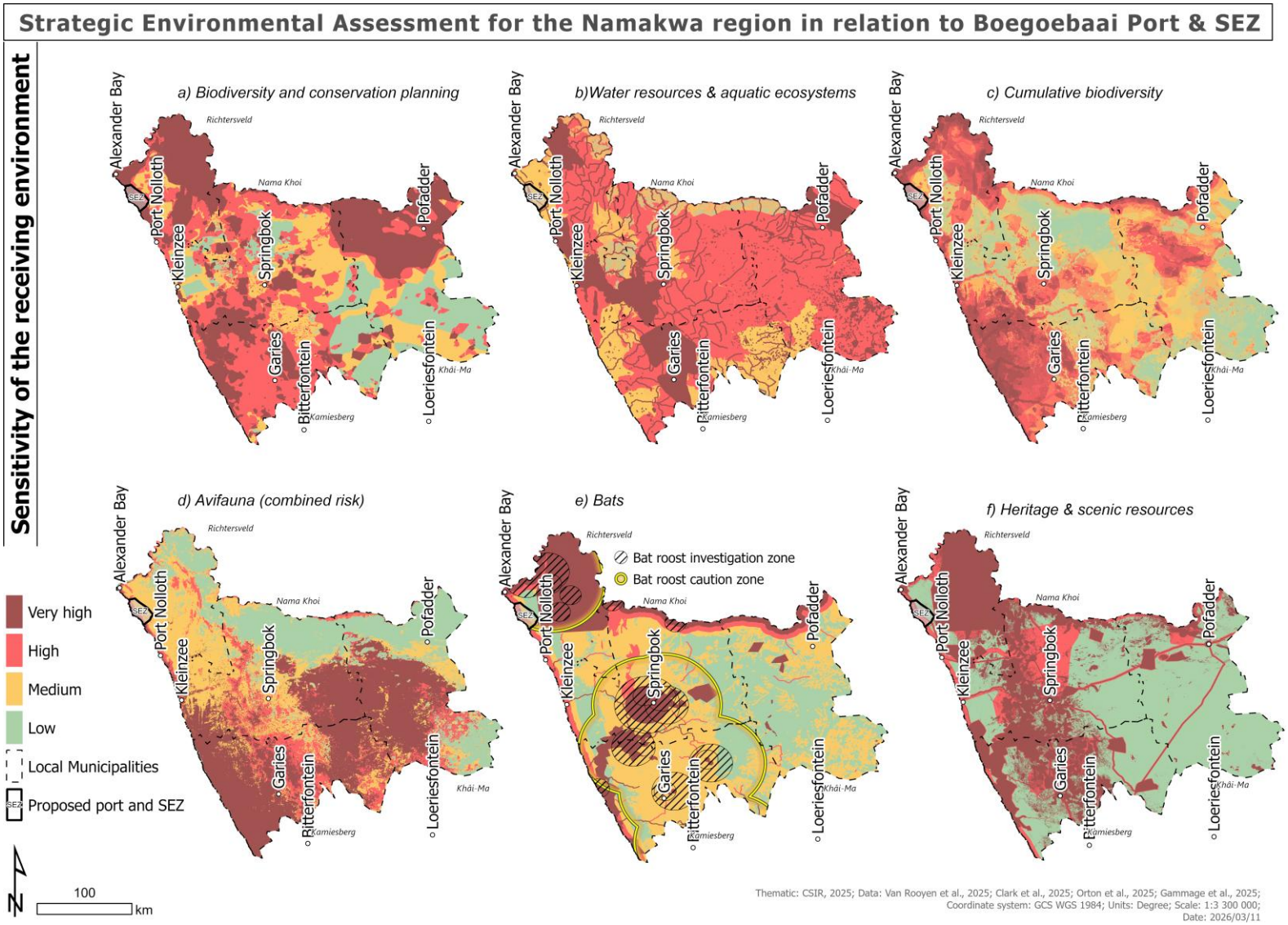


Figure SPM 4: Sensitivity of the receiving environment across the Namakwa Region study area (WP2) for the respective specialist themes – (a) biodiversity and coservation planning, (b) water resources and aquatic ecology, (c) cumulative biodiversity, (d) avifauna, (e) bats, and (f) heritage resources. Finer scale sensitivity mapping for the proposed port and SEZ was conpleted as part of WP1 of the SEA.

2.1.4 Socio-economics (after Atkinson et al., 2026)

The Namakwa Region presents a highly sensitive receiving environment, characterised by an arid climate, high ecological and cultural value, dispersed rural settlements, and structurally vulnerable socio-economic profile. The district is one of South Africa's largest geographically but least densely populated, with very low settlement density (~ 1 person/km^2), long travel distances, and small, isolated towns whose economies have historically depended on mining, pastoralism, and, increasingly, tourism. These conditions create an environment with limited institutional and economic capacity to absorb and adapt to rapid, large-scale industrial development.

From a socio-economic perspective, the region continues to experience high unemployment[16], low household incomes[17], and persistent youth unemployment, alongside long-term out-migration of skilled and economically active residents. Although poverty indicators have improved over time, a substantial proportion of households remain indigent and reliant on social grants and informal income sources. Population change has been accompanied by increasing urbanisation, with rural settlements declining and population and service demand concentrating in the Springbok, Okiep and Nababeep cluster, with Port Nolloth functioning as a key secondary node. Longer-term growth trends are also evident in Springbok, Port Nolloth, Pofadder and Garies, resulting in growing administrative and service pressure in these town despite limited infrastructure capacity.

Box SPM 16: Mining Legacy, Employment Patterns and Sensitivity in the Namakwa Region

Mining has profoundly shaped the socio-economic trajectory of the Namakwa Region, leaving a complex legacy that continues to influence community wellbeing, land use, and local economic resilience. The decline and closure of major diamond operations at Alexander Bay and Kleinzee have contributed to long-term unemployment, town deterioration, and municipal management challenges, with illegal mining emerging as an associated risk factor in the affected areas.

Over time, mining's contraction has reshaped regional employment patterns, with the economic structure shifting away from extraction and toward government services, trade/catering/accommodation (including tourism) and agriculture. However, the region's labour market remains constrained by low incomes, limited technical skills, and long-term out-migration of working-age people seeking opportunities in cities. Mining history can create long-lasting regional "path dependencies" that are difficult to re-orient toward new investment pathways, and reliance on narrow commodity profiles can leave local economies exposed to economic cycles and exogenous "shocks", with potentially severe knock-on employment effects.

The proposed Boegoebaai Port, SEZ and GH_2 programme is considered to have the potential to generate substantial construction-phase employment, but the region remains sensitive to rapid economic change. Without careful planning and governance, in-migration linked to construction activity and uneven distribution of benefits could intensify social pressures, exacerbate inequality and place additional strain on local services and institutions.

Municipal baseline conditions reflect significant infrastructure and governance stress. Water supply systems are unreliable and costly to operate; sanitation backlogs persist; road infrastructure is deteriorating; and municipal capacity for financial management, spatial planning, land-use management and disaster preparedness remains limited. The Richtersveld Local Municipality, where the proposed port and GH_2-related development would be concentrated, faces constraints, including water supply challenges, a housing backlog of about 160 units, shortages of technical staff, and recurring audit and financial governance concerns. These institutional weaknesses substantially heighten sensitivity to rapid population in-migration and expanding service demands.

[16] In 2022, Namakwa District had just under 35 000 people in employment, while more than 13 500 residents were unemployed and actively seeking work. This figure also includes unemployed people in the Hantam and Karoo-Hoogland local municipalities, many of whom could be drawn to potential employment opportunities associated with the proposed Boegoebaai Port and GH_2 development.

[17] The monthly income levels in Namakwa District are extremely low: average household incomes in Kamiesberg (R378.00), Khai-Ma (R420.00), Richtersveld (R528.00) and Nama Khoi (R2 239.00) – which is significantly higher than these towns.

Land ownership in the area, particularly in the Boegoebaai/Richtersveld area, constitutes a further critical sensitivity. Land associated with the proposed Boegoebaai development falls under the ownership of the Richtersveld Communal Property Association (CPA) following the 2007 restitution settlement (Box SPM 17).

Box SPM 17: The Richtersveld land restitution settlement

The Richtersveld Community lodged a land restitution claim in 1998 against the diamond mining company Alexkor, including compensation for diamonds extracted since the 1920s. The claim culminated in South Africa's largest land restitution settlement, confirmed by the Land Claims Court in 2007. The settlement entailed the return of approximately 194 600 ha of land, including about 84 000 ha of diamond-bearing coastal land, agricultural areas and the town of Alexander Bay, to the Richtersveld community. The land is held collectively through the Richtersveld Communal Property Association (CPA), which serves as the legal custodian of restitution land.

Governance within the CPA is fragile, characterised by internal contestation, administrative challenges and disputes over leadership, decision-making and benefit distribution. These challenges have, at times, constrained the outcomes of strategic development initiatives and eroded trust within the community. Given the CPA's legal authority over land access and approvals, unresolved governance issues pose a material risk to future development. Without targeted capacity-building, improved transparency and credible Free, Prior and Informed Consent (FPIC)-aligned engagement processes, CPA-related governance constraints could delay or complicate major investments and intensify social tensions.

Tourism is identified as the strongest growth sector in the Namakwa Region but is highly sensitive to congestion, noise, dust, heavy trucking, industrial viewshed impacts and changes to the sense of remoteness and "rustic" character that define the region's appeal. The region is increasingly recognised for its ecological, geological and cultural heritage values, contributing to its growing tourism appeal. Poorly managed logistics, settlement expansion and transport corridors therefore present a significant risk to one of the region's most resilient economic sectors.

Agriculture makes a proportionally larger contribution to the Namakwa District economy than at the national level[18], despite severe climatic constraints. Livestock farming remains a key livelihood activity with strong cultural and heritage significance for rural communities, while intensive irrigation along the Orange River supports high-value export crops, including table grapes, citrus fruits, raisins, dates and pecan nuts. These agricultural systems are, however, sensitive to water insecurity, land degradation and dust, and logistics impacts, reinforcing the region's overall socio-economic vulnerability.

2.1.5 Infrastructure and planning (after Maritz et al., 2026)

The Namakwa Region's planning environment is constrained, with few registered planners, limited geographic information system (GIS) capability, and planning documents that are often produced in terms of statutory compliance but exhibiting varying degrees of practical, innovative, or context-specific guidance. While most municipalities possess the required statutory planning instruments (including IDPs, SDFs and land-use schemes), capacity to proactively implement, update and align these instruments is limited, resulting in a largely reactive planning environment.

Settlement patterns are shaped by the region's aridity, limited water resources and economic opportunities, resulting in small, dispersed settlements with modest growth (typically under 2% per annum). Port Nolloth is the only settlement within the Richtersveld Municipality housing more than 5 000 residents, while clusters around Springbok and Steinkopf represent the other relatively larger settlements. Informal settlements occur, particularly on the peripheries of towns, driven by housing backlogs, slow urban expansion and limited availability of serviced stands.

[18] A contribution of about 10% of Gross District Product (GDP) compared to just under 3% of South Africa's GDP. In the Richtersveld Local Municipality, agriculture accounts for approximately 6% of the local economy, equivalent to around R96.8 billion in 2023 prices.

The region, particularly the settlements within it, currently face several infrastructure challenges. Municipal water and sanitation systems are highly stressed, with critical Blue Drop scores (below 31%[19] for three of the study area's local municipalities, with the exception of Nama Khoi at ~36%), aging pipelines, unreliable supply, and limited storage capacity (Box SPM 18). These systems remain functional largely because current demand is low, and they operate close to effective capacity limits.

The road network represents a critical lifeline in this sparsely populated region. Several municipal roads require substantial repairs to meet acceptable standards. The R382 (between Steinkopf, Port Nolloth and Alexander Bay) has reached or exceeded its design life and requires upgrading, including over the Anenous Mountain pass. Gravel roads serving smaller settlements are often in poor condition and highly vulnerable to weather-related damage.

Box SPM 18: What is the Blue Drop Certification Programme

By 2008, it became evident that many municipalities were not effectively managing, maintaining and operating their drinking water systems, resulting in poor water quality and sporadic water quality related disease outbreaks. Contributing factors included limited managerial and technical skills, aging and dilapidated infrastructure, rapid housing developments not aligned with infrastructure plans, and inadequate understanding of water purification processes. To address these challenges, the Department of Water and Sanitation introduced the Blue Drop Certification programme, which annually audits municipal water supply systems, including raw water pump stations and purification facilities, and scores their performance. The results are used to benchmark service delivery, identify municipalities at risk, and guide regulatory and support interventions, particularly for systems scoring below 30%, to improve compliance and ensure safe drinking water.

There is no existing rail infrastructure and no established gas or oil pipeline infrastructure in the region, resulting in an inherent reliance on road-based transport for freight and bulk materials. Electricity distribution is split between Eskom and local municipalities, with many municipalities operating at or above their Notified Maximum Demand thresholds. Electricity supply is constrained by a limited transmission grid making it difficult to evacuate power, including new renewable energy generation. Information and communication technology (ICT) coverage is also limited outside larger settlements, including the proposed port and SEZ site. These ICT constraints affect not only household connectivity, but also municipal coordination, regulatory oversight, infrastructure monitoring and emergency response capability.

Securing land or servitudes for regional infrastructure (including roads, transmission lines, pipeline or future rail corridors) is administratively complex, requiring coordinated engagement across multiple landowners, institutions and spheres of government. The southern part of the region is characterised by a larger degree of private land ownership, while the broader Richtersveld area consists largely of state land (58%) and CPA land (28%), with a smaller privately owned component (12%) (Figure SPM 5). Land tenure is fragmented, particularly in Richtersveld, where CPA, state, private and mining-related holdings interlock across extensive tracts. The Richtersveld CPA controls the land around Boegoebaai but faces internal governance disputes, while the municipality has historically been reluctant to assume full service responsibility for Alexander Bay due to ageing assets and compliance challenges within the legacy infrastructure network.

Municipal financial capacity represents an additional baseline sensitivity. Own-revenue bases are weak across the region, with municipalities heavily dependent on intergovernmental transfers to fund infrastructure and service delivery. Underspending and roll-overs of capital budgets reflect institutional and technical constraints rather than an absence of infrastructure need, limiting the ability of municipalities to proactively invest in bulk services or preventative maintenance.

Baseline disaster management and emergency response capacity is limited, particularly across remote settlements and long transport corridors. Long response times, limited staffing and constrained communication systems heighten sensitivity to road accidents, construction activities and the transport or handling of hazardous materials.

Taken together, the infrastructure and planning baseline reflects a system that remains functional largely because development demand has historically been low. Planning, infrastructure and service delivery systems operate with limited institutional capacity and constrained infrastructure systems, including ageing infrastructure, financial limitations and shortages of skilled personnel. Concurrent regional catalytic

[19] Scores below 31% are classified as being in a critical condition (Department Water and Sanitation, 2023).

projects are expected to place cumulative pressure on already constrained planning, infrastructure and institutional systems. **Collectively, these conditions indicate a highly sensitive receiving environment in which even moderate increases in development intensity could translate into disproportionate infrastructure, governance and service-delivery risks without early, coordinated and adequately resourced intervention.**

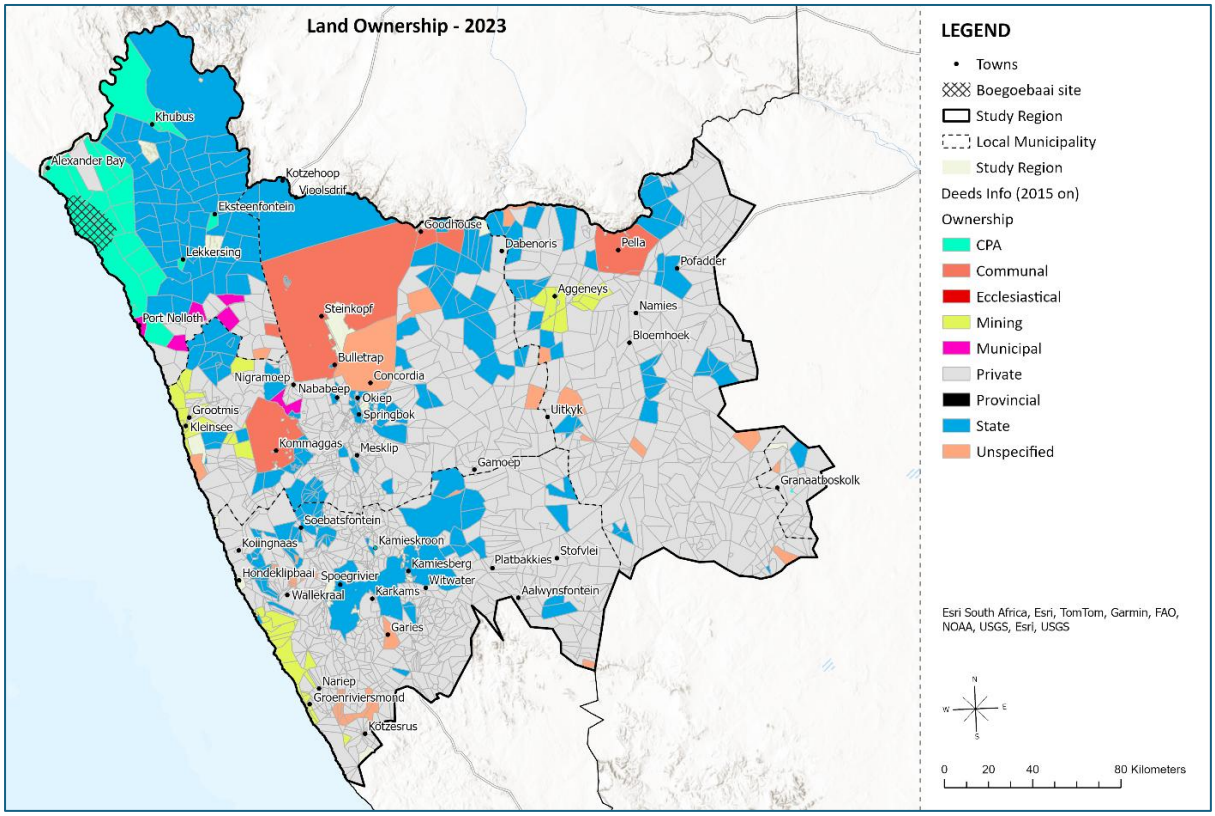


Figure SPM 5: Land ownership in the region based on the 2023 Richtersveld land audit and the Department of Rural Development and Land Reform landownership information (Source: Maritz, 2023)

2.2 Potential Impacts (positive and negative)

This section synthesises the potential negative and positive impacts associated with the three development scenarios [baseline (Sc0), small GH_2 development (Sc1), and large GH_2 development (Sc2)], in relation to the proposed Boegoebaai Port, SEZ and GH_2 development infrastructure components. The baseline scenario assumes that the planned GH_2 economy does not materialise and that current social, ecological, climatic and developmental trends continue.

Ecological and heritage related impacts are presented in Ecological and heritage impacts

Table SPM 3 (negative impacts) and Table SPM 4 (positive impacts) in Section 2.2.1, providing a consolidated, scenario-based comparison alongside recommended management actions. Socio-economic impacts and infrastructure and planning considerations are summarised narratively in Sections 2.2.2 and 2.2.3, respectively, reflecting their cross-cutting and system-level nature.

This integrated overview of specialist findings is intended to inform strategic planning and governance, subsequent project-level EIAs, guide the identification of areas and strategies to enhance positive outcomes and avoid or mitigate adverse effects, and highlight knowledge gaps requiring further fine-scale specialist investigation.

2.2.1 *Ecological and heritage impacts*

Table SPM 3: Consolidated summary of potential negative impacts to ecology and heritage, and recommended management actions for the Boegoebaai Port, SEZ and GH_2 development scenarios.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
TERRESTRIAL ECOLOGY	**Integrated Ecology**			

	In the absence of port, SEZ and GH_2 development –
	• **Desertification and aridification,** driven by climate change and unsustainable land use, resulting in :
	  ○ The **southward expansion of the Namib Desert** (biome shift),
	  ○ **Reduced rangeland productivity and degrading ecosystems**, with the Richtersveld most severely affected.
	  ○ **Vegetation loss and soil erosion intensifying**, resulting in declining soil stability, habitat degradation, and reduced nesting substrates for fauna.
	• **Declining populations** of rare and endemic species.
	• **Habitat fragmentation and protection gaps continuing** as land-use change and limited protected-area coverage weaken ecological connectivity, leaving already threatened ecosystems exposed to ongoing degradation.
	• **Persistent overgrazing**, particularly on communal land, simplifying vegetation structure and compounding climate-driven ecosystem decline, while **invasive species further homogenise habitats** and outcompete native biodiversity.
		In addition to impact trends under Sc0 –
		• **Localised habitat loss**, concentrated where GH_2 infrastructure overlaps MEDIUM–HIGH sensitivity areas.
		• **Direct loss of species of conservation concern** in affected footprints.
		• **Increased fragmentatio**n from new roads, pipelines, transmission lines and other linear infrastructure
		• **Cumulative ecosystem degradation** where GH_2 facilities compound climate-driven browning and grazing pressure.
			In addition to impact trends under Sc0 –
			• **Large-scale, high-magnitude habitat loss** directly affecting **HIGH** and **VERY HIGH** sensitivity zones.
			• **Major biodiversity pattern impacts:** loss of endemic species, SCC populations, and entire local centres of endemism.
			• **Severe fragmentation** of corridors, ecological process pathways, seasonal movement routes and climate-refugia linkages.
			• Increased pressure on **already degraded ecosystems**, amplifying climate-driven browning and pushing threatened vegetation types closer to collapse
				• Continue building a **regional biodiversity information base** to support proactive planning.
				• Improve **livestock management** to reduce climate-amplified degradation.
				• **Strengthen anti-poaching**, monitoring, and restoration programmes.
				• **Complement regional-scale sensitivity mapping** with detailed, fine-scale ecological surveys of proposed development sites **before** infrastructure layout and design begin, to ensure that site planning avoids locally sensitive habitats and biodiversity features.
				• **Development type, site, ecosystem or species-specific mitigation measures** to reduce disturbance, prevent imposition of impermeable barriers to movement and eliminate incidental death of individuals.
				• **Avoidance of development in sensitive landscapes or habitats** at the project planning phase.
				  ○ Avoid HIGH/VERY HIGH sensitivity in siting; in Medium areas apply fine-scale ecological mapping prior to design to avoid sensitive features.
				• Apply full **mitigation hierarchy**; consider offsets only when avoidance and minimisation are exhausted. Where possible align biodiversity offset implementation with the protected area expansion strategy
				• Where avoidance is not possible then **safeguard regional biodiversity using biodiversity offsets** to increase the extent of impacted ecosystems within formal protected areas.
				• Scale implementation of the regions protected area network (i.e. declaration of protected areas, stewardship sites, etc.) that conserves core biodiversity areas connected via a regional ecological corridor network within a scenically natural landscape (preserve natural sense of place) .
				• Implement **restoration of disturbed land**, especially around linear infrastructure.
				• **Minimise linear footprints**, align with existing servitudes, and restore/offset corridor pinch-points post-construction.
				• **Use cumulative-impact assessment** and pair projects with rangeland improvement agreements in the surrounding landscape.

	Avifauna			
	In the absence of port, SEZ and GH_2 development – • **Rising temperatures may push arid-zone birds to exceed their physiological thresholds**, reducing survival potential, breeding success and chick survival and fledging. • **Further reductions in rainfall and higher evaporation may decrease food productivity and availability** (insects, seeds, nectar, fruit), leading to nesting failure, starvation risk and delayed or failed breeding. • **Desertification, vegetation loss and soil erosion may remove nesting substrates, increase dust/heat exposure, and reduce avifaunal abundance/diversity** (notably in the Richtersveld). • **Increased overgrazing, compounded by climate change stressors, simplifies vegetation structure**, **reducing foraging and nesting material for birds**, and **intensifying climate-related declines in bird diversity and abundance**. • **Shifting biome boundaries driven by climate change and**	*In addition to impact trends under Sc0 --* • **Disturbance-driven displacement** from construction/operations (port/SEZ, wind/solar, roads, pipelines, powerlines, masts). • **Displacement due to Habitat loss/ fragmentation/ transformation** from GH_2 and RE footprints and linear corridors. • **Collision mortality** (turbines, powerlines, towers) for priority SCC (raptors, bustards, larks, pelicans). • **Electrocution risk** on expanded grid/substations.	*In addition to impact trends under Sc0 –* • **Severe–extreme disturbance displacement** in **VERY HIGH sensitivity** areas. • Extreme habitat loss/fragmentation, including SCC core areas and KBAs. • Extreme collision risk for EN/CR species (e.g., Ludwig's Bustard, vultures, eagles) across turbines/powerlines. • **High electrocution risk** due to large-scale grid expansion. • **Cumulative impacts** nearing **population viability limits** for several SCC, with residual risk remaining substantial even after mitigation.	• **Expand protected areas and stewardship** in priority habitats; maintain microhabitats. • **Restore degraded habitat** to rebuild structure and minimise desertification effects. • **Improve rangeland management**, including drought-responsive destocking to prevent veld collapse. • **Control invasive plants** and **protect/restore wetlands, pans and seeps** to secure drinking/foraging sites. • **Avoid HIGH/VERY HIGH sensitivity** in siting and align lines with low-risk corridors. • **Bird-safe design and operations**: diverters, raptor-safe pylons, low-impact lighting, anti-perching devices. • **Shutdown-on-Demand and seasonal curtailment; pre-construction surveys and micro-siting** to avoid nests/roosts/flight corridors. • **GenEst[20]-based pre- and post-construction monitoring**, set Thresholds of Potential Concern (TPCs) and **adaptive responses**; **habitat restoration** & hydrology maintenance. • **Advanced collision-prevention** (curtailment regimes, high-performance diverters) and raptor-safe electrical designs.

[20] A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (https://www.usgs.gov/software/genest-a-generalized-estimator-mortality).

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	anthropogenic pressures may result in habitat contraction and fragmentation within the Succulent Karoo, leading to reduced avifaunal abundance and diversity, population fragmentation, range shifts, community restructuring, and potential loss of endemic and habitat-specialist species. • **Increased frequency of hot, dry periods raises wildfire risk which may destroy nesting and foraging habitats**, exacerbating food and water shortages for resident birdlife. • **Drying of wetlands, pans and seep systems reduces drinking and foraging opportunities**, leading to dehydration, nest abandonment, failed breeding and range contractions. • **Increased alien invasive cover may homogenise habitats and displace natural vegetation**, potentially favouring generalist species while reducing suitable habitat, shelter, and persistence of range-restricted and specialist birds, with possible local extinctions in heavily invaded areas.			• **TPC-based adaptive management** with mandated corrective action when thresholds are exceeded
	Bats			
	In the absence of port, SEZ and GH_2 development – • Declining natural foraging habitat due to desertification, overgrazing, soil erosion, and water scarcity, **leading to reduced insect prey and degraded hunting habitat**. • Reduced accessible open water, as hotter, drier conditions and lowered groundwater recharge **reduce surface water sources essential for drinking and insect availability.** • **Declining insect availability** because of hotter, more arid conditions and altered habitat structure. • **Light pollution increases**, favouring light-tolerant generalist species while deterring photophobic and specialist bat species and shifting species composition. • Wind energy expansion (occurring even under the baseline due to Springbok REDZ) may **increase risks of collision/barotrauma if unmanaged**. • Agricultural shifts **may create limited, localised bat foraging opportunities** through irrigated croplands and livestock activity, while declining chemical pesticide use could benefit bats by reducing toxin exposure; **however, these benefits are spatially limited and do not offset broader climate- and water-driven habitat constraints.** • **Expansion of protected areas may help conserve natural bat foraging habitat and insect prey diversity**, partially buffering bats against broader climate- and land-degradation pressures. • Overall, these interacting drivers are expected to **restructure bat communities, with adaptable generalist species persisting or increasing locally, while specialist and water-dependent species decline**.	*In addition to impact trends under Sc0 --* • **Destruction or disturbance of bat roosts** (natural & artificial) due to construction of turbines, PV fields, roads, substations and GH_2 infrastructure. • **Loss & fragmentation of foraging habitat**, both permanent (clearing) and temporary (construction disturbance). • **High collision & barotrauma mortality risk**, especially in **VERY HIGH** and **HIGH** Sensitivity areas; species at greatest risk include *Tadarida aegyptiaca, Sauromys petrophilus, Miniopterus natalensis*. • Attraction to turbines due to insects congregating around lighting or low-pressure air pockets, **increasing collision exposure**. • Fruit bat movement routes (poorly known) may intersect turbines, **increasing mortality risk**, particularly near date farms and riparian corridors.	*In addition to impact trends under Sc0 –* • **Extreme destruction/disturbance of roosts**, with irreversible loss of macro-roosts possible. • **Large-scale foraging habitat loss**, potentially affecting critical habitat supporting high bat diversity. • **VERY HIGH mortality risk**, with **potential collapse of local bat populations** if unmanaged. • **High risk to cave-dwelling species**, where turbine impacts may affect energy input to cave ecosystems via guano reduction. • **Cumulative, region-wide displacement of sensitive species**; potential local extinction of common species.	• **Avoid all VERY HIGH** Sensitivity zones and apply buffers for roosts (500 m–20 km depending on colony size). • Apply **site-specific sensitivity mapping** and 12-month **pre-construction monitoring** (including rainy season). • Areas disturbed during construction should be **rehabilitated following completion**, using appropriate ecological restoration techniques. • Implement **curtailment (increased cut-in speeds)** during high bat-activity conditions. • **Minimise lighting** and **avoid creating artificial water bodies** near turbines. • The design and construction of new buildings and infrastructure should **prevent the creation of artificial bat roosts**. • **Prohibit wind development within major buffers** around confirmed and potential roosts (up to 20–50 km). • If undiscovered bat roosts are encountered during the construction phase, **the respective Environmental Compliance Officer (ECO) must be notified immediately** and a **bat specialist consulted** to advise the appropriate action • Conduct **operational fatality monitoring** and adaptively manage turbines. • Long-term operational monitoring, including **fruit bat monitoring near agricultural corridors**.
	Fauna			
	In the absence of port, SEZ and GH_2 development – • Habitat loss and fragmentation from existing land uses (mining, overgrazing, roads, powerlines, settlements) **disrupt movement corridors, burrow networks and dispersal pathways** - most acute for dune/coastal specialists and fossorial mammals/reptiles (e.g., golden moles, dune mole-rat, tortoises, sand lizards). • **Disturbance (noise, lighting, human activity) elevates displacement and roadkill risk**, particularly for nocturnal mesocarnivores (e.g., bat-eared fox, Cape fox) and slow-moving reptiles (adders, tortoises). • **Degradation of ecosystem processes** (pollination, soil	*In addition to impact trends under Sc0 --* • Construction/operations footprint causing **habitat loss/fragmentation and disturbance across MEDIUM–HIGH** sensitivity plains and into **HIGH/VERY HIGH** sensitivity areas if poorly sited, elevating displacement for burrow-dependent guilds and rock specialists (girdled lizards, padlopers). • **Process-level impacts:** altered ground temperature/structure (PV platforms, roads, hardstands) and fencing disrupt soil engineers (termites, ants, rodents) and amphibian pulse breeders tied to ephemeral pools.	*In addition to impact trends under Sc0 --* • **Scale-driven, cumulative habitat loss and fragmentation** with **Severe–Extreme** consequences in **VERY HIGH/HIGH** zones (coastal dune SCC, lichen fields, koppie complexes); high probability of **irreversible losses** and **local extinctions** if avoidance is not achieved. • **Process disruption at landscape scale**: **collapse risks** for soil engineering, pollination networks, and amphibian breeding dynamics; widespread fencing/roads increase barrier effects and roadkill.	• **Avoid and buffer all VERY HIGH sensitivity features** (coastal duneveld, lichen fields, SCC roost/burrow complexes, rocky inselbergs). • **Species-specific survey & design before layout finalisation** (golden moles, dune mole-rat, padloper tortoises, rain frogs); **re-align footprints** accordingly. • **Route linear infrastructure via least-path routing**; use **existing servitudes** where possible; include **fauna underpasses/culverts** under roads in conjuction with "fauna barriers"/guiding barriers; **crow-proof substation/line designs** near tortoise habitat to reduce corvid predation; mandatory **EMPr** and **roadkill monitoring** with adaptive triggers. • **Hydrology protection**: keep ephemeral pans/sand rivers functional (setbacks, crossing design, no pan infilling); **soil restoration**

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	engineering, amphibian pulse breeding) through overgrazing, soil compaction, hydrological alteration and cumulative linear infrastructure. • Climate change intensification (heat, aridity) **pushes amphibians beyond hydro-ecological thresholds** (shortened hydroperiods), skews reptile Temperature-dependent sex determination outcomes, and reduces forage for herbivores/insectivores.			post-works. • Landscape-level avoidance: exclude all **VERY HIGH** and the majority of **HIGH** sensitivity areas; set development caps to avoid breaching viability thresholds for SCC. • Scenario 2 (big GH_2) may result in high residual impacts which will require biodiversity offsets. • **Mandatory cumulative impact assessment, adaptive management embedded in approvals**, and **monitoring beyond the footprint** (fauna passage efficacy, roadkill, amphibian breeding success, soil process indicators).
WATER RESOURCES AND AQUATIC ECOLOGY	**Groundwater**			
	In the absence of port, SEZ and GH_2 development -- • **Decline in groundwater availability** driven by hotter and drier climatic conditions, including reduced MAP[21], increased MAPE[22], long periods without rainfall and reduced recharge, especially in alluvial aquifer systems. • **Deterioration in groundwater quality** caused by rising salinity from marine aerosol deposition and flushing of salts from heuweltjies during heavy rainfall events, compounded by contamination from failing wastewater treatment works. • **Increasing groundwater abstraction** caused by population growth places additional pressure on aquifers that are already stressed and experiencing declining water levels.	*In addition to impact trends under Sc0 --* • **Significant additional pressure on groundwater resources** caused by increased population influx and water demand from GH_2 operations in towns such as Alexander Bay and Port Nolloth. • **Elevated contamination risks** introduced by high-risk GH_2 infrastructure such as chemical storage facilities, pipelines and hydrogen production systems. • **Reduced groundwater security** in priority GRUs where supply is already insufficient to meet existing demand.	*In addition to impact trends under Sc0 --* • **Severe groundwater depletion** driven by large-scale GH_2 development, with water demand exceeding aquifer supply capacity across several high-sensitivity units. • Heightened **groundwater contamination risks** caused by the expanded industrial footprint and increased potential for spills and effluent leakage. • **Increased likelihood of long-term or irreversible salinisation** of aquifers due to reduced recharge, higher evaporation, and increased abstraction.	• **Avoid high-risk activities** (chemical storage, pipelines, GH_2 processing infrastructure) **in areas of HIGH or VERY HIGH groundwater sensitivity**, including SWSAs and priority GRUs. • **Invest in municipal water infrastructure**, including refurbishment of bulk supply systems and groundwater reticulation networks. • **Implement groundwater and seawater desalination** to augment supply where aquifers cannot meet demand. • **Improve borehole management** through specialised training (e.g., addressing iron biofouling). • **Introduce managed aquifer recharge schemes** to reduce long-term salinisation and stabilise aquifer yields. • **Strengthen regulatory protection** for groundwater quality and **enforce adherence to restrictions** in sensitive areas.
	Surface water resources			
	In the absence of port, SEZ and GH_2 development -- • **Declining surface water availability** caused by reduced rainfall, reduced runoff, and increased evapotranspiration, resulting in long periods with no flow in streams and rivers. • **Increasing vulnerability of towns and agriculture** due to aging, underperforming Orange River abstraction and reticulation systems.	*In addition to impact trends under Sc0 --* • **Increased stress on surface water systems** caused by rising population and GH_2-related water demand that exceeds existing abstraction and reticulation capacity. • **Higher risk of water supply shortfalls** due to dependence on already strained Orange River bulk water schemes.	*In addition to impact trends under Sc0 --* • **Severe surface water scarcity** resulting from large-scale GH_2 expansion, where water demand far exceeds available supply, particularly during long dry periods. • **Increased systemic failure risk in surface water supply infrastructure** due to overwhelming demand during extreme climatic conditions.	• **Develop and optimise new or expanded Orange River abstraction schemes** aligned with ecological flow requirements (EWRs and RQOs). • **Implement and adequately fund desalination for both seawater and saline groundwater** to supplement limited surface water availability. • **Improve operation, maintenance and reliability of abstraction, treatment, reticulation and storage infrastructure**. • **Prevent pollution at abstraction works**, particularly where subsurface filtration is used.
	Inland aquatic ecosystems & estuaries			
	In the absence of port, SEZ and GH_2 development -- • **Loss of biodiversity in ephemeral pans** caused by shortened hydroperiods that prevent invertebrate and plant communities from completing life cycles. • **Decline in riparian vegetation** driven by reduced shallow groundwater availability, making rivers more vulnerable to erosion during sporadic flood events. • **Degradation of watercourses** caused by nutrient enrichment and contamination from failing wastewater treatment works, along with increasing alien plant invasion. • **Continued decline in estuarine condition**, particularly in the Orange River Estuary, driven by reduced flood frequency, elevated salinity and nutrient enrichment from failing wastewater treatment works.	*In addition to impact trends under Sc0 --* • **Increased erosion and sediment disruption** in rivers and wetlands caused by concentrated stormwater flows from hardened GH_2 infrastructure such as roads, turbine pads and solar arrays. • **Fragmentation of aquatic and estuarine habitats** due to new roads, transmission lines and GH_2 infrastructure interrupting natural hydrological and ecological connectivity. • **Increased nutrient pollution** caused by higher effluent volumes from expanding formal and informal settlements. • **Growing human pressure** through fishing, grazing, disturbance and recreational activities on estuarine systems, associated with population growth.	*In addition to impact trends under Sc0 --* • **Widespread and potentially irreversible degradation of Critically Endangered and Endangered aquatic ecosystems** caused by extensive landscape fragmentation and hydrological alteration. • **Significant deterioration of water quality** from increased effluent loads linked to major population expansion and urban footprint growth. • **Increased hypersalinity and reduced breaching in estuaries**, limiting fish recruitment and further degrading ecological functioning in arid West Coast systems.	• **Avoid all development in VERY HIGH Sensitivity aquatic and estuarine areas**, including CR/EN wetlands, NFEPA rivers and estuarine functional zones. • **Apply ecosystem buffers** (20 m for artificial pans/dams; 50 m for natural pans, wetlands and rivers; 100 m for NFEPA rivers). • **Ensure road crossings and stormwater systems maintain natural hydrological pathways** and avoid concentrated flows and erosion. • **Upgrade WWTWs prior to population or settlement expansion** to prevent nutrient pollution and contamination. • **Implement Orange River Estuary rehabilitation actions** and maintain EWRs and RECs to sustain estuarine function. • **Use biodiversity offset banking** where unavoidable impacts occur, especially under large-scale GH_2 development.

[21] Mean Annual Precipitation (MAP) is projected to decrease by between 10-20% in most places, but between 0-10% in other locations.
[22] Mean Annual Potential Evapotranspiration (MAPE) will increase by 6-10%.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
HERITAGE	**Palaeontology**			
	In the absence of port, SEZ and GH_2 development – • Desertification and increased mining may **expose fossiliferous strata and create a risk of fossil loss**, particularly where coastal plain sediments are disturbed.	*In addition to impact trends under Sc0 –* • Most development affects surficial sediments of **LOW** palaeontological sensitivity, so impacts are generally insignificant; **exceptions occur near the coast** where buried marine formations of **HIGH sensitivity** may be intersected by deeper excavations.	*In addition to impact trends under Sc0 –* • Impacts are similar to Sc1 but of higher intensity because a larger overall footprint increases pressure on land and reduces avoidance options, with **the coastal plain most at risk if deep cuts intersect HIGH-sensitivity units**.	• Every project **must be evaluated by a palaeontologist** at EIA stage to determine the need for a palaeontological specialist study, especially along the coast. • No fixed "No-Go" fossil areas are identified at regional scale; **control impacts through case-specific assessment and management**.
	Terrestrial archaeology			
	In the absence of port, SEZ and GH_2 development – • **Archaeological sites threatened** due to an increase in agricultural development along the Orange River and diamond mining along the coast. • Renewed copper mining in Okiep **may impact the historic Copper Mining Landscape**. • Potential artisanal mining licences, oil and gas exploration, and additional prospecting/mining (manganese, iron and granite) **may impact heritage resources**. • Continued development of renewable energy facilities in the REDZ, new roads and industrial corridor along the N14 **may impact archaeological resources**.	*In addition to impact trends under Sc0 –* • Area-wide **impacts to surface resources are possible** but generally not highly significant, except along the coastline where sites of higher significance are more concentrated. • Inland sites will be more dispersed, with opportunity to avoid them during development.	*In addition to impact trends under Sc0 –* • Impacts similar to Sc1 but with **higher intensity** due to the larger footprint, resulting in increased land pressure and reduced likelihood to avoid impacts, **particularly along the coastline**. • Expanded land requirements increase the likelihood of impacts on communal areas.	• Undertake **archaeological specialist studies in all EIAs** and detailed surveys of each project footprint. • **Monitor construction in coastal dune areas** where middens are buried. • Coastal impacts cannot all be mitigated; **archaeologists should determine sites to sample** in order to best characterise the archaeology in each development footprint. • Consider high-density coastal areas during EIAs **for protection**.
	Maritime Heritage			
	In the absence of port, SEZ and GH_2 development – • Potential offshore mining and gas exploration **may impact unknown wrecks and result in destruction**.	*In addition to impact trends under Sc0 –* • **Impacts unlikely to significantly increase** due to generally low probability of wrecks being found; however, there is always **a chance of impacts**.	*In addition to impact trends under Sc0 –* • As with Sc1, impacts remain **generally unlikely**, but a **larger footprint raises the chance** of intersecting sensitive localities near historically recorded foundering points.	• Maritime Heritage **specialist study required for developments affecting marine environment** (e.g., undersea pipelines). • Fieldwork needs should be determined based on the development proposal, with most **underwater fieldwork conducted during the pre-construction or micrositing phase**.
	Graves			
	In the absence of port, SEZ and GH_2 development – • **Impacts unpredictable** as graves are generally completely unmarked; **impacts occur sporadically and can be severe when discovered late.**	*In addition to impact trends under Sc0 –* • Impacts are **unpredictable**; **several graves may be affected, or none at all,** depending on exact siting.	*In addition to impact trends under Sc0 –* • With **a larger land footprint, the chance of encountering graves increases**, escalating the potential for significant to extreme negative outcomes if not managed early.	• Consider graves along with archaeology in any EIA. • **Early consultation** with the Northern Cape Heritage Resources Authority and representatives of local communities **to determine if reburial should be considered, and the identification of suitable locations**. **Exhumation should only occur when no other mitigation options are possible**. • When retained close to development(s), **graves should be fenced** to enhance their long-term protection.
	History and Built Environment			
	In the absence of port, SEZ and GH_2 development – • Incremental increases in mining and infrastructure development **may damage or destroy historic places**, **structures and buildings older than 60 years.**	*In addition to impact trends under Sc0 –* • Significant impacts are **unlikely due to relatively small footprint**. • **Potential threat could be the insensitive 'restoration' of historical structures or demolition in towns where new residential areas are required** (Steinkopf, Okiep, Springbok).	*In addition to impact trends under Sc0 –* • Impacts similar to Sc1 but with higher intensity due to the larger footprint, resulting in **increasing cumulative risks to historic fabric and context where avoidance is constrained**.	• All historical and built environment sites should be **evaluated during EIAs**; restoration may be recommended to enhance protection and cultural significance. • **Farmsteads should be avoided**, with a buffer large enough to not render the structures 'uninhabitable' due to the close proximity of undesirable development.
	Living Heritage			
	In the absence of port, SEZ and GH_2 development – • Small stock farmers likely to continue traditional grazing practices despite **poor environmental conditions and overgrazing**. • Infrastructure and mining in communal grazing lands may further **threaten traditional land-use patterns**.	*In addition to impact trends under Sc0 –* • **Communal areas of Steinkopf, Concordia and the Richtersveld are potentially most at risk** as they are located near potential centres of development.	*In addition to impact trends under Sc0 –* • With far **larger land requirements**, the **likelihood of using communal areas** increases, raising risks to transhumant practices and living heritage; nonetheless, **financial benefits** could accrue to affected communities if negotiated properly.	• BZB **communities should be consulted** to determine their response to the loss of their grazing lands, and understand reasons for areas chosen for grazing, value of the pasturage in terms of seasonal grazing requirements, alternative options, and how the local environment and culture are intertwined within their world view.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	Cultural Landscape			
	In the absence of port, SEZ and GH_2 development – • Population growth and associated development will **gradually alter historical and cultural landscapes** (notably around Springbok/Okiep and Aggeneys), in contrast to seasonal tourism that relies on natural aesthetic and heritage preservation.	*In addition to impact trends under Sc0 –* • The small overall footprint should not have significant landscape impacts **unless projects sit near prominent, aesthetically sensitive features such as the RCBL World Heritage Site** (and buffer), National Parks/reserves, the Kamiesberg and the coastline.	*In addition to impact trends under Sc0 –* • Similar to Sc1 but **more intense**, as a larger footprint increases pressure near **high-sensitivity scenic areas** and reduces avoidance flexibility	• **Consult with the SANParks, UNESCO, SAHRA and local tourism operators** regarding developments near the RCBL Heritage Site or its buffer, or near scenic routes (N7, N14, R382), National Parks/reserves and other iconic landscapes. • The entire **RCBL and its buffer zone should be considered as No-Go area**. • All landscapes in the region have high cultural and natural "sense of place" that needs to be preserved. Include a **Visual Impact Study in every EIA** where landscape effects are a concern; prepare **site-specific management plans** when heritage sites are reused or preserved in close proximity to development.

Table SPM 4: Consolidated summary of potential positive impacts and recommended management actions for the Boegoebaai Port, SEZ and GH_2 development scenarios.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (enhancement)
TERRESTRIAL ECOLOGY	**Integrated Ecology**			
	• Opportunity to **stabilise ecosystems** if improved protected-area management, grazing management and restoration interventions are implemented. • Baseline offers spatial **flexibility for long-term conservation planning**.	• Scope **for strategic biodiversity offsets that expand the protected area network** or secure high-value priority landscapes. • Potential **development of large-scale biodiversity economy initiatives** linked to offsets and stewardship	• **Expand protected-area and stewardship networks** using existing biodiversity priorities.	• Where residual impacts remain after avoidance/minimisation, **implement like-for-like biodiversity offsets in mapped priority areas** within the same planning domain
	Avifauna			
	• Expansion of protected areas/stewardship buffers climate and land-use threats, **safeguarding breeding/foraging/roosting habitats and microhabitats for rare species**.	• **Early, targeted avoidance and mitigation** via sensitivity maps and technology-specific standards. • **Offsets** can secure high-value habitat if correctly applied (same planning domain; like-for-like).	• Potential for **large, programmatic offsets** to secure corridors, refugia and high-value habitats. • Scope to **establish regional monitoring/governance/financing platforms** for ongoing conservation	• **Expand protected areas & stewardship** in priority habitats; maintain microhabitats. • **Landscape-scale avoidance** of all **VERY HIGH** sensitivity areas; set development caps to limit cumulative risk.
	Bats			
	• Increase in artificial roosting structures (buildings, mines, Namakwa SEZ-linked settlement growth) **may create new roosting opportunities** for several bat species. • Agricultural irrigation areas can **locally increase insect abundance**, offering supplemental foraging habitat. • Livestock farming (where it persists) **can attract insects associated with dung, benefiting foraging bats**. • Protected areas preserve natural foraging habitat and insect diversity, **aiding bat diversity**. • Reduced pesticide use (trend toward organic farming) **reduces toxin accumulation risk for bats**.	• **Expanded artificial roost opportunities** from GH_2-related infrastructure (if unintentionally created). • **Opportunities for research and monitoring**: bat EIA monitoring and curtailment trials generate new regional knowledge. • **Regional planning improvements**: sensitivity maps enable steering of GH_2 projects away from Very High bat sensitivity zones.	• **Large-scale strategic research and monitoring programmes** become feasible (migration routes, species behaviour, risk mitigation). • **Opportunity to protect regional corridors** via spatial planning.	• Research programmes to **map cave-dwelling bat migration routes**.
	Fauna			
	• **Protected areas and intact koppies/dune belts still buffer key SCC** (e.g., De Winton's golden mole, Namaqua dune mole-rat, Speckled padloper) where habitat remains intact; these areas anchor **VERY HIGH/HIGH** sensitivity.	• Site-level **SCC surveys enable micro-avoidance and targeted design**.	• **Opportunity to establish programmatic, region-wide offsets**, corridor protection and **long-term monitoring platforms**, but these do not negate permanent losses where avoidance fails.	• **Avoid and buffer all VERY HIGH sensitivity features** (coastal duneveld, lichen fields, SCC roost/burrow complexes, rocky inselbergs). • **Programmatic offsets** (like-for-like; time-bound; independently verified) prioritising **corridors, coastal dune SCC habitat, lichen fields**, and **rocky inselbergs**; integrate with Protected Area expansion.
WATER RESOURCES AND AQUATIC ECOLOGY	**Groundwater, Surface water resources, Inland aquatic ecosystems & estuaries**			
	• **None expected in baseline;** no additional water sources will come online without intervention.	• **Desalination plants could provide new sources of freshwater that reduce pressure on groundwater and surface water systems**, provided it is developed and implemented responsibly and effectively. • **Upgraded WWTWs improve effluent quality and reduce nutrient pollution,** which benefits rivers and estuaries downstream, provided naturally ephemeral systems are not transformed into seasonal or perennial systems from effluent discharges • Economic growth associated with GH_2 may also enable municipalities to strengthen environmental governance and maintenance of water networks, indirectly enhancing water resource resilience.	• The Sc1 potential positive impacts become larger but rely heavily on strong mitigation and advanced planning. • Large-scale **desalination could substantially increase freshwater availability across the region,** ensuring that both human and ecological needs are met even under severe climate stress, and provided that naturally ephemeral systems are not transformed. • Offset banking. if properly implemented, **could support long-term conservation of high-value aquatic ecosystems** by securing protection and restoration at landscape scale. • Integrated infrastructure upgrades, including water reticulation, storage and treatment, **could improve long-term water security for towns and ecosystems alike**. **These benefits materialise **only if significant investment and governance improvements accompany GH_2 expansion**.	• **Investigate the ecological, practical and financial feasibility of supplying treated, desalinised water** to nearby communities. • Invest in water supply, wastewater infrastructure and staff training. • Strict siting to **avoid sensitive areas**. • Large-scale **investment in desalination and managed aquifer recharge**. • Implement proactive watercourse and terrestrial offset banking programmes. • **Maintain ecological flow requirements** for the Orange River and estuary. • Implement proper **upgrading, expansion, and maintenance of wastewater treatment works**. • **Improvements to water treatment and distribution** (reticulation) systems.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (enhancement)
HERITAGE	**Palaeontology**			
	N/A	Discovery, recording and scientific sampling of fossils during development can increase knowledge and benefit science.		
	Terrestrial Archaeology			
	N/A	Discoveries, recording and sampling of archaeological sites can substantially **increase scientific knowledge; responsible restoration and reuse** of historical structures linked to development can prevent neglect and disuse; tourism growth can bolster conservation incentives.		
	Graves			
	N/A	Identification and protection of previously unknown marked graves can occur where systematic surveys are done, improving heritage records and safeguarding culturally significant places.		
	History and Built Environment			
	N/A	**Responsible restoration and reuse** tied to development or accommodation needs can stabilise historic structures and raise their cultural significance; tourism growth can amplify conservation incentives.		
	Maritime Heritage			
	N/A	Discovery and recording of wrecks can **enhance maritime heritage knowledge** where sites are identified and managed.		
	Living Heritage			
	N/A	Where development catalyses **formal recognition and protection** of living-heritage sites and practices, positive outcomes can emerge; well-structured agreements in Sc2 can produce direct community benefits alongside impact management.		
	Cultural Landscape			
	N/A	Rehabilitation associated with development **can improve previously disturbed areas**, and in some cases, expansions of protected areas can strengthen long-term landscape conservation.		

2.2.2 Socio-economic Impacts

2.2.2.1 Potential negative impacts

- Pressure on local housing, services and municipal systems.

The development of the port, GH_2 facilities and associated infrastructure is expected to attract in-migration during construction and early operations. This is likely to place increasing pressure on housing availability, bulk services, health care and municipal administration in the Richtersveld and surrounding towns. Without early spatial planning and investment, these pressures could exacerbate existing service backlogs, contribute to informal settlement growth, and deepen fiscal and governance challenges in municipalities with limited capacity.

Box SPM 19: Boomtown dynamics and uneven development outcomes

Large infrastructure projects often generate rapid in-migration during construction as jobseekers, contractors and service providers move into the area. This phenomenon, commonly referred to as "boomtown" dynamics, can result in sudden increases in housing demand, rental and food prices, and pressure on basic services. While construction activity may generate substantial short-term employment, benefits are often unevenly distributed, with those unable to access project-related jobs experiencing rising living costs without corresponding income gains.

- Rising living costs and social inequality.

Improved employment opportunities and higher wage levels associated with port and GH_2-related activities may stimulate local economies, but are also likely to drive up food, rental and property prices. These dynamics may disproportionately affect poorer households and those not directly benefiting from project-related employment, increasing inequality and potentially generating social tension if inclusive access to opportunities is not ensured.

- Risks to tourism from logistics and transport impacts.

Increased freight transport, particularly if dominated by road-based ore and bulk hauling, could undermine the tourism appeal of the Namakwa region by increasing traffic volumes, noise, dust and landscape disturbance. Tourism is one of the region's most important growth sectors and is highly sensitive to these changes, which may affect visitor safety and degrade the experiential qualities that underpin conservation- and heritage-based tourism.

- Impacts on agricultural production and viability.

Port-related ore handling increased heavy vehicle traffic and associated air quality impacts may pose risks to crop quality and export standards, particularly for irrigated agriculture. Agriculture in the region is already constrained by aridity and is sensitive to dust, water availability and transport reliability. Poorly managed logistics could therefore have knock-on effects for employment and rural livelihoods.

- Institutional and governance capacity constraints.

The scale and complexity of the proposed developments will place significant demands on municipal planning, financial management, disaster risk management and public participation systems. In municipalities where capacity is already constrained, there is a risk that development pressures outpace institutional readiness, weakening oversight, accountability and community trust.

Box SPM 20: Institutional capacity as a binding development constraint

Institutional capacity refers to the ability of local government to plan, finance, implement and regulate development effectively. This includes staffing, technical skills, financial management, spatial planning, disaster preparedness and public engagement. In small or rural municipalities, capacity constraints can limit the ability to respond to rapid growth, even where development opportunities exist.

- Social disruption and community cohesion risks.

Rapid economic change and in-migration may give rise to "boomtown" dynamics, including increased crime, pressure on social and health services, and erosion of social cohesion. These risks are more likely to emerge if community engagement and social support mechanisms are not proactively implemented.

2.2.2.2 Potential opportunities (positive impacts)

- Employment creation and skills development.

The construction and operation of the proposed port, SEZ and GH_2 facilities are expected to create employment opportunities across a range of skill levels. With appropriate training, apprenticeships and career development pathways, these projects could strengthen the regional skills base, reduce out-migration and support longer-term employment beyond the construction phase.

- Regional economic growth and diversification.

The port and associated developments have the potential to act as a new economic anchor for the Namakwa region, stimulating various multiplier effects in sectors such as logistics, manufacturing, services, training, and supplier industries. Over time, agglomeration effects along key transport corridors and around regional hubs such as Springbok could contribute to a more diversified and resilient regional economy.

- Infrastructure investment with shared benefits.

Strategic investments in transport, energy, water and digital infrastructure, if planned in an integrated manner, could generate significant co-benefits for local communities, agriculture and tourism. Examples include improved connectivity, expanded renewable energy access, and desalination infrastructure that supports both industrial and domestic water needs.

- Opportunities for agricultural upgrading and resilience.

Improved port access, enhanced logistics and access to renewable energy may support agricultural diversification and improved competitiveness, particularly for export-oriented irrigation schemes. Corporate social investment and partnerships could further support climate-resilient farming practices and local agricultural development.

- Tourism enhancement and diversification.

Tourism could benefit indirectly from improved access, upgraded regional airports, enhanced destination marketing and the emergence of new heritage- and green-energy-related tourism offerings. These benefits are more likely to be realised if industrial development is spatially separated from key tourism nodes and freight impacts are carefully managed.

- Institutional strengthening and governance innovation.

The scale and visibility of the Boegoebaai GH_2 programme provide an opportunity to strengthen intergovernmental coordination, municipal capacity and public engagement practices. Approaches such as iterative problem-solving and meaningful community participation could help ensure that development outcomes are more inclusive, transparent and durable. Building institutional will require strong leadership and support by national and provincial government, as well as other stakeholders.

2.2.3 Infrastructure and planning impacts

2.2.3.1 Spatial development planning, land use management and governance

- **Baseline Scenario (no port, SEZ or GH_2 development)**

Municipal planning systems in the region already operate under significant capacity constraints, limiting their readiness to manage future development pressures. Municipalities have few professional planners, limited GIS capability, and rely on a District Municipal Planning Tribunal (DMPT) (Box SPM 21) that convenes only quarterly to make key planning decisions, which can result in delays.

Box SPM 21: What is a District Municipal Planning Tribunal (DMPT) and why does it matter?

The District Municipal Planning Tribunal (DMPT) is the legally mandated body that adjudicates land-use and land-development applications under the Spatial Planning and Land Use Management Act (SPLUMA). In the Namakwa region, the DMPT sits quarterly, which is sufficient under low development pressure but becomes a critical bottleneck when volumes spike. Where municipal capacity is already limited, the DMPT's meeting frequency and technical support directly shape how fast large projects can progress.

Existing planning instruments (IDPs, SDFs and land-use schemes) function largely as statutory compliance documents, offering limited proactive spatial guidance. As a result, municipalities face a heightened risk of ad-hoc land-use decisions and limited ability to anticipate spatial or infrastructure pressures.

- **Sc1 (Small GH_2)**

The initiation of the proposed programme of developments is expected to drive significant land use change, including new housing, bulk infrastructure, RE facilities, construction camps, and road upgrades, alongside population growth in towns such as Port Nolloth and Alexander Bay. This will increase demand for land, coordinated spatial and service planning, and coordinated decision-making across multiple authorities, including engagement on communal land in the Richtersveld.

The scale and diversity of development may exceed existing municipal planning capacity, creating risks of application backlogs and institutional bottlenecks. Strengthened regional coordination and additional provincial and national support will be critical to manage the anticipated surge in development over the next 5–10 years.

- **Sc2 (Big GH_2)**

The increased scale of GH_2 production and associated development is expected to place considerably greater pressure on municipal systems and processes. A high volume of land use, infrastructure, and regulatory applications across all spheres of government may impose a substantial burden on less-equipped municipalities. Continued implementation of the planning support mechanisms established under the Small GH_2 scenario will be necessary to sustain investment and manage the increased workload.

Major infrastructure requirements, including a rail link from Kenhardt to Boegoebaai, inland hydrogen pipelines, and expanded wind and solar energy facilities, will intensify land use pressures, servitude requirements, construction impacts, and impacts on affected landowners. Careful spatial planning will also be necessary to prevent over-concentration of investment in a few growth towns, necessitating balanced investment and attention to the preservation of Nama and traditional communities in remote areas.

2.2.3.2 Settlement development and service delivery implications

- **Baseline Scenario (no port, SEZ or GH_2 development)**

Opportunities/Positive Impacts: **Large-scale regional investments could stimulate modest settlement growth and service improvements in key towns across the Namakwa region.** The Namakwa SEZ is expected to attract skilled workers, influencing settlements such as Aggeneys and Pofadder, while the potential Vioolsdrift Dam and Namakwa irrigation projects could affect settlements along the N7 corridor and the Orange River. Incremental growth may also occur in Port Nolloth and Alexander Bay, while Springbok, as the regional anchor town, could experience modest expansion due to its range of services and proximity to mining activity. Additional projects, such as the revitalisation of Port Nolloth harbour, regional solar and wind developments, a new regional hospital, and the Springbok airport upgrade, could also influence settlement patterns and service demands across the region, providing limited opportunities for economic and infrastructure improvement.

Negative Impacts: **Many settlements in the region remain vulnerable due to constrained municipal infrastructure and limited economic diversification.** Alexander Bay, in particular, faces uncertainty and potential decline without continued financial support from Alexkor or the state. Local service infrastructure, including water supply, waste management, and sanitation, requires urgent upgrades to meet current population demands. Without investment and economic diversification, towns may remain dependent on existing industries or government support, limiting their long-term resilience.

- **Sc1 (Small GH_2)**

Opportunities/Positive Impacts: **The development of the Port, SEZ, and associated RE projects is expected to stimulate settlement growth and local economic activity in nearby towns.** Port Nolloth and Alexander Bay are likely to attract both permanent residents and temporary construction workers, while Steinkopf and Springbok may benefit from spillover demand for accommodation and services. Workforce settlement is expected to increase demand for rental housing, estate development, and commercial services, creating opportunities for property investment and business diversification. Aggeneys and Pofadder may continue to benefit from economic activity associated with the Namakwa SEZ.

Negative Impacts: **Increased development activity is expected to place growing pressure on housing markets and municipal services in nearby settlements**. Limited onsite accommodation at the SEZ and Port area means that workers are likely to reside primarily in Alexander Bay, Port Nolloth and possibly Springbok, with commuting patterns shaping settlement choices. Rising demand for accommodation may lead to increased property prices, expansion of temporary housing or site camps, and the potential growth of informal settlements. Municipalities may face increased demand for water, electricity, sanitation, waste services and social facilities, while heavy vehicle traffic associated with construction and freight transport could create safety concerns and reduce the tourism appeal of Port Nolloth.

- **Sc2 (Big GH_2)**

Opportunities/Positive Impacts: **At full development scale, the Boegoebaai GH_2 programme could drive sustained regional investment and more stable settlement growth.** Fully operational port facilities and transport networks may attract significant public and private investment, while the operational phase reduces construction-related pressures such as heavy vehicle traffic. Residential settlement by operational employees and their households is likely to increase demand for housing, commercial services and social infrastructure, supporting local economic diversification. Continued investment in green energy infrastructure may also strengthen regional skills development and long-term employment opportunities, with towns such as Steinkopf and Springbok potentially expanding as residential hubs.

Negative Impacts: **Continued population growth and settlement expansion could place sustained pressure on municipal infrastructure and social services**. Increased demand for water, sanitation, waste

management and social facilities may exceed existing municipal capacity if upgrades are not implemented. Without targeted skills development and economic inclusion, some households may remain dependent on government support. Inadequate housing provision may contribute to the expansion of informal settlements, while smaller and more remote settlements are likely to experience only marginal benefits from regional growth.

2.2.3.3 Construction of large economic infrastructure projects (Rail, hydrogen pipeline, electricity transmission & green energy, and Port & SEZ site)

- **Baseline Scenario (no port, SEZ or GH_2 development)**

Under the baseline scenario, the proposed port and SEZ do not materialise. Infrastructure development in the region remains limited and largely maintenance driven. Existing freight flows continue to utilise established export corridors, including rail links to ports such as Port of Saldanha Bay, Port of Ngqura and Port of Lüderitz. Freight movement remains dependent on the existing road and rail systems, with no new railway link constructed to Boegoebaai.

Road infrastructure, including the N7, N14 and R382, continues to function at relatively low freight volumes. While SANRAL has incorporated sections such as the R382 into its maintenance programme, broader funding constraints limit upgrades, particularly for municipal gravel roads serving smaller settlements. As a result, infrastructure conditions largely remain unchanged, with ongoing deterioration in some areas due to financial limitations.

No new rail line is constructed to Boegoebaai, and regarding the hydrogen economy, the baseline scenario assumes that South Africa's GH_2 transition progresses independently of Boegoebaai, with other hubs (i.e., Lüderitz and Saldanha) continuing to develop. A cross-national hydrogen pipeline remains conceptually possible, although the feasibility of its design may change if Boegoebaai does not contribute hydrogen volumes. Additionally, the absence of Boegoebaai as a hydrogen hub could significantly affect the proposed east–west pipeline, which would depend on Boegoebaai-linked hydrogen production.

- **Sc1 (Small GH_2)**

In the short to medium term, freight transport to the port is expected to rely predominantly on road-based haulage. Mining commodities, especially manganese, are transported via the N14, N7 and R382 corridors. **Heavy vehicle volumes increase substantially, potentially reaching more than 500 trucks per day in early operational years. This places significant pressure on the R382 in particular, which has reached the end of its design life and was not engineered for sustained heavy-haul traffic**. This is likely to curtail tourism and agriculture along that route, particularly east of Augrabies Falls. Reconstruction, strengthening, and the addition of climbing lanes at Anenous Pass become critical interventions.

Construction activities associated with the port, SEZ, RE facilities, pipelines and supporting road upgrades generate further impacts, including:

- Increased risk of traffic accidents and congestion through towns such as Springbok, Steinkopf and Port Nolloth;
- Deterioration of existing road surfaces;
- Temporary disruption due to roadworks;
- Demand for borrow pits, construction camps and bulk materials.

Rail infrastructure is not immediately developed due to high capital costs, and road freight remains dominant until export volumes exceed approximately 10 Mtpa. Planning for a future rail link begins during this stage/phase.

Pipeline infrastructure becomes more defined under this scenario. A north–south hydrogen corridor linking Lüderitz, Boegoebaai and Saldanha is advanced, with feasibility assessments and environmental authorisations underway. **Land acquisition, servitude establishment and routing decisions introduce potential land use conflicts**, although the 2019 Gas pipeline SEA guidance seeks to minimise displacement and ecological disturbance.

Renewable energy generation expands to approximately 10 GW to support a 5 GW electrolyser. This requires extensive land areas for solar and wind facilities, much of which must be located outside the immediate Boegoebaai footprint due to land ownership patterns and ecological constraints. **Increased demand for electricity transmission capacity emerges, requiring alignment with national Transmission Development Planning and potentially new grid infrastructure**.

- **Sc2 (Big GH_2)**

The big GH_2 scenario reflects full industrial maturation and large-scale regional transformation. At this stage, the port is fully operational, GH_2 production has expanded significantly, and freight volumes increase substantially. **Heavy vehicle traffic on the N14, N7 and R382 remains high, but a new rail line (justified once freight volumes exceed 10 Mtpa) is constructed to relieve pressure on the road network**.

The proposed 500 km standard-gauge rail line connects Boegoebaai to the Sishen–Saldanha corridor, including tunnels, bridges and major earthworks. **While this reduces long-term road freight impacts, it introduces substantial construction-phase disturbances, land acquisition requirements, and environmental authorisation risks**.

Hydrogen pipeline infrastructure expands further to include both north–south and west–east corridors, positioning Boegoebaai as a national and transnational energy hub. **The scale of construction increases spatial impacts across the province, with potential effects on biodiversity areas, land use patterns, and settlements along the corridors.** Strategic routing within gazetted corridors should be prioritised to reduce spatial resistance and environmental risk.

Renewable energy requirements escalate dramatically to approximately 80 GW to support a 40 GW electrolyser. This entails very large land footprints for solar and wind installations, potentially distributed across multiple provinces to ensure energy security and grid stability. Transmission infrastructure expansion becomes critical, with new high-voltage lines required to wheel power to the site. **The adequacy and timing of national electricity grid expansion become a key risk factor**.

While this scenario offers significant economic integration and export capacity for the Northern Cape, it also presents heightened environmental, financial and planning risks due to the scale, cost and complexity of infrastructure implementation.

2.3 Risk/Opportunity Assessment

WP2 applied a structured qualitative framework to evaluate the risks (negative impacts) and opportunities (positive impacts) associated with a regional GH_2 economy under different scenarios (Section 2.2), and, where applicable, per spatial receiving environment's sensitivity (Figure SPM 4). Risk or opportunity was determined by combining the likelihood of an event occurring with the severity of its consequence or benefit (refer to WP2 Chapter 1). Consequence and benefit thresholds were defined for each theme (e.g., biodiversity, water resources, socio-economic systems) using categories ranging from Slight to Extreme, while risk and opportunity levels were classified into predefined categories from **VERY LOW** to **VERY HIGH** (Table SPM 5).

Table SPM 5: Predefined risk/opportunity categories.

RISK (-)		OPPORTUNITY (+)	
VERY LOW	Almost indiscernible negative impact.	Almost indiscernible positive impact.	VERY LOW
LOW	Slight negative impact, limited extent, and short duration, well within tolerance.	Slight positive impact, very localised, well below expectations.	LOW
MODERATE	Substantial impact, but less than major; within tolerance and below limits of acceptable change.	Substantial positive impact, but mostly short term, and spatially limited.	MODERATE
HIGH	Major consequence, approaching tolerance and limits of acceptable change.	Highly desirable impact, major medium to long term positive impacts across a broad range of stakeholders at local or regional scales.	HIGH
VERY HIGH	Extremely negative impact, persistent/long lasting, beyond tolerance and limits of acceptable change.	Highly desired, grandiose long term positive impacts across a broad range of stakeholders at local, regional, national, and/or international scales.	VERY HIGH

Each impact was assessed across three scenarios [baseline (Sc0), small GH_2 development (Sc1), and large GH_2 development (Sc2)] and for different receiving environments, both before and after management interventions. Results are presented in structured outputs for risks (negative) and for opportunities (positive).

Table SPM 6 and Table SPM 7 respectively present a consolidated summary of the risk and opportunity assessments conducted across all themes evaluated in the WP2 SEA. Each row reflects a single impact under one of the three development scenarios (Sc0: Baseline, Sc1: Small GH_2, Sc2: Big GH_2), with mean scores reported both without and with the application of management measures on a five-point ordinal scale (1 = Very Low to 5 = Very High). The mean score is calculated by averaging the individual risk or opportunity ratings assigned to each spatial receiving environment assessed for that impact–scenario combination, and cell colour reflects the band of that mean score using the predefined risk and opportunity categories set out in Table SPM 5. It is important to note that these tables are a simplified summary intended to enable cross-theme and cross-scenario comparison at a glance; the mean score compresses the full distribution of ratings across receiving environments, and individual environments of high or very high sensitivity may carry significantly higher ratings than the mean suggests. For the complete impact-by-impact, environment-by-environment assessment — including consequence and likelihood ratings, mitigation measures, and residual risk determinations — consult the full theme-specific assessments, from which these tables are derived (Appendix SPM.1.).

@bAcross most themes, risks were found to be HIGH to VERY HIGH without mitigation, particularly in areas of HIGH or VERY HIGH sensitivity and under the larger GH_2 development scenarios. Implementation of appropriate planning, design and mitigation measures can reduce many risks to MODERATE, LOW or VERY LOW, although residual risks remain in sensitive environments. In a similar way, opportunities generally increase with development scale and are most pronounced in key economic nodes such as Port Nolloth, Alexander Bay, and the SEZ area.

Within the ecology theme, both biodiversity pattern (direct habitat and species loss) and ecological processes show VERY HIGH risks without mitigation across most sensitivity classes. Even under smaller GH_2 scenarios, impacts remain **HIGH** in landscapes of higher ecological value. With mitigation, risks generally reduce to **MODERATE or LOW**, particularly in areas of lower sensitivity. These findings highlight the importance of avoiding sensitive ecosystems and maintaining ecological patterns and connectivity where possible.

For avifauna, key risks include displacement and disturbance caused by infrastructure and human activity, as well as collision and electrocution risks associated with wind turbines, powerlines and substations. These impacts were frequently assessed as **HIGH to VERY** HIGH without mitigation, especially in highly sensitive environments. With mitigation measures, such as careful siting of turbines, bird-safe powerline design and monitoring, risks can be reduced to **MODERATE or LOW**, although highly sensitive areas may still experience unacceptable residual impacts despite mitigation.

For bats, risks relate primarily to destruction or disturbance of roosts, loss or fragmentation of foraging habitat and bat fatalities due to collision or barotrauma caused by wind turbines during foraging and migration. Without mitigation, these impacts range from MODERATE to VERY HIGH, depending on landscape sensitivity and development scale. Mitigation measures can reduce risks to **LOW or VERY LOW** in lower sensitivity areas, and to **LOW or MODERATE** in medium-sensitivity areas, through measures such as avoiding roosts and implementing controls. However, in high and very high sensitivity areas, impacts may remain **MODERATE to HIGH or VERY HIGH** even after mitigation, particularly where important roosting habitats occur.

Impacts on terrestrial fauna relate to habitat loss and fragmentation, disruption of ecological corridors and migration pathways, and increased mortality risks associated with roads, fencing and infrastructure. In highly sensitive landscapes these impacts are assessed as **VERY HIGH** without mitigation, but can be reduced to **MODERATE or LOW** where effective mitigation and spatial planning measures, such as wildlife corridors, buffer zones and fauna-friendly infrastructure, are implemented.

Within the water resources theme, risks vary across groundwater and surface water systems in a region. Groundwater availability and security generally show LOW to MODERATE risks, while groundwater quality may experience MODERATE risks where development intersects sensitive hydrogeological environments. Surface water resources and inland aquatic ecosystems, including rivers, wetlands and pans, show **MODERATE to HIGH** risks without mitigation, particularly where infrastructure intersects aquatic systems. Potential impacts on estuaries, including the Orange River estuary and associated micro-estuaries, are also noted as **MODERATE to HIGH** without mitigation, although these can be reduced through appropriate management. Opportunities associated with groundwater availability and security and surface water resources are generally assessed as **LOW to MODERATE** with management, particularly in higher sensitivity areas where improved water infrastructure and management systems may be required to support development.

For heritage resources, archaeological resources show VERY HIGH risks without mitigation, reflecting the high density of archaeological material across the region. Palaeontological resources show **MODERATE** to **HIGH** risks, while risks to the built environment and cultural landscapes range from **MODERATE to VERY HIGH** depending on sensitivity. With mitigation, these risks generally reduce to **MODERATE or LOW.** Opportunities are generally **LOW to MODERATE**. Palaeontological and archaeological resources show LOW opportunities, mainly associated with improved documentation, research, and heritage management resulting from development-related studies. Within the built environment and living heritage, opportunities increase to **MODERATE or HIGH** with management, particularly where investment in heritage conservation, tourism infrastructure, and cultural recognition accompanies regional development. Cultural landscapes may experience **MODERATE to HIGH** opportunities, particularly where development stimulates heritage-sensitive tourism and landscape interpretation initiatives.

For infrastructure and planning, risks associated with development planning pressure, road corridors, rail corridors, and energy project corridors/sites are consistently rated VERY HIGH without mitigation due to the scale of infrastructure required. With effective strategic spatial planning, corridor consolidation and infrastructure management, these risks can be reduced to **MODERATE or LOW**. Settlement infrastructure development presents **MODERATE to HIGH** opportunities, particularly in emerging development clusters such as the Steinkopf–Springbok corridor and settlements near the proposed development zones. Investments in housing, services, and supporting infrastructure could strengthen regional development capacity and improve living conditions in key settlements.

Within the socio-economic theme, GH_2 development presents both risks and opportunities. Population shifts, pressure on housing and municipal services, pressure on health services show **LOW to MODERATE** risks, although larger scenarios may result in HIGH risks in key nodes such as Port Nolloth and Alexander Bay, where population influx and construction activity are expected to concentrate. Tourism presents opportunities and risks; while new infrastructure and increased regional visibility may support tourism development, particularly in the Port Nolloth–Alexander Bay area and the Springbok region, heavy trucking, industrialisation and loss of the region's remote character could negatively affect tourism if not carefully managed. Export agriculture shows significant opportunities, particularly where improved logistics, port access and regional connectivity support agricultural value chains linked to the Orange River irrigation areas, although risks such as dust contamination of export crops must be managed. Job creation represents one of the most significant opportunities associated with GH_2 development.

Employment opportunities are rated HIGH to VERY HIGH, particularly in the larger GH_2 scenarios and in key development nodes. These opportunities arise from construction activities, energy generation infrastructure, port development, logistics, and associated service industries. Additional socio-economic benefits include improved regional broadband roll-out, where development-driven investment could lead to **MODERATE to HIGH** opportunities for improved digital connectivity across the region, particularly in rural settlements and development corridors.

Table SPM 6: Risk – consolidated summary of the risk assessments conducted across all themes evaluated across. Each row presents the average risk rating for a specific impact under one of the three assessment scenarios (Sc0 Baseline, Sc1 Small GH_2, Sc2 Big GH_2), calculated as the mean score across all assessed spatial receiving environments, before and after the application of management measures.

COLOUR KEY: RISK

VERY LOW **LOW** **MODERATE** **HIGH** **VERY HIGH**

Theme	Impact	Scenario	Mean risk — without management		Mean risk — with management
Terrestrial Ecology	Biodiversity pattern impacts	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Ecological process impacts	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Bats	Destruction/disturbance of bat roosts	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Bat foraging habitat loss	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Bat mortalities	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

Theme	Impact	Scenario	Mean risk — without management		Mean risk — with management
Water Resources & Aquatic Ecology	Groundwater availability and security	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Groundwater quality	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Surface water resource availability, quality and security	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Inland aquatic ecosystems (rivers, wetlands and pans)	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Degradation of estuaries (including the Orange River Estuary) and micro-outlets	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Avifauna	Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Displacement due to Habitat loss/ fragmentation/ transformation	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Injury or mortality due to collisions with wind turbines, solar panels, powerlines and masts/towers	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

Theme	Impact	Scenario	Mean risk — without management		Mean risk — with management
Fauna	Displacement due to Habitat loss & fragmentation	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Changes to Ecological functioning and processes	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Heritage	Palaeontological resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Archaeological resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Maritime resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Graves	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Built environment	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Living heritage	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Cultural landscape	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

Theme	Impact	Scenario	Mean risk — without management		Mean risk — with management
Infrastructure and Planning	Development planning pressure	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Settlement infrastructure development & management	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Construction of Economic Infrastructure Projects	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Socio-Economics	Population shifts	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Pressure on housing and municipal services	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Pressure on health services	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Social ills due to boomtown conditions	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Tourism	S1: Small GH2		→	
		S2: Big GH2		→	
	Export agriculture	S1: Small GH2		→	
		S2: Big GH2		→	
	Municipal capacity - technical	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Municipal capacity - political engagement and facilitation	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

Table SPM 7: Opportunities – consolidated summary of the opportunity assessments conducted across all themes evaluated across. Each row presents the average risk rating for a specific impact under one of the three assessment scenarios (Sc0 Baseline, Sc1 Small GH_2, Sc2 Big GH_2), calculated as the mean score across all assessed spatial receiving environments, before and after the application of management measures.: Theme-specific opportunity assessment of the impacts across the baseline scenario (Sc0) and two GH2 development scenarios (Sc1 & Sc2).

COLOUR KEY: OPPORTUNITY

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

Theme	Impact	Scenario	Mean opportunity score — without management		Mean opportunity score — with management
Water Resources & Aquatic Ecology	Groundwater availability and security	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Surface water resource availability, quality and security	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Heritage	Palaeontological resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Archaeological resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Maritime resources	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

Theme	Impact	Scenario	Mean opportunity score — without management		Mean opportunity score — with management
Heritage (cont.)	Graves	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Built Environment	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Living Heritage	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Cultural Landscape	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
Infrastructure and Planning	Settlement Infrastructure Development	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Job creation	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Skills development	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	
	Regional broadband roll-out	S0: Baseline		→	
		S1: Small GH2		→	
		S2: Big GH2		→	

3. STRATEGIC PLANNING AND GOVERNANCE RECOMMENDATIONS

Given the scale, spatial footprint and transformative potential of the proposed Boegoebaai Port, SEZ and associated GH_2 programme, strategic planning and governance alignment are essential to ensure that development decisions are robust, equitable and environmentally responsible. This section synthesises the multidisciplinary findings of the WP2 SEA into strategic management and regional planning actions to guide policymakers, planners, regulators and project developers. The evidence emanating from WP2 is that development feasibility in the Namakwa Region is not primarily constrained by a lack of space or land availability, but by the need for informed spatial selectivity, institutional readiness and well considered developmental sequencing. While large areas of the region are environmentally and socially sensitive, sometimes extremely so, there are landscapes of lower sensitivity where development could be considered, provided that strict avoidance of critical areas, proactive mitigation, spatial design standards, and coordinated governance arrangements are applied. Additionally, there are landscapes in the region, of which the proposed SEZ is one, where prior ecological degradation has progressed to such an extent that the 'do nothing' alternative is no longer viable for protecting biodiversity, and some scale of restoration intervention is required, whether market-driven or state-funded. This is especially true in the context of shifting climatic patterns in the region and loss of resilience in areas which are already partly or fully degraded.

3.1 Climate Change, Ecosystem Degradation, and Implications for Planning

Land-use planning must move beyond impact minimisation and actively promote ecosystem resilience. Strategic planning frameworks should explicitly integrate climate change refugia and areas of existing ecological degradation into spatial decision-making, ensuring that development is steered away from systems that are already under stress and does not exacerbate ongoing decline. Climate change is potentially the most significant long-term threat to biodiversity in the Namakwa Region, acting as a pervasive pressure that amplifies the impacts of land-use change, infrastructure development and habitat fragmentation. Vegetation productivity trend analyses indicate widespread signals of declining productivity and ecological stress throughout the region, with particularly pronounced trends in the Richtersveld and adjacent landscapes. A high proportion of the region's vegetation types trigger Red List of Ecosystems (RLE) risk thresholds, reflecting disruption of key ecological processes rather than historical habitat loss alone. These patterns signal declining ecosystem resilience and reduced capacity to absorb additional disturbance.

3.2 High Sensitivity Areas that must be Avoided

Extensive VERY HIGH sensitivity areas across the region contain irreplaceable biodiversity features, concentrations of SCC, and critical ecological processes, and are not suitable for development. These areas underpin regional ecological integrity and are central to achieving biodiversity conservation targets.

a) **HIGH and VERY HIGH biodiversity sensitivity landscapes**: much of the region falls within the Succulent Karoo Biome, a global biodiversity hotspot characterised by exceptional endemism and ecological uniqueness. Areas that should be avoided include (Box SPM 22):
   - Core biodiversity areas and protected areas, including national parks, nature reserves and formally identified expansion areas;
   - Landscapes with concentrations of threatened or endemic plant species, quartz patches, gravel plains, south-facing slopes and mountain systems;
   - Areas identified as having **VERY HIGH** cumulative biodiversity sensitivity where multiple ecological receptors (plants, fauna, birds, bats and aquatic systems) overlap.

   Development in these areas would result in irreversible biodiversity loss and would likely trigger offset requirements of a scale that is ecologically and institutionally impractical.

b) **Avifauna- and bat-sensitive areas**: these are extensive areas of **VERY HIGH** sensitivity for avifauna and bats, particularly in relation to wind energy development. These include:
   - Flight corridors used by large raptors and bustards;

- Areas supporting endemic or threatened bird species;
- Water-associated landscapes critical for bat foraging and movement;
- Limestone and cavernous geological formations with high roosting potential.
- Large bat roosts, caves and their associated buffers.

Wind energy and tall infrastructure should be excluded from these landscapes, with avoidance being prioritised over reliance on post-construction mitigation.

c) **Water resource protection areas:** given the extreme aridity of the region, groundwater systems, strategic water source areas, wetlands and the Orange River corridor are highlighted as critical constraints. Development should avoid:

- Strategic Water Source Areas around Port Nolloth, Kommagas and the Kamiesberg;
- Floodplains, pans and ephemeral river systems (these are highly vulnerable to disturbance);
- Areas where pollution risks could compromise already stressed water supply systems.

Overall, water scarcity and the extreme ecological sensitivity of the region's aquatic systems represent some of the most significant constraints on future development. Sustainable expansion of renewable energy and GH_2 infrastructure would only be feasible if paired with major investment in desalination, water treatment, reticulation upgrades, and strict avoidance of high-sensitivity aquatic and groundwater recharge areas, alongside a shift toward a circular water economy designed to prevent unintended changes to natural hydrological regimes.

d) **Heritage and cultural landscapes**: the Namakwa Region contains dense and often unmarked heritage resources, particularly along the coast and within communal lands. Areas to be avoided include:

- The Richtersveld Cultural and Botanical Landscape World Heritage Site and its buffer zones;
- Coastal dune systems with high densities of archaeological material and unmarked graves;
- Recognised cultural landscapes, scenic routes and areas of high sense-of-place value.

Avoidance is especially important because many heritage resources are only detected once disturbed, making post-impact mitigation largely ineffective.

Box SPM 22: Location of biodiversity features requiring strict avoidance

Irreplaceable and non-offsettable biodiversity features are not uniformly distributed, but are concentrated in distinct parts of the Namakwa Region, including:

- **The Richtersveld**, including the Richtersveld National Park, the Richtersveld Cultural and Botanical Landscape World Heritage Site, and adjacent communal lands, which contain centres of endemism, climate refugia, mountain systems and living cultural landscapes.
- **The Kamiesberg mountain system**, where quartzite mountains, south-facing slopes, high plateaus and relict ecosystems support exceptional levels of plant endemism and act as key climate refugia.
- **The Bushmanland Inselberg Region**, where isolated inselbergs and gravel plains host narrowly distributed endemic species concentrated in discrete microhabitats.
- **Intact Sandveld dune systems along the west coast**, which support Sandveld endemic mammals such as De Winton's golden mole, Van Zyl's golden mole and the Namaqua dune molerat, and are highly vulnerable to disturbance and sand mobilisation.
- **The Alexander Bay lichen fields**, located in the far north-western coastal zone, internationally recognised for their unparalleled lichen diversity and extreme sensitivity.
- **Protected areas and formally identified protected area expansion priority zones**, including landscapes required to meet long-term conservation targets and maintain ecosystem representation.

3.3 Targeted Low Sensitivity Development Areas

A defensible approach to enabling development while safeguarding ecological systems, heritage and social systems is to concentrate infrastructure and land-intensive activities in landscapes that are already transformed, degraded, or of comparatively lower sensitivity (Box SPM 23)**, and to avoid expansion into intact, high-value systems.** At a regional scale, areas of comparatively lower sensitivity have been considered. These areas provide opportunities to reduce additional habitat loss, limit fragmentation, and contain impacts within landscapes that have already absorbed substantial historical disturbance. Based on the WP2 findings, three key locational principles emerge to guide spatial decision-making:

a) **Coastal zone landscapes: historic diamond mining along the Namaqualand coast has left an extensive belt of disturbed land, particularly between Kleinzee and Alexander Bay**. These landscapes exhibit substantially altered geomorphology and biodiversity condition, with ongoing challenges related to sand mobilisation and long-term rehabilitation. Within this coastal mining belt, there is comparatively greater flexibility for siting wind energy infrastructure and associated facilities, provided that:
   - Development is restricted to already disturbed footprints;
   - Turbine foundations and access infrastructure are designed to integrate with engineered sand stabilisation measures;
   - Setbacks from sensitive coastal features, estuaries and intact dune systems are strictly enforced;
   - Development avoids avifaunal and bat movement corridors, sensitive heritage resources, and climate refugia; and is spatially configured to minimise any additional fragmentation and disruption of coastal geomorphological processes.

   The proximity of these areas to the proposed Boegoebaai Port also reduces the need for extensive new transmission corridors, thereby limiting additional and sprawling landscape fragmentation.

   This principle requires that turbine placement, access roads, hardstands and transmission infrastructure are confined to existing disturbance envelopes, that new linear

Box SPM 23: Why 'lower sensitivity' does not mean 'low risk'

Lower-sensitivity areas identified in WP2 provide relatively greater flexibility for development, but they are not impact-free landscapes. Even in these areas, poorly planned or cumulative development can result in significant ecological (including avifauna, bats and fauna), hydrological and social consequences. The designation of lower sensitivity should therefore be understood as a comparative planning signal, not a blanket approval for development. All projects remain subject to site-specific assessment, mitigation and monitoring.

Box SPM 24: Wind turbines and coastal fog dynamics

Coastal fog dynamics are vital for sustaining life in arid landscapes like the Richtersveld because many uniquely adapted plants and animals rely on the moisture delivered by regular fog rolling in from the cold Atlantic Ocean (locally called "Ihuries" or "Malmokkies") as a primary water source in an otherwise extremely dry environment (SANParks, 2026).

Although fog plays an important ecological role along the coast, especially in arid environments, scientific research specifically examining how land-based coastal wind turbines influence fog movement inland is currently lacking, and no studies have quantified whether turbines disrupt, delay, or enhance the inland penetration of fog into arid ecosystems. This represents a significant research gap for regions where fog-dependent biodiversity is both unique and vulnerable.

However, evidence from offshore wind farms shows that turbines can alter fog formation and atmospheric behaviour, including cases where windfarm induced blockage and wake effects have triggered or shaped fog patterns (Hasager et al, 2023). While this offshore evidence does not directly confirm similar effects for land based coastal turbines, it suggests plausible mechanisms by which they *could* alter fog dynamics near the shore.

The importance of fog in arid ecosystems, combined with offshore evidence of turbine related fog modification, underscores the need for dedicated research to understand potential impacts of coastal wind development on inland fog dependent biodiversity.

infrastructure is minimised and co-located with existing disturbed routes, and that development does not exacerbate sand mobilisation, interfere with fog-driven ecological processes, or encroach into adjacent intact coastal systems. Where these spatial conditions cannot be met, wind development should not proceed, irrespective of perceived energy potential.

b) **Inland low-sensitivity plains for PV development: inland of the coastal escarpment are extensive tracts of arid plains with comparatively lower biodiversity sensitivity, particularly where vegetation productivity is already low and where threatened ecosystem representation is less concentrated**. These areas are **generally more suitable for large-scale PV installations**, which have a lower vertical footprint and reduced collision risk compared to wind energy. However, even within these lower-sensitivity areas, development must avoid:
   - Drainage lines, pans and ephemeral river systems;
   - Areas associated with groundwater recharge, wetlands or strategic water source areas;
   - Known heritage landscapes, including palaeontologically sensitive formations and archaeological site clusters;
   - Priority biodiversity features.

   Strategic planning should therefore promote PV development as clustered precincts within these inland plains, rather than dispersed individual projects, to reduce cumulative land transformation and simplify monitoring and governance.

   This principle requires that PV arrays are configured to maintain unbuilt corridors and landscape permeability, avoid continuous blanket coverage of large areas, and avoid grading, stripping and sealing of soils critical to arid-zone ecological function. Development suitability is contingent not only on location but on layout and spacing at precinct scale, and on demonstrated feasibility of water supply and servicing without compromising ecological or municipal resilience.

c) **Infrastructure corridors and nodal consolidation**: a corridor-based development model is strongly supported, particularly along the N14 and the proposed SEZ logistics routes. Concentrating pipelines, transmission lines, roads and (where feasible) rail infrastructure within shared servitudes reduces landscape fragmentation, limits repeated disturbance and improves regulatory oversight. This approach is especially critical given the scale of linear infrastructure required under the larger GH_2 scenarios.

   This principle requires proactive co-location of linear infrastructure, avoidance of parallel or duplicated corridors, and alignment that prioritises ecological process integrity over shortest-route or least-cost considerations. Clustering is not appropriate where it would concentrate impacts beyond ecological or social thresholds, compromise sensitive systems, or exceed the institutional capacity required for coordinated planning, monitoring and adaptive management.

3.4 Strategic approach to biodiversity offsets and ecological compensation at a regional scale (after Botha, 2026 and Desmet et al., 2026)

The Namakwa region is characterised by exceptionally high biodiversity sensitivity at a landscape scale, combined with widespread existing and proposed development pressures. Approximately 71% of the regional planning domain contains sensitive biodiversity features, including CBAs, Protected Area Expansion Priority Focus Areas, under-protected vegetation types, and concentrations of SCC. As a result, complete avoidance of biodiversity impacts is unlikely, even under relatively modest GH_2 development pathways.

The WP2 SEA biodiversity framework emphasises that biodiversity offsets and ecological compensation (Box SPM 25) **are not a substitute for avoidance or minimisation, and cannot be used to justify development in areas where impacts on Critical Habitat or irreplaceable biodiversity features are unavoidable**. For developments seeking alignment with international finance standards and GH_2 market requirements, demonstrable application of the mitigation hierarchy is non-negotiable, with offsets positioned strictly as a mechanism of last resort to address residual impacts.

Box SPM 25: Offset versus ecological compensation

Biodiversity offsets aim to achieve no-net-loss or net-gain outcomes for biodiversity features, and ecological compensation may be considered only where residual impacts cannot be fully offset. Ecological Compensation carries significantly higher regulatory, financial and governance risks and should be avoided through early spatial planning and avoidance wherever possible

At a regional scale, biodiversity offsets are most likely to be triggered by the cumulative footprint of GH_2-related infrastructure, rather than by any single facility. Even relatively modest GH_2 development pathways (e.g. under Sc1) are expected to result in extensive cumulative land use, with larger or more accelerated development pathways substantially increasing the scale of residual biodiversity impacts, particularly when linear infrastructure is included, excluding indirect and induced effects. Linear infrastructure, such as transmission lines, pipelines, rail corridors and access roads, substantially amplifies both the spatial extent and ecological significance of impacts, particularly where these intersect with ecological corridors, bird movement pathways or under-protected vegetation types.

Offsets are therefore most likely required where development unavoidably affects (i) CBAs and ESAs, (ii) habitats supporting SCC, (ii) vegetation types that are poorly protected within the national protected area network, and (iv) landscape-scale ecological processes, including connectivity. Where impacts compromise ecosystem persistence thresholds or affect Critical Habitat, standard biodiversity offsets may be insufficient or inappropriate, and the framework identifies the possible need for ecological compensation, subject to stringent justification and regulatory oversight. This significantly elevates regulatory, financial, and governance risk.

The WP2 Biodiversity Offset Framework does not designate specific offset sites, but identifies strategic offset opportunity areas at a regional scale. These receiving areas are defined to guide planning and sequencing decisions, recognising that offset requirements are likely to be large, cumulative, and long-term.

Potential offset receiving areas (Figure SPM 6) are located primarily within:

- **Protected Area Expansion Priority Areas**, particularly where these adjoin existing national or provincial protected areas and can contribute to consolidation of the protected area network;
- **large, intact inland landscapes** with relatively low current development pressure and high ecological integrity; and
- **areas capable of supporting contiguous offset landscapes**, rather than fragmented, isolated parcels.

Areas subject to existing or legacy mining and prospecting rights are explicitly identified as poor candidates for offsets, due to the risk of future land-use conflict and the difficulty of securing durable, enforceable

conservation outcomes. Similarly, degraded or previously mined coastal landscapes, while appropriate for development, are not considered suitable for offset receiving areas, as they are unlikely to deliver additional biodiversity gains.

The spatial pattern illustrated in Figure SPM 6 highlights that offset receiving opportunities are limited and highly constrained, reinforcing the need for early, coordinated regional planning. The map is indicative and explanatory and is intended to inform strategic decision-making rather than to define approved offset sites.

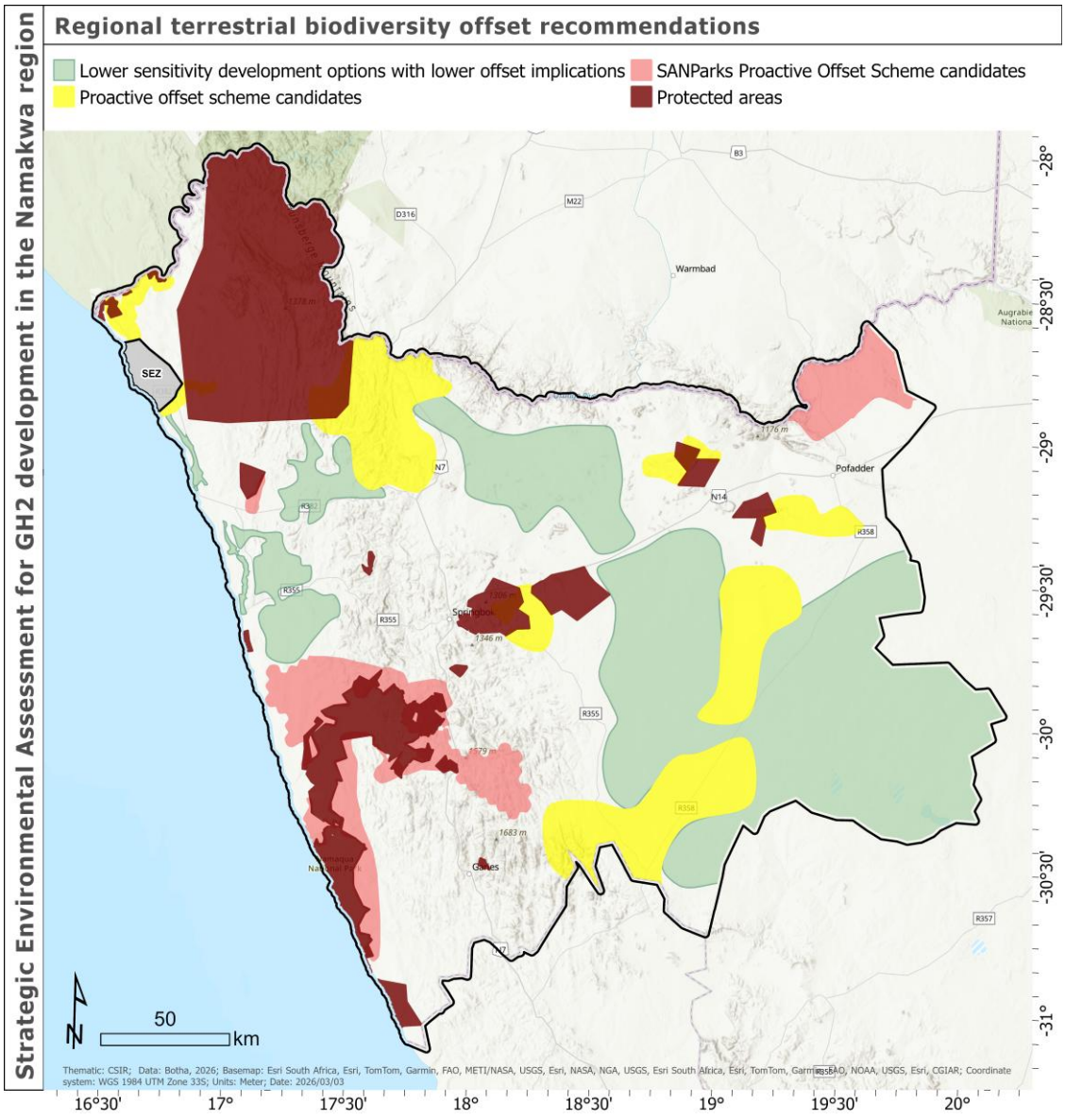


Figure SPM 6: Indicative biodiversity offset receiving opportunity areas and constraints within the WP2 planning domain, highlighting Protected Area Expansion Priority Areas, biodiversity priority features and areas excluded due to mining and development constraints (Botha, 2026)

The determined scale of potential offset requirements is unprecedented in the regional context. Applying nationally aligned offset ratios indicates that large-scale GH_2 development could require securing in excess of 180 000 ha of offset land, while even smaller development pathways could require tens of thousands of hectares. These magnitudes render project-by-project offsetting impractical (Box SPM 26), particularly in a region characterised by fragmented land tenure, legacy mining rights and limited institutional capacity.

To address this, a proactive, aggregated and regionally coordinated approach to biodiversity offsets is recommended, including:

- early identification of large, contiguous offset receiving areas;
- prioritisation of Protected Area Expansion Priority Areas and NPAES focus areas;
- resolution of conflicts with existing mining and prospecting rights in prospective offset zones; and
- establishment of durable stewardship, management and financing arrangements to ensure long-term biodiversity outcomes.

Box SPM 26: Why project-by-project offsets are not viable at scale

When offset requirements reach landscape scale, negotiating, securing and managing offsets on a project-by-project basis becomes inefficient, slow and conflict-prone. The biodiversity offset framework shows that without aggregation and coordination, offsets risk becoming a major bottleneck to development while failing to deliver meaningful biodiversity outcomes.

Offset considerations must be embedded in regional planning and governance frameworks upfront, rather than deferred to downstream project-level assessments. Spatial planning instruments such as SDFs, EMFs, SEZ master plans and renewable energy corridors should explicitly:

- steer development toward already degraded or previously mined landscapes, particularly along the coastal mining belt;
- align renewable energy generation, grid infrastructure and associated corridors with areas of lowest biodiversity sensitivity;
- and delineate areas where development would trigger unmanageable offset or compensation liabilities, effectively functioning as strategic avoidance zones.

Large-scale offsetting is fundamentally a governance challenge. Without early spatial direction, coordinated institutional arrangements and regulatory certainty, offsets can delay projects, increase investor risk, and fail to secure conservation outcomes. Proactive regional offset planning reduces uncertainty for both developers and regulators while improving biodiversity outcomes. It is recommended that proactive strategic and/or pooled offset mechanisms are explored, potentially linked to existing protected areas, to reduce fragmentation, improve efficiency, and enhance conservation effectiveness. Such mechanisms must be additional to, and not a substitute for existing public conservation funding.

3.4.1 Integrated GH_2 mitigation and biodiversity implementation plan

The biodiversity offset framework should not be implemented as a standalone intervention. Biodiversity offsets, ecosystem restoration, biodiversity economy development, biodiversity knowledge generation, refinement of biodiversity spatial planning tools, and protection of the region's sense of place should be coordinated through a single regional-scale GH_2 Mitigation and Biodiversity Implementation Plan. This approach will enable the proactive and coordinated implementation of biodiversity-related recommendations at a regional scale rather than through fragmented project-by-project initiatives. The implementation plan should:

- Support the regional biodiversity conservation vision and provide a spatial framework aligned with national and provincial protected area expansion strategies, Vision 2040, and other biodiversity planning priorities.
- Identify strategic biodiversity offset receiving areas, ecosystem restoration opportunities, and other priority mitigation interventions associated with GH_2 development.
- Clearly define the roles and responsibilities of key implementation partners, including government institutions, the scientific community, civil society organisations, non-governmental organisations and other relevant stakeholders.
- Establish a funding model linked to the scale of GH_2 investment to support biodiversity offset implementation, ecosystem restoration, conservation land acquisition and management, and biodiversity economy initiatives.
- Identify practical pathways for economic beneficiation associated with conservation investments and clarify beneficiaries of biodiversity economy initiatives linked to GH_2 development.

- Establish measurable implementation targets linked to 5-, 10- and 15-year planning horizons and aligned with the anticipated pace and scale of GH_2 development.

3.5 Provide for periodic (3-5 year intervals) review of implementation progress and outcomes, supported by independent oversight and reporting mechanisms.Refinement of biodiversity spatial planning tools

There is a need for continued investment in biodiversity spatial planning and sensitivity mapping to support informed regional decision-making. A priority action is the development of a regional biodiversity spatial framework that integrates biodiversity planning products, protected area expansion priorities and specialist sensitivity assessments into a coherent spatial planning tool. The framework should provide the spatial blueprint for protected area expansion, biodiversity offset implementation, development of the biodiversity economy, and strategic alignment of GH_2-related infrastructure and renewable energy development with biodiversity conservation objectives. The framework should be periodically updated as new ecological information becomes available, including improved understanding of ecological corridors, migratory pathways and other biodiversity features of regional importance.

3.6 Infrastructure and strategic planning recommendations (after Maritz et al.,2026)

Infrastructure capacity and planning readiness are among the most significant limiting factors for sustainable development in the Namakwa Region. **Corridor-led infrastructure planning should be prioritised to align roads, rail, pipelines and transmission infrastructure with the spatial clustering principles and to reduce cumulative impacts**.

Where large-scale ore and bulk material transport is envisaged, early investment in rail infrastructure is strategically preferable to long-term reliance on heavy road haulage, which poses severe risks to road condition, safety, tourism and settlement amenity. Rail transport, particularly for moving mining ore, should be adopted earlier, already in the Small Scenario, to avoid the substantial and growing risks associated with heavy haulage. **Water availability, treatment capacity and operational management must be recognised as binding constraints on development, with desalination and augmentation schemes planned and governed as regional systems rather than project-specific add-ons**.

Infrastructure investment should prioritise nodal settlements such as Port Nolloth, Alexander Bay, and Springbok to avoid dispersed informal growth. Implementation of these recommendations requires strengthened planning and regulatory capacity at municipal and district levels, proactive land access and tenure resolution, and coordinated inter-governmental governance arrangements.

3.7 Preliminary development planning guidance

Based on the integration of WP2 thematic assessments, preliminary development planning guidance is drawn (**Figure SPM 7**). The spatial guidance does not identify preferred or approved development areas, but rather differentiates areas and development options that, from a preliminary, strategic level, could present opportunities.

Theoretically, enough space of lower environmental sensitivity and lower offset implications exist in the Namakwa region to support RE development needed to meet the Boegoebaai GH2 ambitions. Despite the region's high overall ecological sensitivity, comparatively lower-sensitivity land exists across the inland plains, providing sufficient spatial opportunity to accommodate the 52,000–416,000 ha of RE footprints required under the small and large GH_2 scenarios. The identified RE development options (**Figure SPM 7**) are characterised by lower concentrations of priority biodiversity features, reduced heritage density, and fewer hydrological constraints, making them the most defensible areas for large-scale solar PV and associated RE infrastructure.

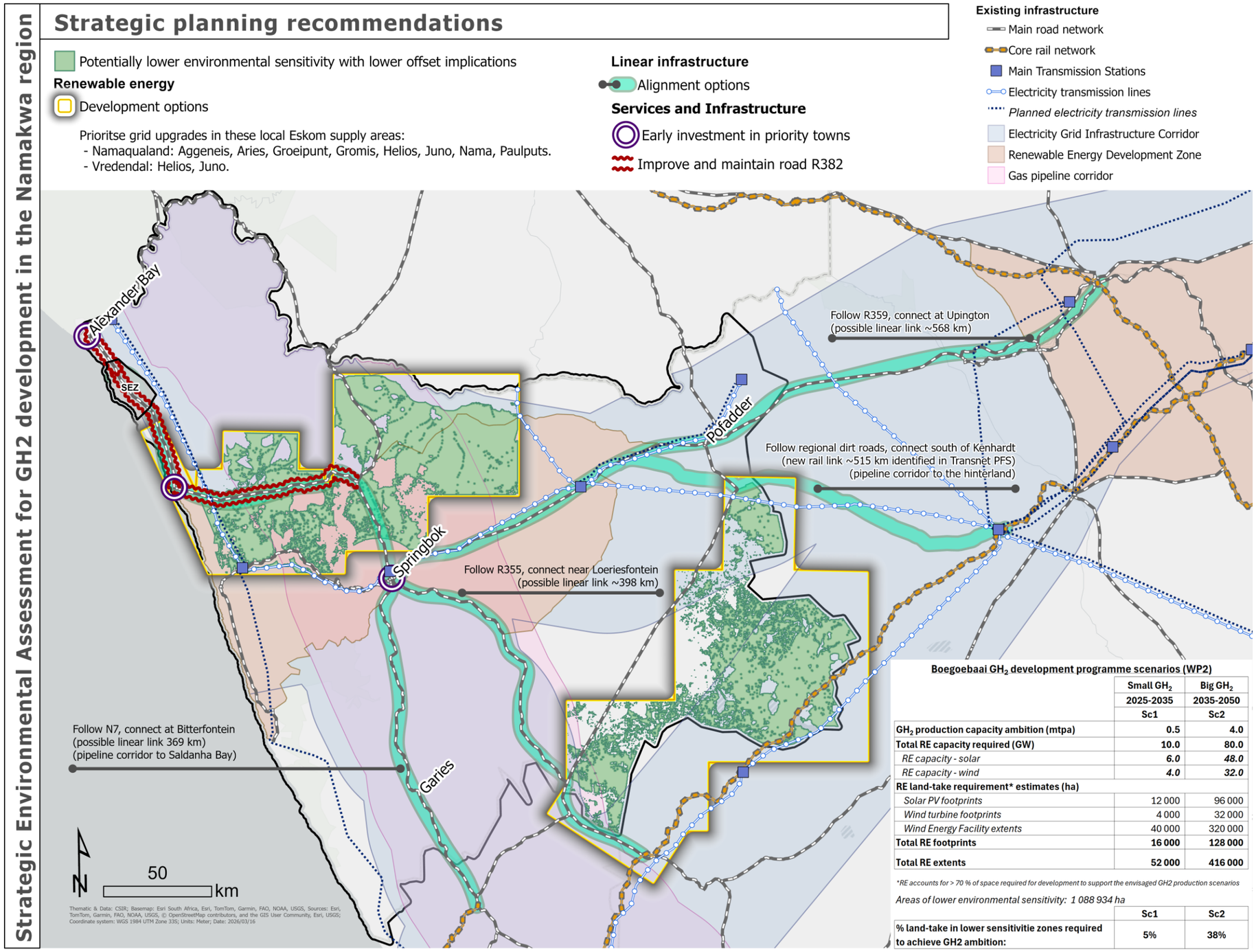
Although the areas exhibit relatively lower sensitivity at regional scale, all development must be subject to project-level environmental assessment and site-specific field verification, as these regions will still contain highly sensitive social and ecological features. While these areas still require site-level verification, the regional mapping confirms that theoretical land availability is not the binding constraint; instead, strategic siting within these lower-conflict zones is the key to enabling the green hydrogen vision without imposing unmanageable offset obligations.

It is necessary to target disturbed areas and existing linear corridors for development. New development footprints should first be directed toward already transformed areas and established infrastructure servitudes, where ecological and heritage sensitivities have already been substantially altered. Co-locating new roads, pipelines, transmission lines and rail within existing linear corridors such as the R382, N7, and N14 (**Figure SPM 7**) can minimise additional fragmentation and helps contain cumulative regional impacts. This approach ensures that development intensification occurs within landscapes already carrying ecological disturbance rather than creating new, parallel disturbance pathways.

Grid infrastructure and capacity availability is one of the most significant limiting factors for realising the Boegoebaai GH_2 programme. While lower-sensitivity land is available for renewable energy generation, the current grid has insufficient capacity and is spatially constrained to evacuate the scale of power required to support 5–40 GW of electrolysis. New and strengthened transmission infrastructure, particularly in the Eskom supply areas of Vredendal and Namaqualand (Eskom, 2023), must be prioritised early and strategically aligned within low-sensitivity zones and existing corridors to avoid high-impact areas. Without early grid expansion the region risks a scenario where RE potential exists but cannot be connected, effectively stalling GH_2 production and undermining the feasibility of the SEZ and port-related industrial development.

Upgrade and maintain upgrading and maintenance of key transport routes, particularly the R382 which would act as primary freight and mobility link to the Boegoebaai coastline. Under the small GH_2 scenario, truck volumes could exceed 500 heavy vehicles per day, placing unsustainable strain on a route that traverses multiple medium to highsensitivity zones near the coast. Upgrading, resurfacing, and maintaining the R382, especially at Anenous Pass, is non-negotiable, both to support construction logistics and to safeguard settlement safety, tourism routes, and emergency response capacity. Ideally, a rail line for transporting mining ore should be planned at an earlier stage to eliminate the need for high-volume truck haulage. Strengthening this corridor also avoids the need to carve new roads through intact dune systems, thereby aligning infrastructure development with the least conflict spatial envelope.

Early catalytic investment in anchor towns is necessary to support port and Special Economic Zone (SEZ) development. Port Nolloth, Alexander Bay, and Springbok area critical spatial nodes that must receive early investment to manage in-migration, construction phase demand, and long-term operational support for the proposed port and SEZ. These towns are relatively isolated settlement nodes surrounded by high-sensitivity landscapes, meaning outward expansion is limited and inward upgrading is essential. Prioritised investment in water supply, wastewater treatment, housing, roads, social services, and administrative capacity is needed to prevent unmanaged growth, informal settlement expansion, and local service pressures. Because these settlements could bear the brunt of Boegoebaai GH_2related economic and demographic pressures, proactive strengthening of their infrastructure and governance systems forms the foundation of a socially and environmentally viable development pathway.



Boegoebaai GH_2 development programme scenarios (WP2)

	Small GH_2	Big GH_2
	2025-2035	2035-2050
	Sc1	Sc2
GH_2 production capacity ambition (mtpa)	**0.5**	**4.0**
Total RE capacity required (GW)	**10.0**	**80.0**
RE capacity - solar	***6.0***	***48.0***
RE capacity - wind	***4.0***	***32.0***
RE land-take requirement* estimates (ha)		
Solar PV footprints	12 000	96 000
Wind turbine footprints	4 000	32 000
Wind Energy Facility extents	40 000	320 000
Total RE footprints	**16 000**	**128 000**
Total RE extents	**52 000**	**416 000**

**RE accounts for > 70 % of space required for development to support the envisaged GH2 production scenarios*

Areas of lower environmental sensitivity: 1 088 934 ha

	Sc1	Sc2
% land-take in lower sensitivitie zones required to achieve GH2 ambition:	**5%**	**38%**

Figure SPM 7: Preliminary regional development guidance for the Boegoebaai GH_2 economy. Approximately 1 million hectares of comparatively lower environmental sensitivity were identified (light green shading). In principle, this area could accommodate the renewable energy (RE) inputs required under the two scenarios: ~10 GW (≈52,000 ha) for Sc 1 and ~80 GW (≈416,000 ha) for Sc 2. Although the areas exhibit relatively lower sensitivity at regional scale, all development must be subject to project-level environmental assessment and site-specific field verification, as these regions will still contain highly sensitive social and ecological features. Enabling infrastructure will be critical to responsible regional build-out, including: (i) expansion and strengthening of the electricity grid within the identified lower sensitivity zones; (ii) upgrading and maintenance of key transport routes, particularly the R382; and (iii) early catalytic investment in anchor towns to support port and Special Economic Zone (SEZ) development. Where feasible, new linear infrastructure should be co-located within existing disturbance corridors to minimise impact.

3.8 Socio-economic strategic recommendations and governance principles (after Atkinson et al. 2026 and Maritz et al., 2026)

The findings of the SEA demonstrate that socio-economic risks and opportunities are core determinants of whether environmentally defensible spatial decisions can be implemented successfully. The Socio-economics Chapter identifies six interrelated strategic themes that should explicitly guide planning, consultation and decision-making for the Boegoebaai Port, SEZ and associated GH_2 economy.

Box SPM 27: Why socio-economic risks can be managed through strategic planning.

The socio-economics assessment demonstrates that many of the most significant risks associated with the Boegoebaai Port and GH_2 programme arise not from the physical footprint of development, but from the pace, sequencing and governance of change. In-migration, service overload, land access disputes and unmet employment expectations can undermine environmental management, erode institutional capacity and generate conflict that delays or derails projects. Addressing socio-economic risks at the strategic planning stage, through spatial differentiation of receiving areas, early consultation, realistic employment planning and strengthened governance, is therefore essential to ensuring that development remains socially acceptable, implementable and sustainable.

1) Receiving-area differentiation and spatial targeting of impacts

The Richtersveld Local Municipality is identified as the primary receiving environment for or construction phase impacts, land access pressures and social change associated with the port, SEZ and linear infrastructure. Springbok is expected to function as the regional administrative, service and economic hub, with secondary coastal settlements such as Port Nolloth and Alexander Bay playing more specialised roles linked to port-related activity. **Strategic planning and investment must recognise these differentiated roles, ensuring that impact management, service provision and benefit distribution are spatially targeted rather than applied uniformly across the region**.

2) Sequencing of development to manage in-migration and service pressure

The Socio-economics assessment highlights construction-phase in-migration as one of the most significant social risk drivers. Where housing, water, sanitation, health, safety and policing infrastructure lag behind construction activity, unmanaged settlement growth, service backlogs and social conflict are likely to emerge. **Strategic planning must therefore sequence development so that bulk services, housing and social infrastructure are in place ahead of peak construction phases, particularly in high-pressure receiving areas.**

3) Consultation, legitimacy and consent as strategic risk management tools

Compliance-based consultation is insufficient for development of this scale and complexity. In areas characterised by communal land tenure, living heritage and customary land use, consultation processes must begin early, continue throughout planning and implementation, and be sufficiently transparent to support informed participation. Strategic engagement approaches aligned with Free, Prior and Informed Consent (FPIC) principles are essential to maintaining legitimacy, reducing conflict and avoiding delays that can undermine both social and environmental outcomes.

4) Land access, tenure complexity and negotiation frameworks

Land access emerges as a binding constraint in the Namakwa Region, given the prevalence of communal land, CPA arrangements, state land and historical mining legacies. **Ad hoc, project-by-project negotiations increase uncertainty, delay and inequitable outcomes. Strategic planning should therefore be supported by clear, upfront negotiation frameworks that address land access, compensation, benefit-sharing and long-term land use arrangements in a consistent and transparent manner**.

5) Employment realism and avoidance of boom–bust dynamics

The Socio-economics assessment cautions against over-reliance on construction-phase employment as a measure of long-term socio-economic benefit. While construction activity may generate short-term employment, operational employment opportunities are limited and highly skilled. **Strategic planning**

should therefore focus on expectation management, early investment in technical skills development (including Technical and Vocational Education and Training (TVET) colleges, artisan training and specialised GH_2-related skills), local procurement and economic diversification to avoid boom-bust cycles and post-construction socio-economic decline.

6) Institutional and governance capacity as a limiting factor

Weak institutional capacity significantly amplifies socio-economic risk. Municipalities in the region are already under pressure, and even the smaller GH_2 development scenario is expected to strain planning, regulatory and service delivery systems. **Strengthening institutional capacity, clarifying roles across spheres of government and aligning socio-economic planning with spatial and infrastructure decision-making are therefore prerequisites for sustainable outcomes.** This institutional strengthening should also include disaster management capability, hazardous materials preparedness, emergency response systems and coordination across municipalities.

The socio-economics assessment (Chapter 7 of the SEA WP2) argues for collaborative governance across governmental spheres, and including public and private participation in ongoing planning, decision-making and evaluation.

3.9 Effective consultation and negotiations (after Atkinson et al., 2026)

The long-term viability and legitimacy of the proposed Boegoebaai Port, Green Hydrogen and SEZ developments are critically dependent on equitable, well-structured and sustained consultation and negotiation processes. Given the scale, duration and transformative nature of the proposed developments, **consultation and negotiation processes that are equitable, inclusive and sustained over time are essential.** In contexts where communal and restituted land, Indigenous rights and culturally embedded livelihoods are implicated, meaningful engagement is a critical determinant of social legitimacy and long-term project viability.

Communities directly affected by the proposed developments particularly those holding communal land rights, need to be engaged as legitimate negotiating counterparts. In the Boegoebaai context, community acceptance functions as a social licence to operate, and inadequate or poorly structured engagement presents a material risk of contestation, delay and loss of trust.

The assessment highlights the importance of early and deliberate engagement design, particularly in contested institutional environments. This includes clarity regarding representative structures, mandates and decision-making processes, as well as attention to power asymmetries between project proponents, government institutions and local communities. **Independent facilitation is identified as an important enabling mechanism to support transparent dialogue, trust-building and constructive negotiation**.

Where proposed decisions have long-term or irreversible implications for land use, livelihoods or cultural heritage, **The assessment recommends that engagement processes be guided by FPIC principles** (Box SPM 28). FPIC is framed as a process-oriented governance approach that emphasises early engagement, access to adequate and understandable information, sufficient time for internal deliberation, and respect for collective decision-making systems, rather than as a single procedural event.

Box SPM 28: FPIC Principles

- **Free:** Consent must be voluntary and without coercion.
- **Prior:** Engagement must occur before any project decisions or activities begin.
- **Informed:** Communities must receive full, accessible, and culturally appropriate information.
- **Consent:** Communities have the right to approve or reject, and to withdraw consent.

Consultation processes should avoid technocratic or once-off engagement models and instead adopt adaptive and iterative engagement approaches, such as Problem-Driven Iterative Adaptation (PDIA)[23], which allow dialogue and negotiation processes to evolve over time in response to emerging concerns, changing project parameters and shifting local priorities.

The capacity of local institutions to participate meaningfully in consultation and negotiation processes is identified as an important contextual constraint. that limited municipal and community institutional capacity can undermine continuity, credibility and responsiveness in engagement processes. **Strengthening institutional readiness and governance capability is therefore integral to sustaining effective engagement across planning, construction and operational phases**.

Overall, equitable consultation and negotiation are foundational to achieving socially legitimate, resilient and just development outcomes in the Boegoebaai region, and should be embedded strategically across subsequent planning, approval and implementation phases.

3.10 Concluding remarks

The findings from the SEA highlight that while GH_2 development could contribute substantially to South Africa's energy transition and regional economic diversification, the receiving environment is characterised by high ecological, cultural and socio-economic sensitivity. At the ecological level, the Namakwa Region forms part of a globally significant biodiversity hotspot, containing exceptional levels of plant endemism, important habitats for threatened fauna, and landscapes that function as climate change refugia. VERY HIGH and HIGH sensitivity areas are widespread, particularly along the coastal belt, mountain systems, and key ecological corridors. Development within these areas carries a substantial risk of irreversible biodiversity loss and should therefore be avoided wherever possible. Although most of the landscape contains some form of biodiversity constraint, only a smaller proportion of the region contains overlapping high-value biodiversity features. This creates opportunities for strategic spatial planning that directs infrastructure toward comparatively lower-sensitivity areas, while safeguarding critical ecological assets.

The Namakwa Region is an extremely water-limited landscape with high dependence on groundwater and limited surface water availability. Several groundwater resource units and strategic water source areas are already under pressure, and municipal water infrastructure is fragile. Without careful planning, additional water demand associated with GH_2 development could exacerbate existing water scarcity and service delivery challenges, although substantial opportunities exist for the creation of new water resources in the form of seawater desalination. Heritage and cultural landscapes are also prominent features of the region.

The Richtersveld Cultural and Botanical Landscape World Heritage Site, alongside numerous archaeological resources, graves, and historically significant mining landscapes, contribute to a strong sense of place and cultural identity. These features require early identification and avoidance planning to ensure that development does not undermine heritage values.

From a socio-economic perspective, the region exhibits both high vulnerability and significant development opportunity. Long-standing unemployment, economic restructuring following mining decline, limited municipal capacity, and governance complexities create a sensitive development context. At the same time, GH_2-related infrastructure investment could stimulate employment, infrastructure improvements, and economic diversification. Realising these benefits will depend heavily on effective governance, inclusive consultation processes, and careful management of in-migration, service demand, and local expectations.

[23] An approach to policy design and implementation that focuses on solving locally defined problems through incremental learning and adaptation, rather than applying pre-packaged solutions. Applied to consultation and negotiation processes, PDIA recognises that complex, contested development contexts (such as large-scale infrastructure and green hydrogen programmes) cannot be managed through fixed consultation templates. Instead, engagement processes must evolve in response to emerging social, institutional and governance challenges.

A future GH_2 economy in the Northern Cape is not constrained by a single environmental or social factor, but rather by the cumulative interaction of ecological sensitivity, water scarcity, institutional capacity, and spatial planning considerations. Findings emphasise the importance of strategic planning, early environmental/social screening, and strong governance frameworks to ensure that any future development proceeds in a manner that maximises socio-economic benefits while safeguarding the region's globally significant ecological and cultural heritage.

For the voluminous findings of the SEA to be most saliently applied, policymakers should consider various instruments through which scientific findings can be best used to guide policymaking. **In this case, several policy instruments, aligned to supporting a regional GH_2 economy, are already in place in the Namakwa region, for example**:

- **Springbok REDZ** (Figure SPM 7) within the SEA WP2 study area, as well as the Upington REDZ further north, were gazetted under Government Notice (GN) 114, dated 16 February 2018. Benefits for large scale RE development (> 20 MW) include: BA Process instead of a full Scoping and EIA Process and reduced authority decision-making time on EA applications from 107 days to 57 days.
- **Electricity Grid Infrastructure Corridors** (GN 113, dated 16 February 2018) (Figure SPM 7) within the SEA WP2 study area. Benefits for high-voltage transmission and distribution infrastructure (> 275 kV): BA Process instead of a full Scoping and EIA Process; reduced authority decision-making time on EA applications from 107 days to 57 days on routings pre-negotiated with landowners; Generic EMPr available, must be populated with site-specific information, applies to EGI development anywhere in the country; no EA required if located in verified areas of Medium/Low environmental sensitivity in which case an EGI standard applies (GN 2002, dated 7 April 2022).
- The *Boegoebaai Port and Rail Infrastructure Project*: Northern Cape and the *Boegoebaai Green Hydrogen Development Programme*, designated **Strategic Integrated Project (SIP)** status under the Infrastructure Development Act (GN 812, dated 24 July 2020; GN 2835, dated 6 December 2022, respectively). Benefits include reduced authority decision-making time on permitting from 107 days to 57 days.
- **Gas pipeline corridors** (Figure SPM 7) within the SEA WP2 study area were published under GN 836, dated 31 July 2020, with procedures confirmed under GN 411, dated 7 May 2021. Benefits for development and related operation of facilities or infrastructure for the bulk transportation of dangerous goods in gas, liquid or solid form using pipelines (e.g. hydrogen) include: BA Process instead of a full Scoping and EIA Process; reduced authority decision-making time on EA applications from 107 days to 57 days; availability of a generic EMPr which must be populated with site-specific information (applies to gas transmission pipeline infrastructure development in the entire country).
- **Solar exclusion norm** (GN 4558, dated 27 March 2024) which excludes solar PV development from the requirement of obtaining EA, proposed in areas of low or medium sensitivity as identified by the national web-based environmental screening tool (ST) and verified by qualified specialists.

Further policy actions to operationalise the outcomes of this SEA could include, but are not limited to:

1. **Mandate integration of SEA outputs into statutory planning instruments such as municipal, regional and provincial SDFs, IDPs, EMFs and biodiversity conservation planning to ensure consistent decisions across government, for example sensitivity maps, avoidance zones, and development corridors as national planning reference tools**. Specifically, a regional biodiversity offset / compensation mechanism should be adopted which provides for a pooled offset bank enables large-scale, long-term conservation outcomes and meets lender requirements.
2. **Develop environmental management instruments** which is provided for in Section 24 (2) of NEMA in conjunction with the Environmental Management Instruments Regulations:
    a. **Minimum Information Requirements for GH_2 development in the Namakwa region** i.e. the minimum information that must be provided by project proponent for EA applications and EIA processes when proposing to undertake specific GH_2-related development activities.
    b. **Integration of the SEA study area in National Web-based Screening Tool** (ST) such that proponents using the ST when planning their development proposals or as required for EA Applications are directed to the SEA reporting for consideration.
3. **Establish a multi-sphere Boegoebaai Intergovernmental Steering Committee** – a political and administrative forum to oversee responsible and consequent consideration of SEA recommendations, coordinate development sequencing, permitting, land access, offsets, FPIC engagement and bulk infrastructure.

4. **Implement a formal FPIC and Community Negotiation Framework**, which is essential to secure social licence and avoid delays linked to Richtersveld CPA governance constraints.
5. The SEA findings provide new evidence that could support future updates to the national Red List of Ecosystems (RLE). **South African National Biodiversity Institute (SANBI) could, at their own discretion, in collaboration with the SEA technical team and independent experts, review the degradation analysis and assess potential updates to the RLE, particularly for ecosystems in the Namakwa Region.**

The SEA should be regarded as a living strategic planning instrument that evolves alongside the emerging GH_2 economy. To ensure that planning guidance remains current and responsive to changing environmental, social, economic and development conditions, it is recommended that a provincial or regional scale SEA focused on cumulative impacts, regional development trends and strategic planning be undertaken every five years. Based on the current assessment, the next review or update should be undertaken in 2031.

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5. APPENDIX SPM.1: FULL THEME-SPECIFIC RISK AND OPPORTUNITY ASSESSMENTS

Theme-specific risk assessment of the impacts across the baseline scenario (Sc0) and two GH2 development scenarios (Sc1 & Sc2)

WATER RESOURCES & AQUATIC ECOLOGY

Chapter	Impact		Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
WATER RESOURCES	Groundwater	Groundwater Availability and Security	S0: Baseline	Very high sensitivity	High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		Very High	High
			S0: Baseline	High sensitivity	Moderate	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Moderate	Very Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
		Groundwater Quality	S0: Baseline	Very high sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Moderate
			S0: Baseline	High sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Low	Low
			S2: Big GH2		Low	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Surface Water Resources		S0: Baseline	Very high sensitivity	Very High	Moderate
			S1: Small GH2		Very High	Moderate
			S2: Big GH2		Very High	Moderate
			S0: Baseline	High sensitivity	High	Low
			S1: Small GH2		High	Low
			S2: Big GH2		High	Low
			S0: Baseline	Medium sensitivity	Moderate	Low
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Low	Very Low
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Inland Aquatic Ecosystems (Rivers, Wetlands and Pans)		S0: Baseline	Very high sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate
	Estuaries (including the Orange River Estuary) and Micro-outlets		S0: Baseline	Very high sensitivity	Low to Moderate	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate

AVIFAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to Habitat loss/ fragmentation/ transformation	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Low	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
Injury or mortality due to collisions with wind turbines, solar panels, powerlines and masts/towers	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate

TERRESTRIALECOLOGY

Biodiversity pattern	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
Ecological process	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate

BATS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Destruction/disturbance of bat roosts	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat foraging habitat loss	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat mortalities	S0: Baseline	Very High	High	N/A
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low

FAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to habitat loss & fragmentation	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
Changes to Ecological functioning and processes	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Paleontological Resources	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Archaeological Resources	S0: Baseline	Very high sensitivity	Very High	High
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Very High	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Medium sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
Built Environment	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Moderate	Low
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Moderate	High
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Population Shifts	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	SEZ area	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Pressure on housing and municipal services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Low
	S2: Big GH2		Low	Low
Pressure on health services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		Moderate	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Social ills due to boomtown conditions	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Moderate	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low

SOCIO-ECONOMICS *Cont...*

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S1: Small GH2	Port Nolloth, Alexander Bay	Very High	Moderate
	S2: Big GH2		Very High	High
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Springbok area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	SEZ area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Rural settlements	Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Export Agriculture (includes railway as management option)	S1: Small GH2		Very High	Very Low
	S2: Big GH2		Very High	Very Low
Municipal capacity - technical	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Municipal capacity - political engagement and facilitation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Development Planning Pressure	S0: Baseline	Richtersveld (Primary Receiver)	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Kamiesberg, Nama Khoi, Khai-Ma (Rest Of Region)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	District, Province and National (Incl. Agencies: NCEDA, COGSTA)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		High	Moderate
Settlement Infrastructure Development & Management	S0: Baseline	Richtersveld (Alexander Bay And Port Nolloth)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Nama Khoi (Steinkopf and Springbok Settlement Cluster)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Khai-Ma (Poffadder And Aggeneys)	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Construction of Economic Infrastructure Projects	S0: Baseline	Port & SEZ	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Road Corridor (focus on R382)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Low	Low
	S0: Baseline	Pipeline Corridors	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Rail Corridor	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very High	High
	S0: Baseline	Transmission Corridors	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Green Energy Projects/ Corridors/Sites	Moderate	Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate

Theme-specific opportunity assessment of the impacts across the baseline scenario (Sc0) and two GH2 development scenarios (Sc1 & Sc2).

WATER RESOURCES AND AQUATIC ECOLOGY

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Groundwater Availability and Security	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
Surface Water Resources	S0: Baseline	Very high sensitivity	N/A	Moderate
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Medium sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	Very Low
	S1: Small GH2		N/A	Very Low
	S2: Big GH2		N/A	Very Low
Inland aquatic ecosystems and Estuaries:	No positive opportunities identified			

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	High
	S0: Baseline	Springbok area	Moderate	High
	S0: Baseline	SEZ area	Low	Low
	S0: Baseline	Rural settlements	Low	Moderate
Export Agriculture (includes railway as management option)	S0: Baseline	Port Nolloth, Alexander Bay, Orange River	Moderate	High
Job creation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Very High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
Regional broadband roll-out	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	Springbok area	Very Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	SEZ area	Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		Very Low	Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Palaeontological Resources	S0: Baseline	Very high sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	High sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	Medium sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
	S0: Baseline	Low sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
Archaeological Resources	S0: Baseline	Very high sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	High sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Medium sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Low sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Settlement Infrastructure Development	S0: Baseline	Port Nolloth and Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Steinkopf and Springbok cluster	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Pofadder and Aggeneys	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Built Environment	S0: Baseline	Very high sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	High sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	Moderate
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

Work Package 2:

Strategic Environmental Assessment for the proposed Boegoebaai Port, Special Economic Zone and Namakwa Region

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CHAPTER 1

Introduction and context

CHAPTER 1: Introduction and context

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CHAPTER 1. INTRODUCTION AND CONTEXT

1.1 PURPOSE AND SCOPE OF THE CHAPTER

This chapter provides the context for the Strategic Environmental Assessment (SEA) of the proposed Boegoebaai Port, Special Economic Zone (SEZ), and Green[1] Hydrogen (GH_2) development in the Namakwa region of the Northern Cape. Its purpose is to:

- Provide the strategic rationale of the GH_2 economy proposed in the Northern Cape.
- Describe the proposed development components of such an economy and their spatial extents.
- Outline the approach and methods adopted by the SEA, including introducing the scenarios and risk/opportunity approach underpinning the assessment.

1.2 STRATEGIC RATIONALE AND REGIONAL SCOPE

GH_2 and its derivative Power-to-X (PtX) products, such as green ammonia and green methanol, could assist South Africa's transition to a low-carbon economy. The high energy density of GH_2 and PtX products, along with the ability to be produced emission-free using renewable energy through electrolysis, makes these energy carriers particularly suitable for decarbonising sectors that are traditionally difficult to abate, such as steel, cement, ammonia, and plastics manufacturing, as well as long-distance transport modes including aviation, shipping, and heavy freight (Department of Science and Innovation (DSI), 2021; International Energy Agency (IEA), 2022).

The Northern Cape Green Hydrogen Masterplan (NCGHM) (2023) proposes that the Northern Cape is well positioned to lead this transition. It is South Africa's largest and most sparsely populated province, with vast tracts of land and a globally competitive endowment of solar and wind resources. These attributes make it ideal for large-scale renewable energy generation, which is a prerequisite for GH_2 production. The province also has a 300 km coastline, and studies are underway to determine the feasibility of developing a deep-water port at Boegoebaai, which would enable strategic maritime trade links to both the Atlantic and Pacific basins. GH_2 presents a transformative opportunity for the Northern Cape, with the potential to drive industrialisation, address unemployment, inequality and poverty, and contribute to global climate change mitigation. Coupled with the province's growing mining sector, it could catalyse a significant shift in the region's and the country's development trajectory (NCGHM, 2023).

The Northern Cape targets include an initial 5 gigawatts (GW) of electrolyser capacity supported by 10 GW of renewable energy generation by 2033, with a long-term vision to scale up to 40 GW by 2050. The realisation of this ambition will require extensive infrastructure development across multiple municipalities, including energy generation sites, transmission corridors, desalination plants, and transport networks. These developments could potentially intersect with sensitive ecological systems, heritage landscapes, and socio-economic dynamics across the Namakwa District.

For this reason, a SEA was initiated through a collaboration between the South African National Energy Development Institute (SANEDI), the Northern Cape Economic Development, Trade and Investment Promotion Agency (NCEDA), and Transnet National Ports Authority (TNPA). Given their experience in SEA, renewable energy, port and GH_2 planning, the Council for Scientific and Industrial Research (CSIR) was appointed to lead and coordinate an independent SEA process.

Given the multiscale scope of the SEA, its processes and outputs were split between two Work Packages: Work Package 1 and Work Package 2. Work Package 1 of the SEA (available at: Individual Chapters | CSIR) assessed the social and ecological sensitivities of the local-scale receiving environment around the proposed port and SEZ development. Its purpose was to inform local-scale feasibility and planning studies

[1] There are many different definitions and perspectives on the concept of "green". Here, we use the term in the narrow sense, meaning a product developed where upstream production facilities are supplied by renewable energy.

and to guide future decision-making processes, including Environmental Impact Assessments (EIAs) and other planning processes related to the port and SEZ.

Work Package 2 (the focus of this report and associated chapters) provides a more strategic, region-wide assessment of the cumulative social, economic, and ecological implications of an expansive GH_2 economy in the Northern Cape, extending beyond the localised footprint considered in Work Package 1. Covering a regional spatial extent of over five million hectares, it encompasses the Richtersveld, Nama Khoi, Kamiesberg, and Khâi-Ma Local Municipalities (Figure 1-1). The regional scope enables the identification and evaluation of systemic risks and opportunities that may not be apparent at the individual project level, providing a robust evidence base to support decision-making across multiple governance and planning frameworks.

Table 1-1: Summary of the SEA Work Packages across different spatial scales, methods, and data collection practices.

	Work Package 1	Work Package 2
Spatial scale	Local (33 500 ha) covering the extent of the proposed port and SEZ.	Regional (>5 million ha) across four Local Municipalities, including the 33 500 ha extent covered by Work Package 1.
Temporal scale	Introspective, fixed view on currently existing sensitivities in the receiving environments of the proposed port and SEZ.	Expansive, forward looking up to 2050 considering existing land-uses and trends in accumulation to any future regional GH2 infrastructure.
Methods	High resolution determination of receiving environment sensitivity with a view to practicing avoidance (top of the mitigation hierarchy).	Determination of the cumulative social and ecological impacts of a regional expansive GH_2 economy across development scenarios within a structured risk/opportunity framework.
Resolution	Fieldwork, coupled with desktop reviews (peer reviewed and grey literature) and other sources where necessary (e.g., interviews).	Desktop reviews (peer reviewed and grey literature, interviews etc.) and other publicly available data and sources.
Application of outputs	Local-scale feasibility and planning studies (especially for the new proposed port) and future decision-making processes, like EIAs and other local-scale planning exercises which may occur in the future.	Regional/national planning documents, through processes like Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs) and Environmental Management Frameworks (EMFs), national energy planning and any EIA processes that may be undertaken in the region.

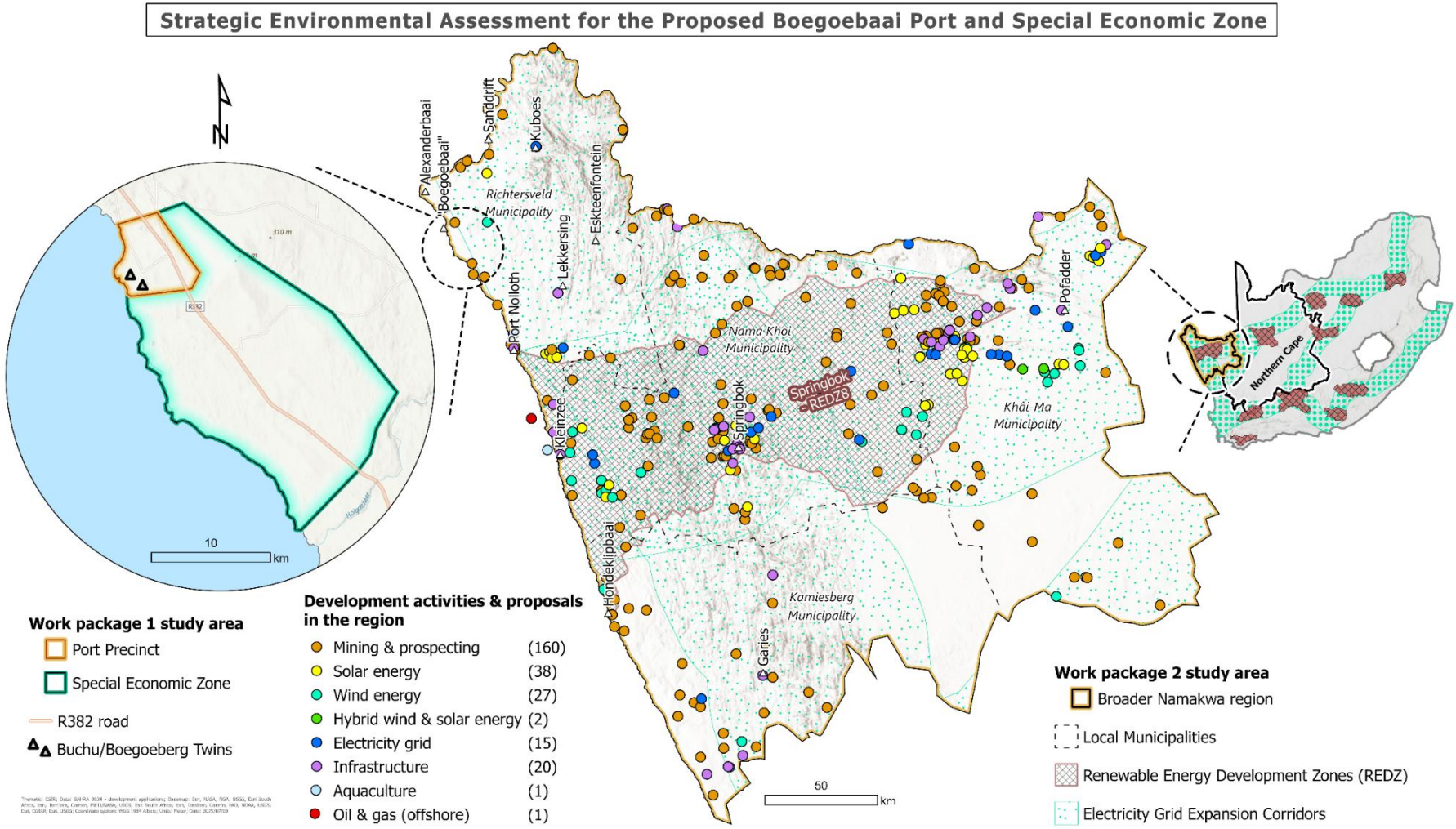


Figure 1-1: The proposed Boegoebaai port, SEZ (Work Package 1 study area) and Namakwa region study area (Work Package 2 study area) in the Namakwa District of the Northern Cape Province. Economic activities include widespread mining and prospecting. The area between Port Nolloth and Alexander Bay, including the land to the west of the R382 where the port and SEZ are proposed, has been mined for diamonds for over a century. A renewable energy sector is also emerging with established Renewable Energy Development Zones (REDZ) and Electricity Grid Infrastructure (EGI) Corridors.

1.3 OVERVIEW OF THE PROPOSED DEVELOPMENT COMPONENTS

This section describes the types and scale of infrastructure and development activities considered within the scope of Work Package 2 of the SEA.

1.3.1 The Proposed Boegoebaai Port

The proposed port precinct, an area of approximately 2 187 hectares (ha), will be developed in phases. The short-term (Phase 1A) port layout (Figure 1-2), is intended to accommodate bulk liquid items such as ammonia and diesel oil, dry bulk materials such as iron ore and manganese, and assorted break bulk cargo, which arrives in bulk and is then separated into individual components, such as lead and zinc. Consequently, TNPA needs to make provision for the infrastructure necessary to facilitate the import and export operations for all these commodities. According to the current project schedule, an estimated 5 million tonnes per annum (Mtpa) of dry bulk (manganese) and 1 Mtpa of break bulk (lead and zinc) are expected to be exported by 2033. There are also plans to export 1.4 Mtpa of GH_2 derivatives and various agricultural products (0.2 Mtpa). Diesel imports are expected to reach around 1.3 Mtpa by 2033. All exports and imports will be transported mainly through the road network in the first phase of the new port.

The port will include a two-berth jetty connected to the land via an access trestle; a sea-side berth dedicated to dry bulk and liquid cargo and a conventional multi-purpose berth (landside). The berths are sheltered from wave energy by a concrete armoured breakwater. The bulk berth will be fitted with a ship loader and a conveyor system connected to landside closed stockpiles. The bulk berth will be capable of liquid bulk import and export, and fitted with pipelines that are connected to diesel and ammonia storage tanks. The multi-purpose berth will handle containerised cargo and break bulk using two mobile cranes. Multi-purpose cargo will be stored in a dedicated multi-purpose terminal. An Admin Craft Basin will initially store equipment for breakwater construction and will be used to berth the marine fleet once the port is operational. The Admin Craft Basin will be designed as a dig-out basin within the main breakwater, protected by a secondary breakwater. The short-term port layout also involves constructing the required dry bulk terminal, multi-purpose terminal, and port administration and control buildings. Security fencing, port entrance facilities, fire station and clinic will be required. Internal port roads and rail, and truck staging facility will also be required to respond to the needs of the first phase of development.

Figure 1-2: Artist's impression of the Boegoebaai port layout. indicating the initial elements of Phase 1A development required to meet initial import and export demands (TNPA, 2024).

Detailed descriptions of the infrastructure aspects associated with the proposed short-term Boegoebaai port layout (Phase 1A) are provided in Table 1-2 below.

The longer-term vision for the Boegoebaai port (Phase 1B) is designed for flexibility to accommodate future changes in commodities and operations. This assumes that the port will continue to primarily export commodities from Phase 1A, with the potential for other GH_2 derivatives such as methanol, naphtha and e-kerosene to be added to the export mix. The projected export volumes of green ammonia, combined with methanol, naphtha and e-kerosene is expected to increase to 2.15 Mtpa from 2035 to 2050. By 2050, plans include extending the breakwater, adding multi-purpose and liquid bulk berths, a container terminal, a ship repair yard, and expanding stockpiling and enclosed warehouses for dust control. Supporting infrastructure will include rail connections, road-over-rail bridges, and tippler facilities.

Table 1-2: Detailed description of infrastructure aspects in the vicinity of the proposed Boegoebaai port (Phase 1A).

Infrastructure aspect	Description
Jetty	The jetty structure will act as a multi-use berth facility, designed to handle dry bulk, liquid bulk and multi-purpose cargo. The main jetty will consist of two berths: a 295 m long multi-purpose berth designed to accommodate Panamax vessels and a 350m long bulk berth that can accommodate Capesize vessels. The main jetty is connected to the shoreline via a 160m long access trestle. The main jetty and access trestle are founded on circular reinforced concrete piles with a sacrificial steel tubular casing. The superstructure includes reinforced concrete precast beams and slabs with in-situ concrete casts and topping to stitch the structure together. The main jetty supports ship loaders, conveyor and mobile cranes which service the bulk and multi-purpose terminal berths respectively. Vehicular access is provided via a single carriageway located beneath the ship loaders with turning circles provided at the ends of both the dry bulk and multi-purpose terminal jetty. The access trestle comprises of a single carriageway for vehicular access with the conveyor and ancillary services running adjacent.
Breakwaters	The rubble mound main and secondary breakwaters protect against wave energy at the berths and in vessel turning areas. The primary armour will require an estimated 2 785 million m^3 of rock, 63 150 m^3 of reinforced concrete, and approximately 13 150 armour units.
Admin Craft Basin (Harbour)	A dig-out admin craft basin provides additional wave protection inside the main breakwater for marine fleet. The structure comprises a concrete deck supported on vertical concrete piles cast into steel casings, with a transverse beam supported by an anchored concrete abutment on the land side.
Materials Handling Equipment	The equipment will be defined by the terminal operator based on operational requirements and contracted volumes. For the bulk berth, this includes a travelling shiploader, conveyors, and stacker/reclaimers for dry bulk cargos like manganese, lead, and similar break bulk. The multi-purpose terminal berth will use mobile cranes, trucks, and front-end loaders for break bulk and containers.
Dry Bulk Material Handling	Manganese will be stored in closed stockpiles, similarly to lead and zinc which require enclosed warehouses. Dust suppression systems, which involve water spraying the stockpile and conveyor cargo, are specified for manganese storage. A mobile stacker and bucket wheel will handle stacking and reclaiming operations.
Quayside Material Handling Equipment	Travelling ship loaders are selected for efficiency in handling large volumes of dry bulk cargo, with spatial dimensions allowing truck passage underneath during operations.
Conveyor Belts	Systems handling zinc and lead must be fully enclosed, while those handling manganese require arched coverage. Elevated belt conveyors are designed with handrailed walkways for safe access and maintenance.
Dust Control	Dust suppression and collection systems are incorporated, with all material handling equipment designed to prevent material accumulation outside the dust collection system.
Buildings	Proposed port buildings include a Port Access Gateway and Induction Centre, Port Authority Building (with a Wellness Centre and Emergency Services Building), and Terminal Operator's Building (with workshops and satellite ablution buildings).

Infrastructure aspect	Description
Bulk Services: Water	Average daily water demand is estimated at 660 kL/day. Two options were considered: a pipeline from Alexander Bay with a water treatment plant, or an onsite desalination plant. The desalination plant (1ML/day capacity) is considered more feasible. Elevated reservoirs will provide pressure for fire suppression discharge.
Bulk Services: Sewer	The site will be divided into separate drainage areas with isolated reticulation systems, on-site treatment, and disposal. Drainage areas will use a combination of wastewater treatment plant, septic tank and soak-away systems.
Stormwater	The drainage system will separate clean and dirty water, with clean water runoff diverted around the site. High-risk dirty runoff water will flow into concrete-lined channels, and low-risk dirty runoff water will flow into block and vegetated channels. Pollution control ponds will be lined with HDPE, attenuated to the 1:50 year pre-development condition and discharged to the receiving natural environment, such as the ocean.
Electrical	The internal electrical network will include an intake substation (22kV), primary and secondary substations, distribution substations, street and area lighting, and small power and lighting for buildings.
Electronics	Security systems include fencing, CCTV coverage, access control, and coastal/railway protection systems, and will comply with the International Ship and Port Facility Security requirements. General electronic systems include fire detection, public address, evacuation systems, building management system, and security control room. Information and Communication Technology services include fibre connections, server rooms, network equipment, microwave links, and manhole and sleeve infrastructure.
Fuel storage	A liquid bulk storage facility with two 35 000 m^3 tanks and tanker loading facilities is included. Tanker vessels will discharge into storage tanks via pipeline at the multi-purpose terminal berth. This represents the first phase of the liquid bulk terminal development.
Internal Port Roads and Bridges	Port Access Interchange: Located 60 km north of Port Nolloth off the R382, designed to accommodate large volumes of heavy vehicle traffic for continuous flow. Port Access Control: Separate entrances with an access gateway and a combined weighbridge and access gateway, allowing multiple trucks to queue without causing congestion. Truck Offloading Area: Designed with three offloading terminals operating independently to prevent congestion and ensure continuous offloading.
External Roads	Development of the port in the short-term will attract mining ore transported by trucks along the R382, serving as the primary route for transporting mining commodities until rail transport viability is considered for future port expansion phases.

1.3.2 The proposed Boegoebaai Special Economic Zone

The Boegoebaai SEZ is envisioned as a multifaceted hub, primarily focusing on the export of GH_2/PtX products and commodities through the port. The SEZ will prioritise opportunities in manufacturing, logistics, and agro-processing to deliver a broad range of products and services (NCGHM, 2023). The Northern Cape targets include an initial 1.2 GW of electrolyser capacity to be completed by 2028, scaling up to 5 GW by 2030, and reaching 40 GW by 2050. The Boegoebaai SEZ area, encompassing approximately 33 500 ha (inclusive of the proposed conservancy area adjacent to the Boegoebaai port), will be developed in phases (as described in Table 1-3 and depicted in Figure 1-3) consisting of 10 proposed zones:

- **Zone 1**: Port Precinct (described in Section 1.3.1) – 2 187 ha
- **Zone 2**: Conservancy area – 1 170 ha
- **Zone 3:** Confirmed green ammonia facility – 4 508 ha
- **Zone 4:** SEZ Phase 1 – 499 ha
- **Zone 5:** SEZ Phase 2 – 411 ha
- **Zone 6:** SEZ Phase 3 – 833 ha
- **Zone 7:** Future green hydrogen facility – 3 713 ha
- **Zone 8:** Future expansion 01 – 3 408 ha
- **Zone 9:** Future expansion 02 – 15 067 ha
- **Zone 10:** Future tank farm – 1 704 ha

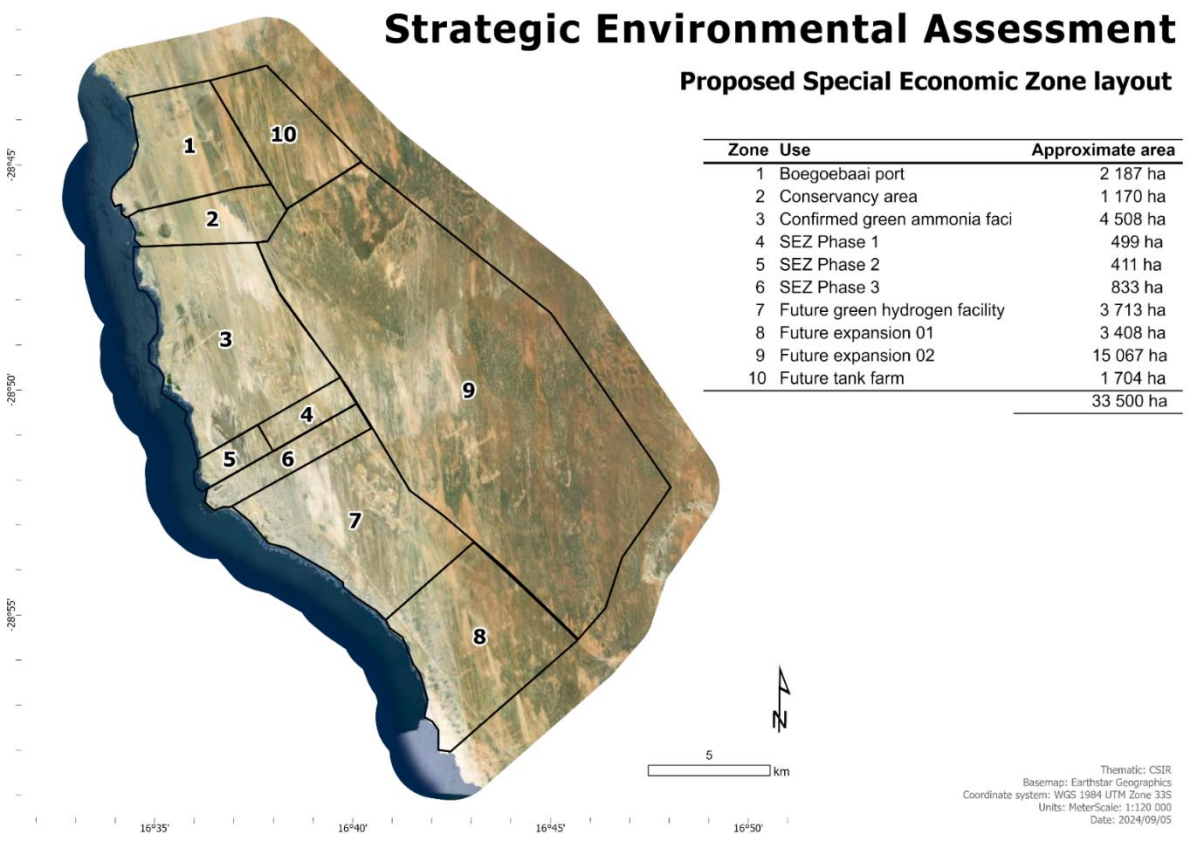


Figure 1-3: The footprint of the proposed Boegoebaai Port (Zone 1) and phases of the proposed SEZ which include a diversity of landuses across Zones 2 to 10.

The initial development of the SEZ will accommodate the green ammonia facility and the envisaged 5 GW of electrolyser capacity by 2030. This will include a sea water intake line, discharge lines to the ocean, a desalination plant, 5 GW electrolyser GH_2 production facility and green ammonia production facility, and hydrogen and ammonia storage tanks. Future SEZ activities are outlined in Table 1-3. Two entrances to the SEZ Phase 1 are proposed: a northern entrance for commercial, socio-service, and private traffic, and a southern entrance for industrial traffic. The truck staging area and the SEZ desalination plant are planned to be located near the southern entrance, facilitating road freight to and from the N14 and N7 highways.

Table 1-3: Proposed infrastructure and development activities per SEZ zone

SEZ zone	Description of infrastructure
1) TNPA port precinct	See Section 1.3.1 and Table 1-2 above.
2) Conservancy area	Conservancy area of approximately 1 170 ha that has been roughly demarcated based on initial inputs on conservation priorities such as the Boegoeberg koppies and seal colony on the Boegoebaai point. A habitat unit known as Swartvygie Heuweltjie Strandveld, located just inland of Boegoebaai, has suffered extensive damage from mining over the past century. The only intact areas are protected by the Buchuberg twins and hardened roads, which prevent sand scour. It is crucial for any port and GH_2 projects to avoid these intact portions, as they cannot be offset. There is also an interesting archaeological site at the proposed development – the Boegoebaai cave/lair.
3) Green ammonia facility	The green ammonia facility will be located near the TNPA port precinct to minimise pipeline length and enhance efficiency. The site is adjacent to the coast to facilitate desalination processes and house the 188 ML/day desalination plant. Infrastructure will include desalination plant and associated infrastructure (including seawater intake infrastructure and discharge pipeline); Water treatment unit and water reservoir; Containerised units for the electrolysers; Air separation unit; Liquid air energy system for nitrogen storage; Hydrogen and oxygen storage; Ammonia processing unit and liquid ammonia storage tank; Pipelines required for hydrogen, its' derivatives and by-products, and a control room. Seawater will be desalinated through a Reverse Osmosis (RO) process and then further processed to Demineralized water, which is needed for the production of GH_2 via water electrolysis. Cooling tower blowdown will be disposed of back to sea with the Reverse Osmosis brine and other treated wastewater streams. It is expected that the blended total dissolved solids of the cooling tower blowdown stream and the Reverse Osmosis brine and waste streams will be acceptable for seawater discharge. Firewater will be provided through firewater tanks on site. There is an opportunity to combine firewater and desalinated water storage on site. Seawater will be the backup source of firewater in case of an emergency and the stored firewater is not adequate. Lye solution purge from the GH_2 Plant will be discharged with the other return streams to the sea. Other effluents are oxygen and small quantities of off-gas which are expected to be safe to vent to atmosphere.
4-6) SEZ Industrial Park	The Industrial Park will be designated for mixed-use purposes, a manufacturing cluster, logistics and warehousing, offices. The SEZ will also include a 2.7 ML/day desalination plant, including pump station, supply pipelines, feeder pipelines etc. Seawater will be extracted and filtered, with a portion of the filtered water supplied to the SEZ Industrial Park for its use and for distribution to Port Nolloth. The SEZ Industrial Park will then desalinate this water at its own facility. The remaining filtered water will be processed through a separate desalination plant for operational use.
7) Future GH_2 facility	This will be a replication of the work that is anticipated at the initial Green Ammonia Facilities: Water treatment unit and water reservoir; Containerised units for the electrolysers; Air separation unit; Liquid air energy system for nitrogen storage; Hydrogen and oxygen storage; Ammonia processing unit and liquid ammonia storage tank; Pipelines required for hydrogen, its' derivatives and by-products, and a control room.
8) Future expansion area 01	This will be a replication of the work that is anticipated at the initial Green Ammonia Facilities: Water treatment unit and water reservoir; Containerised units for the electrolysers; Air separation unit; Liquid air energy system for nitrogen storage; Hydrogen and oxygen storage; Ammonia processing unit and liquid ammonia storage tank; Pipelines required for hydrogen, its' derivatives and by-products, and a control room.
9) Future expansion area 02	This will be a replication of the work that is anticipated at the initial Green Ammonia Facilities: Water treatment unit and water reservoir; Containerised units for the electrolysers; Air separation unit; Liquid air energy system for nitrogen storage; Hydrogen and oxygen storage; Ammonia processing unit and liquid ammonia storage tank; Pipelines required for hydrogen, its' derivatives and by-products, and a control room.
10) Future tank storage	Proposed area of approximately 1 704 ha inland of the R382 road.

1.3.3 Regional Renewable Energy and Linear Infrastructure

To power electrolysers, large scale renewable energy infrastructure (solar and wind farms) will be developed within the broader Namakwa region, covering parts of the Namakwa District of the Northern Cape Province. Some power generation infrastructure (wind and solar PV) will be located in reasonably close proximity to the SEZ, however, due to the sensitivity of the local receiving environment and potential impacts of the coastal environment on the generation facility (e.g. corrosion), in most cases, power will be generated from dispersed renewable energy projects (each requiring their own EIA processes), in some cases, several hundred kilometers away. Electricity will then be delivered to the GH_2 production plant using a combination of new and existing transmission and distribution infrastructure. In such cases the development and permitting of the generation components will be undertaken by 3rd parties, and the developer may not have control of the whole project. The project owner will purchase power from 3rd parties (or purchase the projects outright and own and operate them) and negotiate with the utility to wheel the power using the existing or new build grids. The project components are likely to be permitted separately, with the hydrogen developer permitting the electrolyser, ammonia plant, desalination plant and, in some cases, the export port facilities, and the generation (wind and solar PV) and transmission being permitted by several other 3rd party entities such as Independent Power Producers (IPPs) and Eskom. Table 1-4 Provides a brief description of the anticipated main renewable energy aspects.

Table 1-4: Brief description of the main renewable energy aspects

Renewable energy	Aspect	Description
Wind	Turbines	Rotor with blades, nacelle, tower; sizes 4-8 MW, hub height 150-180 m, blade length ~100 m.
	Other	Foundations (~32 m^2), access roads, Battery Energy Storage System (BESS), on-site electrical system, substation, transmission lines, construction camp, operations & maintenance facilities, meteorological towers.
Solar PV	Solar panels	Monocrystalline/polycrystalline silicon cells; height ~6 m. Fixed or dual-axis tracking. Single or bifacial modules.
	Other	Inverters, mounting structures, BESS, foundations, access roads, electrical system, substations, transmission lines, electrical components, construction camp, operations & maintenance facilities.

The Northern Cape plans to collaborate with local stakeholders to secure land or engage IPPs. Environmental assessments will be conducted on identified land parcels for the installation of renewable energy infrastructure. The objective is to expand renewable energy capacity to enable GH_2 production, as well as to supply electricity for local needs. By 2040, the goal is to meet industrial demand and eventually meet national electricity needs.

The proposed GH_2 development at Boegoebaai also includes a comprehensive network of linear Infrastructure to connect the production site, export facilities, and regional demand hubs. This includes transmission lines, pipelines for GH_2 and derivatives, rail links and upgraded roads, all of which are considered catalytic infrastructure for the Northern Cape GH_2 economy.

Transmission lines will wheel power from solar and wind farms to electrolysis plants and, when necessary, supply surplus electricity to the national grid for load balancing. A new rail corridor is proposed to connect Boegoebaai with Kenhardt, linking into the existing Saldanha–Sishen railway route. This rail link will facilitate the transport of bulk commodities such as manganese and iron ore, as well as GH_2 derivatives like ammonia and methanol. Rail will also support the movement of renewable energy components and other industrial goods to and from the SEZ, ensuring efficient logistics for both export and local

beneficiation. Dedicated hydrogen and ammonia pipelines will form the backbone of the GH_2 corridor. Proposed pipeline system routes include:

- Boegoebaai to Namibia, creating a cross-border corridor for regional integration.
- Boegoebaai to Saldanha Bay.
- A direct inland pipeline to Prieska, unlocking opportunities for local industrial use and distribution.

These pipelines aim to provide secure, cost-effective transport for high-volume flows of hydrogen and its derivatives, supporting both export markets and domestic decarbonisation initiatives.

The development of the GH2 economy will also require new roads and upgrades to existing routes as part of a broader linear infrastructure network proposed to ensure efficient movement of goods and materials.

1.4 APPROACH TO THE SEA

The SEA is being undertaken to guide strategic planning for proposed infrastructure development in and around Boegoebaai, as well as the broader Namakwa region of the Northern Cape, South Africa. Readers are reminded that the SEA is not a decision-making process, in the same way that, for example, an Environmental Impact Assessment (EIA) is. The purpose of the SEA is to, in a transparent way, guide downstream planning and decision-making processes that may, or may not, occur over many years, if not several decades into the future. Integrating a variety of best practice science-policy processes, SEAs should provide an evidence-based, cross-disciplinary perspective on the main opportunities and constraints associated with the proposed port, SEZ and network of regional renewable energy generation facilities (wind and solar PV), electrical grid infrastructure, roads, pipelines and other GH_2 support infrastructure development.

A key gap in the current knowledge and decision-making base regarding GH_2 development in the Northern Cape is the absence of an integrated, cumulative, long-term understanding of what a medium- to large-scale GH_2 economy might entail. To address this, the Work Package 2 SEA adopts an interdisciplinary, scenario-based assessment designed to explore both the scale and implications of GH_2 development in the region.

This scenarios assessment serves two main purposes:

1. To provide a concrete representation of what a large Northern Cape GH_2 economy could look like, in terms of the nature, scale, and spatial footprint of infrastructure and development.

2. To estimate the potential cumulative positive and negative impacts of GH_2 development and identify strategies to enhance benefits and mitigate adverse effects.

1.4.2.1. Figure 1-5No-Development Scenario: Scenario 0 – Dynamic Baseline (2023–2050)

The foundation of this analysis is a dynamic baseline scenario (Scenario 0), which represents a future without GH_2-related infrastructure, port development, or SEZ establishment (i.e., a "no GH_2 development" future). This baseline is important for understanding how existing trends and drivers of change will shape the region in the absence of GH_2 development and provides the reference point against which the impacts of the two GH_2 development scenarios (Scenarios 1 and 2) are assessed.

Under Scenario 0, the Boegoebaai Port and SEZ remain undeveloped, and no GH_2 production occurs in the Northern Cape. However, the region continues along its current trajectory of socio-economic and environmental change, driven by multiple interacting factors. These drivers include climate variability, land-use pressures, biodiversity loss, water scarcity, and socio-economic challenges, as summarised in Table 1-6. A trend direction explanation is also included in Table 1-5.

Table 1-5: Trend direction explanation

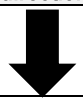
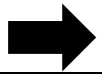
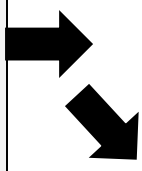
Trend direction	Explanation
	Evidence/experience suggests a substantial decrease in the driver or its quality
	Evidence/experience suggests a moderate decrease in the driver or its quality
	Evidence/experience suggests no change in the driver or its quality
	Evidence/experience suggests a moderate increase in the driver or its quality
	Evidence/experience suggests a substantial increase in the driver or its quality
	Insufficient Evidence/experience to predict the direction of the driver or its quality, or evidence/experience is conflicting

Table 1-6 Scenario 0: Drivers of macro change in the Northern Cape province (2025-2050) in absence of GH_2/PtX, SEZ and port development

Theme/Driver	Trend	Explanation
Climate change		
Temperature		Climate change is causing a substantial increase in temperatures in the Northern Cape, with projections indicating a rise of ~2°C by 2040–2060 (DEA, 2018). Heatwaves and very hot days (above 36°C) are becoming more frequent, with up to 100 extremely hot days annually by 2050 (CSIR, 2019). Cold extremes are decreasing (Davis et al., 2016). These changes threaten agriculture, human health, and biodiversity (Mbokodo et al., 2020), highlighting the need for urgent climate adaptation measures. Heat-stress thresholds and heatwave mortality risks for small, ground-dwelling birds such as larks, chats, and coursers as well as bird species with poor evaporative cooling efficiency (McKechnie et al., 2021).
Rainfall		Historical trends in the Northern Cape show no significant change in annual rainfall totals over the past 50 years, though there are weak indications of increased wet days (CSIR, 2019). Most areas are projected to see minimal increases (up to 100 mm) by 2050, while 60% of the Namakwa district is expected to experience no change (CSIR, 2019). However, rising temperatures will likely increase evaporation, reducing groundwater availability, particularly in the western regions (DEA, 2018). Reduced winter rainfall lowers plant productivity (Milton et al., 2022) and insect prey, driving nesting failure, and lower chick survival rates and delayed or failed breeding for birds (Bourne et al., 2020).
Flooding		Increased atmospheric moisture and intensified heat lows in the eastern province may lead to higher summer rainfall and extreme rainfall events, causing localized flooding and infrastructure damage (DEA, 2018). By 2050, extreme rainfall days are projected to increase by 1–2 days annually (CSIR, 2019). While flood risk remains low to medium in most areas, some regions show medium to high flood hazards, with a potential for worsening impacts due to projected rainfall decreases (CSIR, 2019).

Theme/Driver	Trend	Explanation
Wildfires		Rising temperatures, prolonged droughts, and an increase in very hot days in the Northern Cape are expected to create ideal conditions for wildfires. Projections indicate that heatwave events and increased frequency of hot days, particularly in the Richtersveld, Khai-Ma, Nama Khoi, and Hantam municipalities, will elevate the likelihood of wildfires (CSIR, 2019). Drought conditions will intensify due to higher evaporation rates, further increasing wildfire risks, especially in the northern parts of the province (CSIR, 2019). This necessitates enhanced fire management strategies and proactive environmental management to protect ecosystems, human settlements, and water resources. Altered fire regimes destroy nesting/perching and foraging substrates, compounding food and water shortages (Hoffmann et al., 2009; Nunes, 2023).
Sea level		Accelerated sea level rise is projected for the Northern Cape coastline, posing risks to coastal infrastructure and settlements. Rising sea levels will likely disrupt marine ecosystems and species distribution (DEA, 2018).
Storminess		Increased storminess is expected to affect the province's coastline, with coastal storms becoming more frequent and intense, which will impact both coastal infrastructure and marine ecosystems (CSIR, 2019).
Ocean temperatures		Expert interpretation indicates that ocean temperatures along the Namaqualand coast are likely to decrease. The increased frequency and velocity of dominant southerly winds will intensify coastal upwelling, increasing both its occurrence and strength. These changes have important implications: 1. Fog Formation As offshore ocean waters warm and evaporation increases, moist air moving over colder inshore waters will likely lead to more frequent fog events. This may reduce sunshine and provide additional moisture for plants and animals able to utilize it. Anecdotal evidence from South Africa's south and east coasts suggests that stronger easterly summer winds—comparable to Namaqualand's southerlies—are associated with more frequent and intense upwelling. 2. Fisheries and Coastal Economy Increased upwelling will affect sea fisheries and may have significant impacts on coastal ports and the fisheries economic sector. 3. Flood Risk While climate change is expected to increase thunderstorms and flooding, these events will remain largely east of the escarpment. The cold ocean will continue to prevent such weather systems from penetrating west of the escarpment, so increased flood risk is unlikely to affect the coastal plain.
Biodiversity & conservation		
Desertification		Desertification in the Namakwa region is worsening due to climate change and unsustainable land use. The southward migration of the Namib Desert is decreasing rangeland productivity and negatively impacting biodiversity (Jürgens et al., 2025). The Richtersveld area is experiencing the most severe desertification, while higher-altitude areas such as Kamiesberg receive slightly more rainfall (Desmet & Venter, 2025). Loss of vegetation accelerates soil erosion, leading to reduced nesting substrates and increased dust and heat exposure, and an overall decrease in avifaunal abundance and avifaunal diversity (Hoffmann et al., 1999).
Overgrazing		Farmers, particularly those in communal areas, are likely to persist in traditional grazing practices despite declining conditions, exacerbating land degradation. Land-use change, including agricultural expansion, overgrazing, is another critical driver of the ecological trends in the Namakwa region (Bourne eta al., 2015; Walker et al., 2018). These activities are reducing natural habitat, fragmenting ecosystems, and placing additional stress on species already struggling to adapt to changing climate conditions. The cumulative effects of these pressures exacerbate soil degradation and desertification, further limiting the capacity of ecosystems to recover. Grazing pressure simplifies vegetation structure, reducing foraging and nesting material for avifauna (Todd et al., 2009; Le Maitre et al., 2009). Due to the divide between commonage and private land in patterns of ownership and livestock use, the overgrazing trend is expected to follow two distinct trajectories: continued or increased overgrazing and desertification on commonages, and a static to slightly negative trend on private farms. It is important to note that land-use impacts on ecosystems occur in addition to climate change impacts, and the latter may outweigh any land-use improvements. Consequently, even with best-practice livestock management

Theme/Driver	Trend	Explanation
		aimed at improving rangeland condition, climate change effects may override these efforts, resulting in an overall negative trend.
Protected areas		The distinctive biodiversity of the Succulent Karoo biome has gained global attention, prompting substantial investments from the government, non-governmental organisations, and the private sector to expand conservation areas across the biome (Hoffman et al. 2015). While conservation and protected area development are expected to expand in the Namakwa region, the rate of expansion remains slower compared to sectors like mining and energy. The transition to biodiversity-based economies is hindered by entrenched local economic behaviours, despite the greater employment potential offered by biodiversity industries (Bourne et al., 2015). A point to note is the entrenched economic behaviours in the region - characterised by strong conservatism and limited capacity to adopt/enter new or emerging economic activities due to financial and skills constraints - resulting in reluctance or inability among local communities to diversify livelihoods. Consequently, major developments in sectors such as tourism are predominantly driven by in-migrants rather than local actors. This dynamic may have implications for cultural and living heritage and could reinforce the existing social and economic status quo within the region. The Succulent Karoo is rich in endemic and range-restricted bird species, and Protected Areas expansion will help buffer against increasing threats such as climate change, habitat loss, overgrazing and invasive species (Khavhagali, 2010), and assist in the protection of microhabitats and ecological niches essential for rare bird species (Dean, 1995) contributing to an increase in avifaunal abundance and diversity. Furthermore,
Change in Habitat and species		Projected biome shifts, such as the southward movement of the Desert Biome and the replacement of the Nama Karoo with the Succulent Karoo, are expected to cause habitat degradation and alter species distributions (Bourne et al., 2015). Additionally changes in temperature, rainfall levels and patterns could shift vegetation and corresponding animal distributions, with combined effects potentially being substantial. This will likely lead to local extinctions of certain species, especially those unable to adapt to the new climatic conditions (Walker et al., 2018). Loss of specialised habitat could also lead to shifts in avian species ranges, population fragmentation, community restructuring and endemism loss (Dean, 1995).
Avifauna (birds)		Rising heat and reduced rainfall push arid-adapted, small ground birds beyond physiological limits (McKechnie et al., 2021), lowering survival and breeding success (Conradie et al., 2019); wildfire, desertification and overgrazing degrade nesting/foraging habitats (Hoffmann et al., 1999; Todd et al., 2009); alien invasion favours generalists (Clusella-Trullas & Garcia, 2017); drying ephemeral wetlands reduce water/food for sandgrouse, doves, waders and migrants (Smit et al., 2019). Outcome by 2050: declining abundance/diversity, with range contractions for specialists (Simmons & Barnard, 2005; Milton et al., 2022).
Bats		Desertification, overgrazing, rising temperatures and declining surface water availability will reduce natural foraging habitat and insect prey availability. Drier, hotter conditions and declining groundwater recharge are expected to substantially reduce accessible open water sources required for drinking. Expansion of mining, settlements and associated infrastructure will increase artificial roosting opportunities and light pollution, favouring light-tolerant and generalist species while displacing photophobic and specialist bats, resulting in altered species composition. Renewable wind energy development is expected to increase substantially and may pose collision and barotrauma risks if not appropriately managed. Overall outcome by 2050: stable to increasing abundance of a few adaptable species, but declining diversity and increased pressure on water-dependent and specialist bat species. Overall, these interacting drivers are expected to restructure bat communities, with stable or increasing populations of a few adaptable, generalist species, and declining diversity and abundance of specialist and water-dependent bat species
Alien invasive species		Climate change and human activities are facilitating the spread of invasive alien species, which outcompete native species and alter ecosystems. These invasive species further exacerbate biodiversity loss and disrupt local ecosystems (Bourne et al., 2015; Walker et al., 2018). Although invasive species lead to higher biomass and increased vegetation cover in affected areas, they pose significant risks to the Karoo's biodiversity and its limited water resources (Hoffman et al., 2018). Invasion can increase perching sites but homogenization favours generalist bird species (Clusella-Trullas & Garcia, 2017) and may cause local extinctions of specialist bird species (Simmons & Barnard, 2005).
Surface Water resources		

Theme/Driver	Trend	Explanation
Evapotranspiration		Projected increase in Mean Annual Potential Evapotranspiration (MAPE) of 6 to 10% (WRC 2023). Increased vegetation uptake will impact agriculture and ecosystems. Human comfort levels will deteriorate, and water demand will increase. Stored open water bodies will experience higher losses.
Rainfall		Mean Annual Precipitation (MAP) (Rainfall) has reduced from 100 years ago, but past 50 years has been stable (Benito 2011). MAP is projected to decrease between 10-20% in most places, but some locations between 0 -10% (WRC 2024). Less local water in quaternary catchments.
Mean Runoff		Runoff has been dropping marginally over past 50 years in Namaqualand (Benito 2011 – check). Mean Annual Runoff (MAR) is projected to reduce by up to 50% in most quaternary catchments but may increase by up to 25% in a few places. The sporadic nature of runoff events offers very limited opportunity for useable storage. Some small farm dams are concentrated in the mountainous areas of the Buffels river and in the Salt pan areas of quaternaries D53F and D53G.
Runoff Extremes		Flood events are not likely to increase in intensity. (Present to Near-Future Climate change GCMs predict a 20% reduction in maximum discharge). Riparian areas will be subjected flood levels and crossings exposed to flood damage.
Dry Periods		Current average duration of runoff-free periods is 350 days, with some places reporting dry periods of several years (SRK Quaternary Runoff Analysis). These dry intervals are likely to increase (Climate change GCMs predict slight increase in average duration – 1%, but large increases in the maximum dry periods up to 45%). Extended runoff-free dry periods will impact ecosystems and agriculture.
Water use		Climate change projections for the Namakwa District indicate drier, hotter conditions, heightening water demand. This trend is expected to significantly increase pressure on water resources, with rising temperatures and reduced rainfall exacerbating water scarcity (Bourne et al., 2015).
Water demand		Increasing MAPE, reduction in average rainfall and decrease in rainfall frequency (WRC 2023) will intensify the pressure on existing and future water resources..
Water scarcity		Within quaternary catchments, higher mean annual potential evaporation (MAPE) combined with lower mean annual precipitation (MAP) will further reduce surface water availability and groundwater recharge, while extreme runoff events are unlikely to meaningfully enhance aquifer replenishment; instead, salinity levels may increase under higher evaporative demand (Benito, 2011). Although some climate models project increased flows in the Orange River due to higher future MAP in upstream catchments in Lesotho and the eastern RSA, the extent to which this may translate into additional water available for abstraction in Namakwa will depend heavily on upstream water use and allocations within the Orange–Vaal system. Overall, despite potential upstream increases, declining local recharge, high evaporation rates, and sustained water demand pressures indicate a worsening trend in water scarcity across the region.
Bulk water supply & infrastructure		Increase in demand will be met from Orange river abstractions due to projected increase in Orange river MAR at points of abstraction due to predicted Climate Change increases in runoff in Lesotho and eastern RSA (WRC, 2023). However, availability for abstraction will depend on upstream water use in the Orange-Vaal systems. Increased water demand, driven by higher temperatures and population growth, will require expansion of bulk water supply infrastructure to meet growing needs, especially as current resources become more strained. It is anticipated that desalination of seawater will become the primary source of bulk water in the region. At present, regional settlements, including Pofadder, Aggeneys, Springbok/Okiep, Steinkopf, Port Nolloth, and Alexander Bay, are largely dependent on bulk water supplied from the Orange River. This supply is likely at its maximum and is expected to decline as upstream demand increases. As the unit cost of renewable energy decreases, a transition to desalination will become feasible. When this occurs, significant development of the Sandveld under renewable energy and agriculture, such as aquaculture and tunnel cropping, is likely.
Groundwater resources		
Water Use		Groundwater recharge is expected to decrease over most parts of the district (CSIR, 2023) and possibly impact on households or settlements that are dependent on this source of water.

Theme/Driver	Trend	Explanation
Water Demand		Increasing MAPE, reduction in average rainfall and rainfall frequency (WRC 2023) will intensify the pressure on existing and future water resources. Consequently, overutilisation of water sources like the Orange River, will likely increase surface water scarcity in the region. The depletion of surface water in the region will result in increased demand on groundwater resources (CSIR, 2023).
Water Quality		Marine aerosols contribute to increased groundwater salinity through dry deposition in coastal areas. Additionally, the presence of salt-rich heuweltjies in the region, has been linked to elevated groundwater salinity (Francis et al., 2022). Projected increase in runoff extremes may result in the flushing of concentrated salts from these mounds, into the groundwater, exacerbating salinization (Van Gend et al., 2021). Increased salinity in the alluvial aquifers is likely to affect basement aquifers which are dependent for indirect recharge.
Water Availability and Recharge		Reduction in groundwater availability in the alluvial aquifers due to decreased rainfall (CSIR, 2023), particularly a decrease in rainfall events that are able to sufficiently infiltrate into the aquifer systems to provide recharge. Higher extreme runoff events are not likely to improve or lessen recharge to riparian aquifers. Reduced recharge to alluvial aquifers will result in reduced recharge to dependent fractured aquifers. In many cases, aquifers are already stressed due to over-abstraction for various reasons including: high demand, poor infrastructure and improper management (Pietersen et al., 2009). Increased development and settlement will exacerbate this. Heavy reliance on groundwater in the region has already resulted in declines observed in water levels of monitoring boreholes between 1990 – 2008 (DWS, 2008).
Aquatic ecosystems: Inland and Estuarine ecosystems		
Water quality		Water quality in aquatic ecosystems is expected to be on a deteriorating trajectory, with increasing salinities associated with predicted decreased rainfall (Benito 2011). Increases in populations in some local municipalities means increased loads of sewage, and associated increased risks of nutrient enrichment and possible microbial and other contamination of local watercourses, depending on wastewater treatment works efficacy.
Ephemeral pans		Reduced rainfall will be compounded by increased evapotranspiration. Pan hydroperiod may decrease – if it decreases over thresholds of concern (e.g. inundation period is too short for temporary pan-adapted fauna to complete lifecycles) then aquatic biodiversity will be impacted, while terrestrial fauna dependent on pans for water for parts of the year would also be impacted. Plants in and around pans could also be impacted if conditions become hotter, drier and more saline. If plants die back, this would impact on the value of some pans for provision of grazing material.
Seasonal and temporary rivers		Where extended dry periods result in loss of riparian vegetation, ephemeral and seasonal rivers will be more vulnerable to erosion when flooding occurs, particularly at road crossings, where episodic flows are concentrated. These systems are already impacted in some areas by over-grazing, focused along riverine channels, and this would be expected to be ongoing, with its impacts exacerbated by vegetation under increasingly water-stressed conditions.
Wetlands		Extended dry periods and reduced MAP will impact on wetland condition, shifting permanently saturated and seasonally wetlands towards seasonal to ephemeral systems. Although such wetlands are limited in the study area they do occur (e.g. Kamiesberg mountains) where wetlands retain water and allow drinking and foraging by indigenous biota and livestock throughout the year (Samuels, 2013; Kotze et al., 2010) and provide other benefits, such as erosion control and flow regulation (Kotze et al., 2010, Black and Turpie 2016). Changes in wetland condition and type may trigger erosion and reduce crucial wetland ecosystem services in these areas. Ephemeral wetlands and seasonal streams drying impacts sandgrouse, doves, waders and migrants (Smit et al., 2019; Czenze et al., 2020).
Orange River		Increased water stress may increase abstraction from the Orange River near Alexander Bay and (potentially) upstream river reaches (possibly offset by increase in MAP in upper catchment). Increased salinity in the lower estuarine salt marshes may be exacerbated by increased MAP and MAPE, in the absence of remedial measures (see DWS 2017b)
Other estuaries		Estuaries already impacted by hypersalinity (e.g. the Groen River Estuary) would be further impacted. Fish recruit into the Arid Predominantly Closed estuaries in the study area during peak flow periods overtop the estuary and links it to the sea – but hypersalinity in these estuaries affects fish survival (DWS 2024). Reduced MAP and increased MAPE, leading also to increased pressure on water resources, may further threaten ground-water dependent systems (e.g. upper Spoeg and Groen

Theme/Driver	Trend	Explanation
		estuaries).
Socioeconomics		
Agricultural economy		Agriculture in the Namakwa District is shifting toward high-value crops such as table grapes and dates along the Orange River, benefiting from favourable climatic conditions and water availability (CSIR, 2023). However, further expansion depends on sustaining water quality. Irrigation agriculture along the river is labour-intensive, thereby attracting population to the area. The crops are largely exported, with markets expected to remain robust. Extensive grazing operations in the hinterland face challenges due to water scarcity and harsh climatic conditions. Infrastructure developments like desalination improved roads and telecommunications, and export ports could enhance agricultural competitiveness. Irrigation-based agriculture is only relevant along the Orange and Olifants rivers. Livestock numbers are likely to remain static or decline gradually as rangeland productivity. Increasing divergence within the livestock sector is anticipated: among white commercial farmers, consolidation of economic units into larger entities is anticipated as older farmers retire and sell land, either to conservation initiatives, the state (land reform), or corporate farming enterprises. However, desalination of seawater could unlock substantial agricultural expansion along the coast, potentially driving large-scale development under renewable energy and intensive production systems.
Biodiversity and Tourism economy		Tourism in the region is projected to experience steady, gradual growth, supported by investments in conservation, adventure tourism, and cultural heritage tourism. Remote locations, desert landscapes, and botanical tourism (such as the wildflower season) are key attractions. Potential exists for new tourism routes, but successful development depends on leadership and policy support. The revitalisation of ports may enhance local economic prospects, particularly in the fishing industry and eco-tourism.
Mining economy		New mining developments, particularly in Aggeneys and the Namakwa Special Economic Zone, the Okiep copper belt and coast mineral sands and also rare earth minerals, are expected to drive economic growth. These developments, along with infrastructure projects such as port improvements led by Infrastructure South Africa, are anticipated to shape regional settlement patterns.
Municipal service delivery		Many municipalities, particularly outside Springbok, struggle with poor service delivery and inadequate governance. While Nama-Khoi Municipality has improved, others, such as Richtersveld, face financial constraints that hinder infrastructure maintenance (CSIR, 2023). However, they may follow the lead of Nama-Khoi, if new coalitions take over the reins. Namakwa District Municipality has sufficient and growing skills to assist Local Municipalities regarding planning and investment.
Municipal infrastructure		Infrastructure development is expected to progress through projects such as the proposed Alexander Bay to Port Nolloth water pipeline. However, financial stress and inadequate municipal revenue continue to hinder infrastructure maintenance in key settlements like Alexander Bay. For smaller municipalities, the absence of private investment in infrastructure would likely result in complete institutional collapse. Under current conditions, the status quo reflects a lack of progress.
Human settlements		The population of the Namakwa area is likely to increase slowly over the next 25 years., with Kamiesberg facing a 42% decrease, while Richtersveld and Karoo Hoogland may see moderate population growth (CSIR, 2023). Settlements like Alexander Bay are declining due to reduced mining activities and financial instability. The population is urbanizing, due to the availability of services and jobs in urban areas.
Heritage		
Palaeontology		Desertification and increased mining may expose new fossil sites but also risk potential fossil loss without adequate mitigation measures.
Archaeology		Increasing agricultural development along the Orange River continues to pose a significant problem to archaeological sites (including graves) on the banks of the river. Renewed copper mining centred in Okiep may impact the historic Copper Mining Landscape, damaging historic infrastructure which has not been adequately recorded.

Theme/Driver	Trend	Explanation
		Artisanal mining licences and an increase in oil and gas exploration along the coast may impact archaeological and historical sites. Prospecting, and an increase in mining, for manganese and iron, as well as granite in the northern part of the study area (centred around Aggeneys and Pofadder), may impact on heritage resources in this area.
Archaeology (cumulative)		Despite environmental impact assessments, the continued development of renewable energy facilities in the area, will have a cumulative negative impact on archaeological resources.
Knowledge of Palaeontology & Archaeology		The increase in development will lead to an increase in environmental impact assessments, and hence our academic knowledge of the area.
Maritime Heritage		Potential offshore mining and gas exploration may impact on unknown wrecks and may result in their destruction.
Built Environment		Incremental increases in mining and infrastructure development, may impact on historic structures and buildings older than 60 years which may be destroyed, damaged or vandalised.
Built Environment		The increase in money into the region will have a positive impact on tourist numbers, facilities and potentially also in the preservation of particularly the Built Environment which is the most tangible and threatened of heritage resources.
Graves		Graves will continue to be impacted very occasionally. Given that they are generally completely unmarked, impacts are unpredictable.
Living Heritage		Small stock farmers in the communal areas are likely to continue with traditional grazing practices despite poor environmental conditions and overgrazing. This may threaten certain aspects of living heritage. Infrastructure and mining development may also occur in communal grazing lands.
Cultural & Historical Heritage		Population growth and infrastructure expansion will gradually alter historical and cultural landscapes. This is already happening in the Springbok/Okiep and Aggeneys areas. This is in contrast with the seasonal tourism initiatives which rely on the natural aesthetic and heritage preservation of the region.
Built Environment & Cultural Landscapes		Growth in tourism may reinforce the need to protect heritage resources which are tourist attractions.
Living Heritage		Small stock farmers in the communal areas are likely to continue with traditional grazing practices despite poor environmental conditions and overgrazing. This may threaten certain aspects of living heritage. Infrastructure and mining development may also occur in communal grazing lands. Therefore, development, erosion, and desertification may reduce the availability of land necessary for sustaining traditional lifestyles, thereby threatening certain aspects of living heritage.

1.4.2.2. GH2 Development Scenarios

The Work Package 2 assessment considers two GH_2 development scenarios, each compared to, and on top of, the Scenario 0 dynamic baseline where no GH_2 development occurs but other anthropogenic and climate-related changes continue. The development scenarios are summarised as follows:

- **SCENARIO 1 – "Small GH_2" (by 2030):** A 5 GW electrolyser produces 0.5 million tonnes per annum (mtpa) of GH_2 and derivatives, supported by 10 GW of renewable energy, assumed to be 60% solar and 40% wind.

- **SCENARIO 2 – "Big GH_2" (by 2050):** An upscaled GH_2 development with a 40 GW electrolyser producing 4 mtpa of GH_2 and derivatives, supported by 80 GW of renewable energy (60% solar / 40% wind).

All three scenarios are illustrated in Figure 1-4, with each GH_2 development scenario then quantified in Table 1-7, detailing approximate footprints and development scales for the port layout, electrolysers, ammonia plants, desalination facilities, renewable energy clusters, and associated linear infrastructure (pipelines, rail, roads and powerlines).

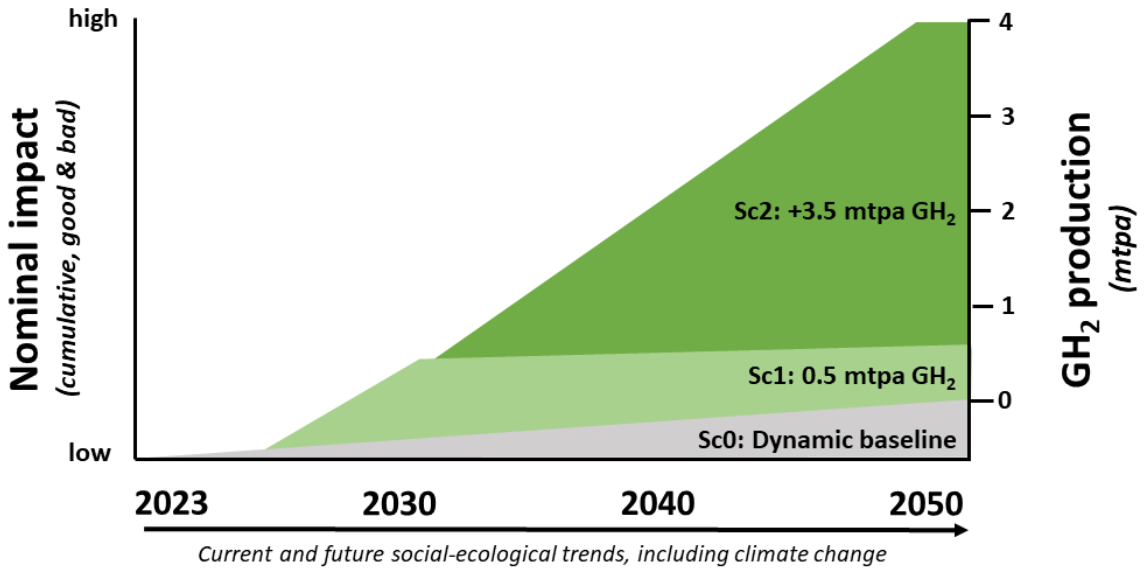


Figure 1-4: Indicative diagram of the scenarios approach for assessing cumulative impacts

Table 1-7: GH_2 development scenario quantifications (Sc1 and Sc2) for Work Package 2.

Aspect		Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
PORT	Port layout	ha	1 280	1 280	From draft port layout
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	Assume 15 ha per 1 GW. "Estimated footprint of 8 hectares (ha)-13 ha for a 1 GW facility using PEM, compared to 10 ha-17 ha using alkaline.
	GH_2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mpta GH2
	GH_2 storage footprint	ha	250	2 000	Assume 10 ha per 20 000 tpa (e.g. Enertrag Hendrina) (500 ha for 1 mpta)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	56,7	453,6	Assume 1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28,4	226,8	Assume 0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mpta)
	Desalination output volume (GH_2 prod only)	Ml/day	35,7	285,7	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 days (Note: Assumed 350 days per year operational, to allow some maintenance time and/or shut down of intake due to unsuitable intake water quality).
	Desalination footprint (GH_2 prod only)	ha	7,1	57,1	Assume 5 Ml/day output needs 1 ha (e.g. Saldanha Desal EIA (CSIR, 2013)) where 25.5 Ml/day desal plant required fenced area of 5 ha for operational phase. This excludes marine infrastructure. Assume linear increase in area with increased Ml/day capacity.
	Desalination discharge (GH_2 prod only)	Ml/day	48,3	386,6	Assume ratio of desalinated water to brine discharge water to be 425:575. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine). This is based on the CSIR Saldanha Desal EIA (2013) which assumed 40-45% desalinated water and 55-60% brine. The Namwater Desal EIA (CSIR, 2009) assumed a similar desal:brine ratio of 40:60.
	Water pipeline intake volume (GH_2 prod only)	Ml/day	84	672,3	Output + discharge
	Desal output volume (GH_2 + oversize)	Ml/day	39,3	328,6	+10% oversize for Sc1; +15 % oversize for Sc2
	Desal footprint (GH_2 + oversize)	ha	7,9	65,7	
	Desal discharge (GH_2 + oversize)	Ml/day	53,2	444,5	
	Water pipeline intake volume (GH_2 + oversize)	Ml/day	92,4	773,1	
	Water surplus	Ml/day	3,6	42,9	Assume surplus water is made available for other water users such as local municipalities, agriculture, other industrial users.
	Main infrastructure components footprint (port & SEZ)	ha	1 697,2	4 617,5	
	Main infrastructure components footprint (port & SEZ + desal oversize)	ha	1 697,9	4 626,1	

Aspect		Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	*GW*	*6*	48	60 % solar : 40 % wind
	RE footprint - solar	*ha*	*12 000*	96 000	0,5MW/ha
	RE extent - solar		*12 000*	96 000	Footprint = extent
	RE facilities - solar	*no of facilities*	*6*	48	Clusters of 1 GW facilities
	RE capacity - wind	*GW*	*4*	32	60 % solar : 40 % wind
	RE footprint - wind	*ha*	*4 000*	32 000	1 MW/ha
	RE extent - wind	*ha*	*40 000*	320 000	0,1 MW/ha
	RE facilities - wind	*no of facilities*	*2.7*	*21.3*	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 650	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	1 200	20 m servitude
	Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.
	Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)
	Main infrastructure components footprint (region)	**ha**	**20 750**	**140 183**	
	Main infrastructure components footprints (all)	**ha**	**22 447**	**144 801**	
	Main infrastructure components footprint (all + desal oversize)	**ha**	**22 448**	**144 809**	
Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; Ml/day = million litres per day; km = kilometre					

1.4.2.3. Risk/Opportunity Assessment

Work Package 2 applied a structured qualitative framework to evaluate risks and opportunities associated with a regional GH_2 economy under different scenarios. Risk or opportunity was determined by combining the **likelihood of an event occurring** with the **severity of its consequence or benefit** (Figure 1-5). Consequence and benefit thresholds were defined for each theme (e.g., biodiversity, water resources, socio-economic systems) using categories ranging from Slight to Extreme, while risk and opportunity levels were classified into predefined categories from Very Low to Very High (Table 1-8).

Each impact was assessed across three scenarios [baseline (Sc0), small GH_2 development (Sc1), and large GH_2 development (Sc2)] and for different receiving environments, both before and after management interventions. Results are presented in structured outputs for risks (negative) and for opportunities (positive).

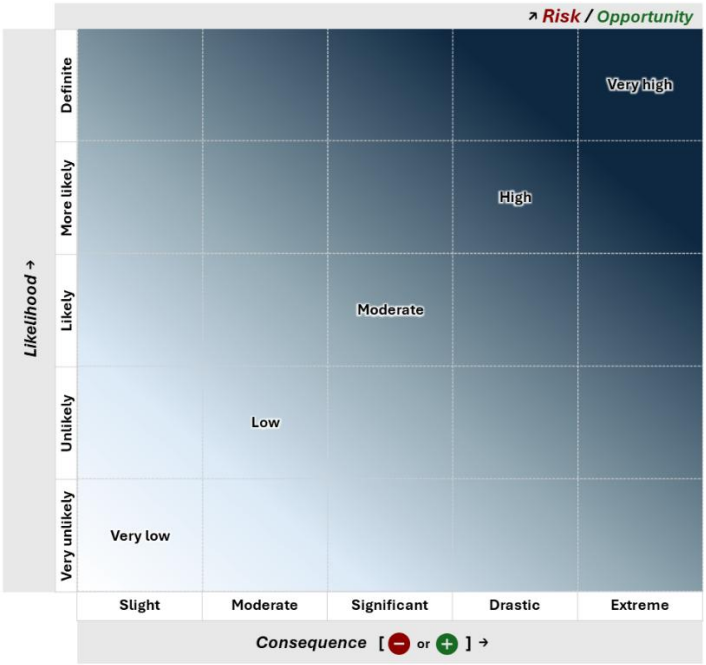


Figure 1-5: Risk and opportunity was assessed by qualitatively "multiplying" the likelihood of an impact (negative or positive) by the severity of the consequence or benefit.

Table 1-8: Predefined risk/opportunity categories.

RISK (-)		OPPORTUNITY (+)	
VERY LOW	Almost indiscernible negative impact.	Almost indiscernible positive impact.	VERY LOW
LOW	Slight negative impact, limited extent, and short duration, well within tolerance.	Slight positive impact, very localised, well below expectations.	LOW
MODERATE	Substantial impact, but less than major; within tolerance and below limits of acceptable change.	Substantial positive impact, but mostly short term, and spatially limited.	MODERATE
HIGH	Major consequence, approaching tolerance and limits of acceptable change.	Highly desirable impact, major medium to long term positive impacts across a broad range of stakeholders at local or regional scales.	HIGH
VERY HIGH	Extremely negative impact, persistent/long lasting, beyond tolerance and limits of acceptable change.	Highly desired, grandiose long term positive impacts across a broad range of stakeholders at local, regional, national, and/or international scales.	VERY HIGH

1.4.2.4. Work Package 2 Chapter Structures

A multi-author team model was adopted for both Work Packages in the SEA. A multi-author team, in the context of SEA, refers to a structured, pluralistic authorship model designed to integrate diverse perspectives and expertise across an assessment process (see Schreiner et al., 2025). For this SEA, multi-author teams were constituted through a consultative process with the Working Group (which included representatives from government, academia, NGOs, and other stakeholders) to nominate researchers who possess the required niche knowledge of this remote region, along with an understanding of strategic infrastructure impacts, academic credibility, and expertise in high-level strategic assessments. Multi-author teams were assembled for both Work Package 1 and Work Package 2 (Figure 1-6). The teams developed peer reviewed reports, with the Work Package 1 teams focusing on identifying the key sensitivities and impacts associated with the port and SEZ development, and the Work Package 2 teams undertaking a more strategic assessment of the cumulative risks and opportunities at a broader scale. Writing teams worked closely across both Work Packages for the duration of the SEA process, ensuring that all the salient issues were covered in at least one of the Work Package Chapters.

Work Package 2 represents a collaborative scientific effort, comprising of seven chapters developed by a team of thirty-four authors, peer-reviewed by thirteen independent experts. The content has also been enriched by contributions from a diversity of stakeholders engaged in the process via a formally constituted Working Group. In addition to the Summary for Policymakers (SPM) (Schreiner et al., 2025), Work Package 2 includes the following chapters (Table 1-9):

Table 1-9: Chapter numbers, titles and recommended citations for work Package 2

Chapter	Title	Citation
Chapter 1	Introduction and context (***this Chapter***)	Mqokeli et al., 2026
Chapter 2	Ecology, biodiversity and conservation planning	Desmet et al., 2026
Chapter 3	Biodiversity offset framework	Botha, 2026
Chapter 4	Water resources and aquatic ecology	Day et al., 2026
Chapter 5	Heritage resources	Orton et al., 2026
Chapter 6	Infrastructure and planning	Maritz et al., 2026
Chapter 7	Socio-economics	Atkinson et al., 2026

Work Package 2 author teams were tasked with developing the following chapter content, as far as practicable (with due recognition that some chapters had to deviate somewhat given their scope):

1. Executive Summary of 2 pages with headline findings/recommendations (including one iconic image/map to assist communication of findings to policymakers);

2. Spatial classification of receiving environments across the study area (e.g., tiered sensitivity map - LOW, MEDIUM, HIGH, VERY HIGH);

3. Description of the likely baseline receiving environment up to 2050 (Sc0) in view of current social and ecological trends e.g., mining activities, rising unemployment, decreased rainfall and water supply, other land use changes, increased tourism etc.

4. Brief description of the potential impacts, positive and negative, associated with a regional GH2 economy and other developments in the Port and SEZ.

5. Define consequence / benefit categories.

6. Description of what would constitute best-practice for effective management / mitigation / enhancement of positive and negative impacts

7. Assess the risk/opportunity of the impacts across each of the scenarios (before & after management) according to methodology provided.

8. Recommended Strategic Management Actions to guide policymakers and regional planning in, for example, Environmental Management Frameworks (EMFs), Spatial Development Frameworks (SDFs), Infrastructure Development Plans (IDPs) and future EIAs.

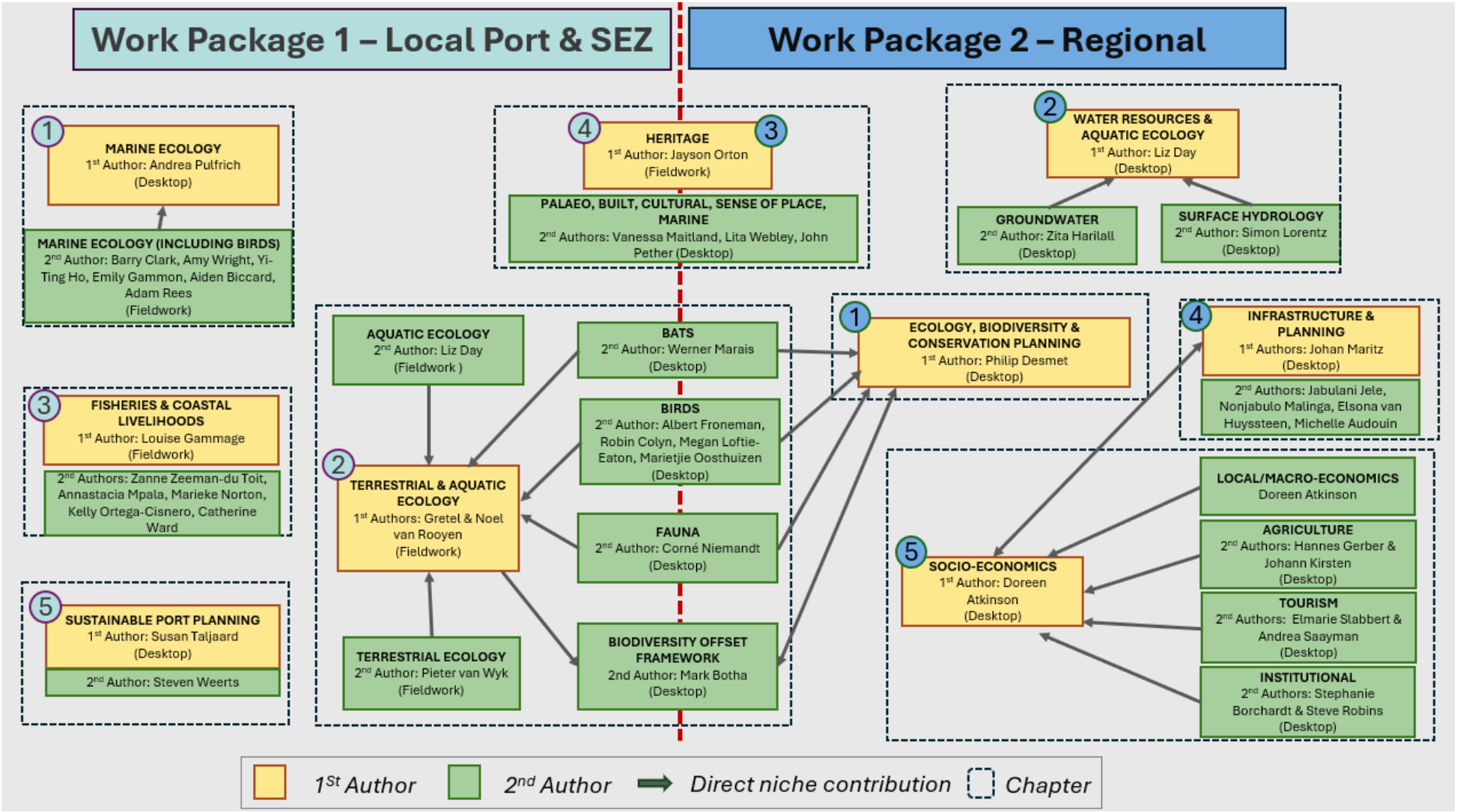


Figure 1-6: Multi-author teams and specialist chapters across the two Work Packages with notional intersections and points of collaboration and overlap indicated

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CHAPTER 2

Ecology, Biodiversity and Conservation Planning

CHAPTER 2: Ecology, Biodiversity and Conservation Planning

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The view looking south from the top of Boegoeberg in 1994, a time before the great sand mobilisation and when there was still veld in this landscape. (photograph: Philip Desmet)

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Executive Summary

This report forms part of Work Package 2 for the Boegoebaai Strategic Environmental Assessment (SEA), focusing on regional biodiversity sensitivities and risks in the Namakwa Region, Northern Cape, South Africa. It integrates spatial biodiversity planning informants to guide development scenarios, particularly in relation to the emerging green hydrogen (GH2) economy.

The Namakwa Region study area covers approximately 5.75 million ha, including the Kamiesberg, Khai-Ma, Nama Khoi, and Richtersveld Local Municipalities. This is a landscape comprising coastal plains, escarpment mountains, sand-covered Bushmanland plains, and the Orange River valley, straddling a key biogeographic boundary between winter and summer rainfall zones and most significantly is the centre of the Succulent Karoo Biome.

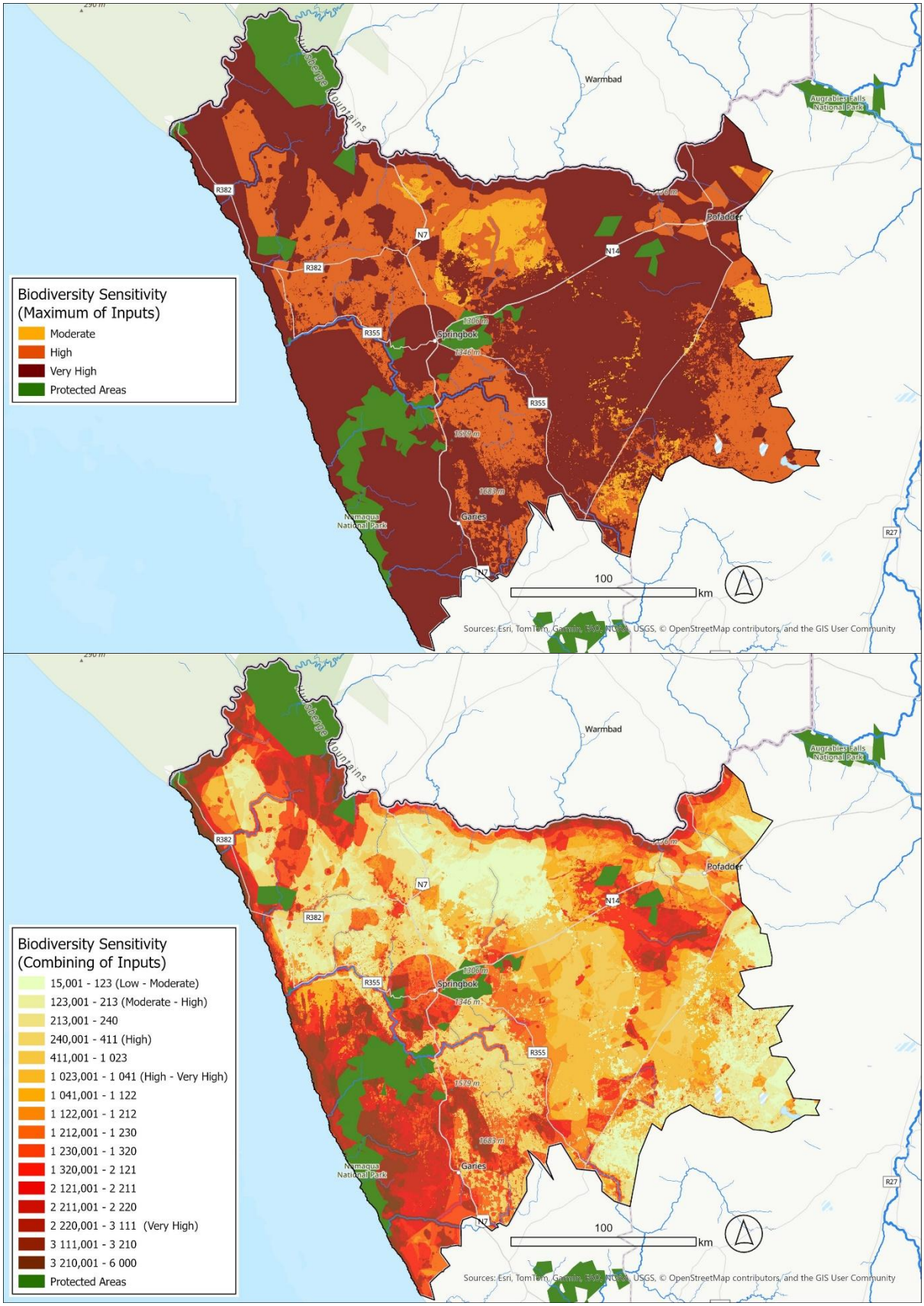
The region is a global biodiversity hotspot. The Succulent Karoo Biome is the world's most species-diverse arid region, with exceptional levels of plant endemism and diversity. This biodiversity is unevenly distributed, with local hotspots being especially sensitive. Key habitats for biodiversity include gravel patches, quartzite mountains, south-facing slopes, high plateaus, and relic ecosystems (fynbos, renosterveld).

Current threats to the region include livestock grazing (most widespread, reversible if managed), mining (current and future, especially mineral sands), renewable energy (solar and wind farms), linear infrastructure (transmission lines) and poaching of plants and animals for the collectors' trade (real-time species extinction risk).

Climate Change is possible the most significant current threat. The region is experiencing significant ecosystem degradation, with desert biome expansion predicted by 2070. Vegetation productivity trends show widespread browning, especially in the Richtersveld. Based on an analysis of EVI trends and the levels of degradation quantified indicates that at least 65% of the regions 71 vegetation types can be considered as threatened ecosystems in terms of Red List of Ecosystems (RLE) criterion D1.

Protected Areas: Currently, less than 8% of the region is formally protected, with efforts underway to expand this to 30% by 2030. At least 70% of the region is currently earmarked by one or more protected area expansion plan. In terms of Ecosystem Protection Levels (EPL) only 28% of ecosystems are well protected; 66% are poorly or not protected. There is still a significant amount of work required to reach the 30x30 targets.

The biodiversity sensitivity analysis combines available biodiversity informants (into a single 4-class high-low biodiversity sensitivity map. The informants were combined into six intermediate sensitivity maps: (1 biodiversity planning [CBA maps, plants species of conservation concern and expert mapped areas], 2 protected area expansion plans, 3 birds, 4 bats, 5 animals, and 6 aquatic ecosystems. Based on a maximum of the inputs at least 70% of the region is medium to very high sensitivity. This is expected as the region is a global biodiversity hotspot and this implies that there are high biodiversity sensitives in one form or another across almost the entire landscape.



Biodiversity sensitivities in the SEA regional landscape. Six intermediated sensitivity map are combined using a maximum of inputs (top map) and cumulation of inputs (bottom)

The cumulation of inputs indicates that only 11.5% of the region is very high sensitivity for 3 or more inputs. This indicates that there is some, but not a high degree of spatial correlation between the sensitivity inputs. In other words, areas important for plants are not necessarily also important for bats or birds. From the development perspective, this map illustrates where there might be more flexibility in the sensitivity map for development. For example, areas that are very high sensitivity for only one input implies that significant impacts may be lower and the required mitigation less than in an area that is very high for two or three inputs.

Three development scenarios are assessed (Baseline, Small GH2, Big GH2) each associated with increasing biodiversity loss. Impacts are grouped into two high-level groups: biodiversity pattern impacts (direct habitat/species loss), and ecological process impacts (disruption of processes, fragmentation). Mitigation emphasizes avoidance of sensitive areas, use of biodiversity offsets, and site-specific measures in relation to specific receptors. The consequence and likelihood of impacts with and without mitigation are considered similar, however, the risk assessment differs based on the contribution of sensitivity categories to achieving our conservation goals.

Strategic Management Actions include:

- Invest in the biodiversity knowledge base particularly data derived from RE operational monitoring, place this in the public domain and use this data to inform management aimed at avoiding, reducing and mitigating biodiversity impacts.

- Invest in refining spatial biodiversity planning with which to improve biodiversity informants for developing planning. A key immediate activity is the development of the regional biodiversity spatial framework to provide the spatial blueprint for protected area expansion, biodiversity offset implementation, developing the biodiversity economy and informing the spatial alignment of GH2 economy with the biodiversity economy.

- Plan for the biodiversity economy by aligning GH2 development with that of the biodiversity economy.

- Consider visual impacts of GH2 and explicitly plan for protecting the “wilderness” sense of place that the region’s most important tourism resource.

- Implement proactive mitigation and biodiversity offsets strategies to spatially and financially optimise the mitigation and offset requirements for the entire GH2 development, and to ensure alignment of offset objectives across all RE projects with the national biodiversity conservation goals and objectives.

- Invest in building a community of practice around RE in the region or South Africa generally to support growing human capital and support the adaptative management process by creating a forum for sharing of data and ideas between scientists, managers and regulators.

The Namakwa Region’s status as a global biodiversity hotspot requires careful and informed spatial planning to balance development (especially GH2 and renewables) with conservation. The sensitivity analysis demonstrates that while there is room for development, this must be strategically located to avoid undermining biodiversity conservation goals and the region’s economic potential founded on this biodiversity.

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CHAPTER 2. ECOLOGY, BIODIVERSITY AND CONSERVATION PLANNING

2.1 INTRODUCTION

As part of Work Package 2 for the Boegoebaai Strategic Environmental Assessment (SEA), this report presents a region assessment of biodiversity sensitives and risks in relation to three development scenarios (Table 2-1). The analysis integrates available biodiversity-related spatial planning informants, including those from WP1, to provide a regional perspective on the spatial distribution of biodiversity sensitivities across the Namakwa Region. This can be used at the desktop level to assess the impacts of future development and help development planning avoid high biodiversity sensitive areas at the planning stage.

Table 2-1: The spatial extent of the three development scenarios considered in the regional analysis.

Scenario	Assumed extent of biodiversity loss
Baseline	background biodiversity loss, <100 ha per year
Small GH2	21 082 ha
Big GH2	142 240 ha

In terms of report structure, the first section provides an overview of biodiversity patterns in the region. Only through better understating the spatial components of patterns of diversity and ecological processes in the landscape will we better able to consider or integrate biodiversity into land use planning.

The second section of the report provides a summary of the most significant current threats to biodiversity and is followed by an in-depth perspective on real-time climate change impacts observed in vegetation productivity trends.

The final part of the report integrates the available spatial biodiversity planning informants and taxon-specific assessments developed as part of this project into a single biodiversity sensitivity map for the WP2 region. Inputs to the biodiversity sensitivity analysis include:

1. Focus areas for protected area development combining protected area planning and development products from the implementing agencies and NGO partners in the region.

2. Plant-focused biodiversity sensitivity based on combining the available maps of critical biodiversity areas (Namakwa District 2009 and Northern Cape 2025) and other plant distribution information.

3. Bird biodiversity sensitivity prepared by Kellerman *et al.* (2026).

4. Bat biodiversity sensitivity prepared by Marais and Welch (2026).

5. Fauna biodiversity sensitivity prepared by Niemandt (2026).

6. Aquatic ecosystems sensitivity prepared by Day (2026).

The results of the sensitivity assessment are interpreted with regards to the spatial opportunities and constraints for regional development, and particularly a spatial perspective of where likely biodiversity offset receiving areas will be located. Whilst we cannot predict the future of development in the region,

good spatial planning now can help the region prepare for and mitigate the impacts of current and future development pressures.

2.2 STUDY AREA

The study area for the regional assessment is the "Namakwa Region" includes the entire northern parts of the Namakwa District Municipality comprising the Kamiesberg, Khaî-Ma, Nama Khoi and Richtersveld Local Municipalities, an area of approximately 5.75 million ha (Figure 2-1).

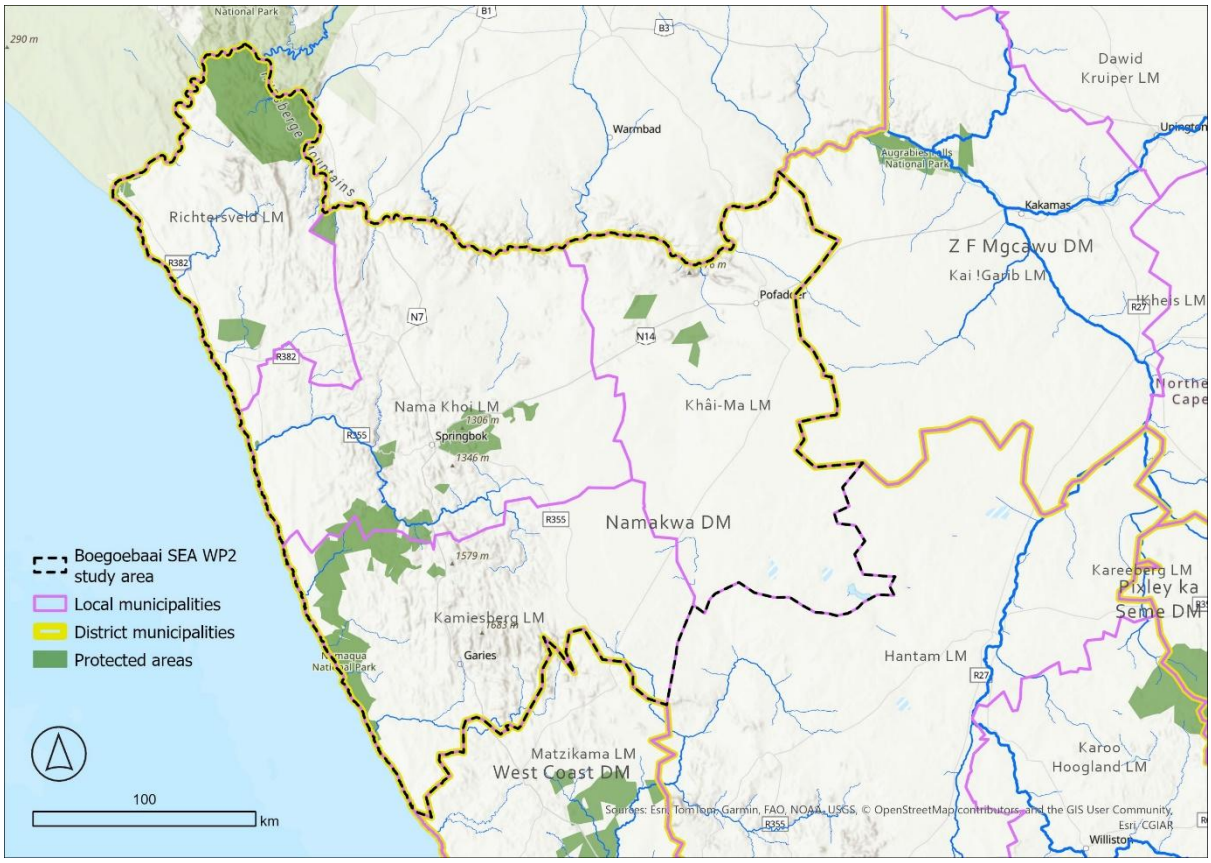


Figure 2-1: Location of the SEA study area in the north west of South Africa.

2.3 DESCRIPTION OF THE BASELINE RECEIVING ENVIRONMENT

2.3.1 Patterns of Diversity

The Namakwa Region lies in the north-west corner of South Africa. The region encompasses a wide coastal plain in the west adjoining the cold Atlantic Ocean; the north-south trending mountains of the African escarpment in the centre; wide-open sand-covered plains of the Bushmanland on the African plateau in the east; and the region is bounded in the north by the rugged Orange River valley.

This is a semi-arid to arid region (<250mm rain annually) that straddles a very important biogeographic boundary between the winter and summer rainfall zones of southern Africa. This boundary is orientated north to south in the east of the Namakwa Region running through the Bushmanland plains. Globally, the winter-summer rainfall divide is the most significant biogeographic boundary that there is in the world separating Mediterranean-type ecosystems (winter growing ecosystems) from all other ecosystems on earth (viz. summer-growing ecosystems). In southern Africa ecosystems of the winter-rainfall zone are

grouped into the Greater Cape Floristic Region that includes the Fynbos and Succulent Karoo Biomes. The arid ecosystems in the summer rainfall zone are grouped into the Nama Karoo Biome.

The central and western parts of the Namakwa Region fall within the Namaqualand bioregion of the Succulent Karoo Biome. The Succulent Karoo is globally recognised as the most species diverse arid region in the world. On an area-equivalent basis the Succulent Karoo contains 2.65 times more species per unit area than the neighbouring Nama Karoo, and nearly 4 times more species than equivalent winter-rainfall deserts elsewhere in the world. The Namaqualand bioregion contains about 2800 species of plant in an area of about 100 000km^2 of which 27% are endemic to the bioregion (Snijman 2013). The exceptional biodiversity richness of the Succulent Karoo is the primary reasons why it is recognised as a global biodiversity hotspot and a priority focus area for biodiversity conservation.

The Namakwa Region is divided into nine distinct biophysical / biogeographic regions (bioregions) that reflect the impact that the underlying physical environment (primarily patterns of rainfall and substrates/geology) have on patterns of diversity across the region (Table 2-2) (Desmet 1997 and 2007; Snijman 2013, van Wyk and Smith 2001). Understanding these patterns of diversity in the region is the first step towards properly considering biodiversity in spatial planning and development decision making. Each bioregion is discussed in more detail in the sections that follow.

Table 2-2: A summary of the bioregion encountered in the Namakwa Region.

	Region	Bioregion	Biome
1	Coastal plain	Sandveld	Succulent Karoo
2		Hardeveld	Succulent Karoo
3	The Escarpment	Richtersveld Mountains	Succulent Karoo
4		Namaqualand Klipkoppe	Succulent Karoo
5		Kamiesberg Mountains	Fynbos
6	The Bushmanland	Bushmanland Sandy plains	Nama Karoo
7		Bushmanland Inselbergs	Succulent Karoo
8	Orange River Valley	Eastern Gariep	Desert
9		Western Gariep	Desert

2.3.1.1 The Sandveld

The great sand-covered coastal plain of Namaqualand is called the ***Sandveld***. Millenia of sand deposition by the sea and constant re-working by the wind have created a vast, mostly continuous sea-of-sand with a flora and fauna distinctly different to the rest of the region. As a general ecological rule, after rainfall seasonality and amount, sandy substrates vs other soil types (rocky colluvium or loam/clay) are next most important discriminator of ecosystems in the Succulent Karoo. The Sandveld is characterised by vast serene "wilderness" landscapes of strandveld vegetation. Pockets of plant diversity occur where inland habitats co-inside with the strandveld, such as along river valleys (e.g., Buffels River at Kleinzee) or rocky promontories along the coast (e.g., Boegoeberg). Whilst plant diversity in the strandveld is generally low by regional standards there are none-the-less a suite of species, notably fauna, that are endemic to the peculiarities of living in sand. For example, three species of fossorial mammals are endemic to the Sandveld: De Winton's golden mole (*Cryptochloris wintoni*) that is only know from the dunes around Port Nolloth; Van Zyl's golden mole (*C. zyli*); and the rodent Namaqua dune molerat (*Bathyergus janetta*). Within the Sandveld in pockets of acid sandy soils, and especially in precipitation traps (i.e., fog traps in depressions) one encounters sandplain fynbos vegetation. This is a relic ecosystem that is more closely related to the fynbos on the high peaks of the Kamiesberg than to the vegetation communities in the surrounding Sandveld. The Sandveld sea-of-sand is kept in place by the veneer of strandveld that blanket the surface. Where this blanket is removed immediately causes sand mobilisation by the wind smothering vegetation in its path. This movement snowballs eventually creating plumes of actively moving sand marching northwards towards the Orange River. Nowhere is this more apparent than along the coast where

a century of un-mitigated diamond mining activities has caused virtually the entire coastal landscape to begin moving.

2.3.1.2 The Hardeveld

On the coastal plain between the Sandveld and the base of the escarpment lies the ***Hardeveld*** with its characteristic "heuweltjies" or fossilised termitaria that create the distinctive pockmarking in the landscape. The soils are shallow over calcrete, loamy and base rich. The vegetation is dominated by short leaf-succulent vygies. Within the Hardeveld and usually associated with drainage lines are quartz gravel patches. Geologically these are a type of erosion gravel pavement, but only in the Succulent Karoo is there a unique biodiversity specifically adapted to this habitat type. Quartz patches (and other gravel patch types in the Succulent Karoo) with their associated biodiversity are a globally unique biodiversity phenomenon found now where else outside of the Succulent Karoo! From a spatial planning perspective gravel patches are a very high sensitivity habitat type and a key focus for conservation efforts.

2.3.1.3 Namaqualand Klipkoppe

The bulk of the African escarpment in Namaqualand is comprised the Namaqualand **Klipkoppe** bioregion. This is an extensive region of gneiss koppies and hills stretching from the break with the coastal plain (Hardeveld, ca. 300m) through to where the mountains of the escarpment merge with the sandy plains of the interior plateau (Bushmanland, ca. 800m). This region is synonymous with the spectacular spring flower displays that the region is famous for. Despite having a rich flora this region has comparatively few endemic species. This is perhaps because none of the habitat features generally associated with local centres of diversity are present in this bioregion (see Section 2.3.1.10). An interesting aspect of the regional vegetation, and which is encountered generally on mountains throughout the region, is the floristic affinities of vegetation on north vs south slopes. North-facing slopes are hot and generally support vegetation with summer-rainfall affinities especially the tree flora what are all palaeotropical affinities. South-facing slopes are cool and support winter growing vegetation with Succulent Karoo and other Cape Flora affinities.

2.3.1.4 The Kamiesberg

Located in the centre of the Namaqualand Klipkoppe bioregion is the granite massif of the **Kamiesberg**. Rooiberg (1700m) is the highest peak in the Namakwa Region and all the high peaks above 1200m support fynbos vegetation with renosterveld occupying upland valleys and plateaus between 900-1200m. These are fire-driven ecosystems typical of the Core Cape Flora that share few floristic affinities with the surrounding Succulent Karoo vegetation types. The Kamiesberg is a significant centre of endemism with at least 114 endemic or near-endemic species.

2.3.1.5 The Bushmanland Plains

East of the escarpment mountains, the entire eastern portion of the Namakwa Region is covered by the **Bushmanland** Plains bioregion. These expansive, gently undulating plains occupy the interior continental plateau at between 800-1100m. They are for the most part entirely covered with a thin veneer of red sand overlying a thick calcrete hardpan layer. The vegetation here is Bushmanland arid grassland, a species poor Nama Karoo Biome vegetation type but none-the-less highly productive and resilient vegetation type that is critical habitat for arid zone birds. To the south-east of the region, the sand sheet and desert grassland gives way to the barren rocky plains of the Bushmanland vloere, an even more species poor and depressing place for botanists. In the centre of these plains, the Koa River Valley marks south-north paleo river channel the ancient proto-Orange River. This valley is marked by the presence of large sand dunes that are the core habitat of the endemic Red Lark. This valley is also large enough to produce valley fog in the winter months that is an important moisture source for the Succulent Karoo vegetation on the surrounding inselbergs (see Section 2.3.1.6). Whilst the species diversity of these grasslands bares no comparison neighbouring Succulent Karoo vegetation units, around the fringes of this unit occur gravel patches on exposed calcrete or paleo river terraces each with their own suite of endemic plan species.

2.3.1.6 The Bushmanland Inselberg Region

At the northern end of the Bushmanland plains is a region of scattered inselbergs known as the **Bushmanland Inselberg** Region. These inselbergs are distributed in an east-west swathe marking approximately the southern edge of the Orange River valley. A feature of all these inselbergs is their relatively flat, quartzite-capped plateaus and associated quartzite rock/boulder covered scree-slopes and aprons, the presence of several types of gravel patches (quartzite, calcrete, feldspar), as well as the region being located on the ecotone between summer and winter rainfall zones. Therefore, the vegetation of the plains and warmer north-facing aspects is characteristic of the Nama Karoo Biome whereas that of cooler higher-elevation plains and south-facing aspects is characteristic of the Succulent Karoo Biome. The overlap of two biomes is a unique feature of the regions flora and sets these inselbergs apart from other inselbergs elsewhere in the Nama Karoo. The overlap of biomes is observed in the species of conservation concern. Of the 44 species of conservation concern know from the region, 7 have Nama Karoo affinities whereas the remainder all have Succulent Karoo affinities.

There are two ecological features of the inselberg region that are reflective of ecological patterns through the broader Namakwa Region and Succulent Karoo. These insights provide important lessons for spatial planning.

Firstly, The Bushmanland inselbergs effectively comprise an archipelago of rocky “islands” within a “sea” of sand. These “islands” share common floristic affinities but show distinct east-west and north south gradients in species turnover and population-level variation. The surrounding sandy plains form a continuous vegetation fabric that is widespread beyond this region, however, the inselbergs have very few species in common with the vegetation on the surrounding sandy plains – chalk and cheese! This pattern of diversity is demonstrated in across all regions discussed here. Key habitats are distributed as islands across the landscape, and each habitat island shows different patterns of diversity depending in its size and proximity to other islands. The ecology of species living on islands provide key ecological process principles that need to be considered in spatial planning.

Secondly, where the Bushmanland plains rise to approximately 1000m, rocky plains and inselbergs intersect the zone of winter-rainfall influence and Succulent Karoo vegetation makes an appearance in the form of Aggeneys Gravel Vygieveld. This vegetation type occurs as far east as Pofadder, is a distinctly Succulent Karoo vegetation type that occurs deep within the summer rainfall zone because the elevation at which it occurs it receives winter precipitation from passing cold fronts and valley fog from the Kao River valley. Similarly, the south facing slopes of the larger inselbergs support outposts of Namaqualand Klipkoppe vegetation. This vegetation typically occurs on rocky hills around Springbok, 100km to the west of these inselbergs. These vegetation anomalies point to the importance of aspect and elevation on quartzite rock and local precipitation traps are critical ecological components of climate change refugia.

2.3.1.7 Eastern Gariep

The lower Orange River valley east of the Richtersveld and north of the Bushmanland Plains is considered South Africa’s only true desert. Hot and dry, the ***Eastern Gariep*** Centre of Endemism stretches inland from the Richtersveld as far as Onseepkans. There are many endemic plant species associated with this centre of endemism, but unlike in the valley to the west of the Richtersveld where the flora is derived from the Greater Cape Flora, here species have family affinities with Africa’s summer-rainfall or Afro-tropical deserts such as the Namib, Kaokoveld, Kalahari and even the Horn of Africa. However, as with the adjacent Bushmanland Inselberg Region to the south, the high mountains peaks above 1100m intersect the winter rainfall zone and contain outposts of the Succulent Karoo vegetation. This Eastern and Western Gariep (see Section 2.3.1.9) bioregions are classified as Desert Biome in South Africa and not Succulent Karoo.

2.3.1.8 The Richtersveld

The Richtersveld mountains terminate the northern end of the African escarpment in South Africa. At first glance, the Richtersveld is part of an entirely different geological suite to Namaqualand, giving rise to rugged landscapes with steeply trending mountains of metamorphic rocks with high peaks and sheltered valleys. The central mountain ranges of the ***Richtersveld*** are possibly the most species diverse centre of endemism within the Succulent Karoo biome. More than 2000 plants species have been recorded from

the Richtersveld with at least 305 considered endemic plants (P. van Wyk pers. Comm.). This topographic and geologically diversity area is home to a wide diversity of life. North-facing slopes tend to harbour elements with summer rainfall affinities, whereas south-facing slopes are home to the winter-rainfall elements associated with the Greater Cape Flora. The highest peaks are wet enough to still have remnants of Renosterveld and Fynbos vegetation types (Fynbos Biome). South slopes and high elevation areas are important climate change adaptation habitats for species – these are locally mesic (wetter, cooler) habitats that provide species with refuge when climates become more arid or hotter. Consequently, there are many "paleo-relic" species associated with these habitats. These are species characteristic of the Core Cape Flora far to the south with outlying occurrences in the Richtersveld.

A key trend in the patterns of diversity in the Richtersveld, as with all bioregions in the Succulent Karoo, is that this diversity is not distributed evenly throughout the landscape. Concentrations of species of conservation concern occur in distinct local nodes of diversity Each area represents a local hotspot that hosts components of the endemic flora of the Richtersveld. These areas are mostly topographic features such as mountains that provide unique and often isolated evolutionary niches for species. Mountainous areas provide more habitats for biodiversity due to greater diversity of geology (rock chemistry); geomorphology (physical properties); aspect (exposure to the sun); elevation (cooling and increased moisture); refuge from disturbance (grazing); and, in many cases increase moisture availability (e.g., fog traps). Some plains areas are also noted as being centres of diversity and all are associated with the occurrence of gravel plains of various types: the lower Orange River valley around Alexander Bay; Sun Valley; and the quartz gravel patches southeast of Eksteenfontein, the Holgat River and, Lekkersing.

These local areas of endemism are highly sensitive from a development perspective. Throughout the Namakwa Region all such areas mapped by biodiversity experts are a key informant of high sensitivity zones for development.

2.3.1.9 Western Gariep

In the Orange River valley west of the Richtersveld from Sendelingsdrift to Alexander Bay is the ***Western Gariep*** Centre of Endemism. This is the southern boundary of the ***Namib Desert.*** Just south of Alexander Bay, the Boegoeberg inselbergs mark the boundary on the coast between Namaqualand and the Namib Desert. This winter-rainfall section of the Namib Desert is the most northern extent of the Succulent Karoo biome, and stretches northwards to Lüderitz in Namibia, and inland as far as the western mountains of the escarpment. This arid area is still well within the winter-rainfall zone, and frequent fog from the Atlantic Ocean is the primary source of moisture in this landscape. Many plant species are endemic specifically to this small geographic area. At its western extremity, the area from Brandkaros to Alexander Bay and Oranjemund has possibly the most endemic rich vegetation in South Africa, a testament to the highly unique environment found here.

Included in this area is South Africa's largest ***lichen field*** just outside the town of Alexander Bay. This is the world's most species-rich lichen field, and whilst there are extensive lichen fields in the central Namib these bare no comparison in terms of species diversity or biomass to this lichen field at Alexander Bay. It is truly a global wonder!

2.3.1.10 Key biodiversity patterns informing spatial planning.

From our understanding of the local and regional patterns in the occurrence and distribution of biodiversity in the Namakwa Region it is possible to summarise important spatial aspects of these patterns of diversity that are important to consider in spatial planning and decision making:

1. Exceptionally high levels of plant species diversity and endemism. The likelihood of any development impacting species of conservation concern is generally high throughout the region. This likelihood is very high in the many local centres of diversity recognised throughout the region.

2. Plant species diversity is not evenly distributed through-out the landscape. Distinct local geographic areas with concentrations of species of conservation concern are recognised that from a plant conservation perspective are the most important areas for species conservation in the region. For the most part these are generally well mapped in the region.

3. The reasons for the occurrence of these centres of diversity are varied. Several habitats are well known to be associated with higher species diversity or concentrations of endemic species. These include:

    a. Gravel patches (quartz, calcrete, feldspar, paleo-river terraces)
    b. Quartzite mountain systems
    c. Climate refugia habitats (south-facing slopes, high mountains and plateaus, precipitation traps, dune systems, kloofs)
    d. Relic ecosystems specifically fynbos (depressions in the Sandveld) and renosterveld (escarpment edge) ecosystems.
4. Close observation of patterns of diversity highlights elements of local ecosystems that provide climate change refugia for species. The ecological attributes of habitats that support extra-limital populations of species provide useful insights into to what ecological factors to include in spatial planning for climate change resilience. Factors such as aspect and elevation are easy to map or model from a digital elevation model. Other factors are more nuanced such as moisture traps. This can only reliably be mapped through experts identifying these areas based on field experience.

2.3.2 Biodiversity Status and Trends

Biodiversity and ecosystems in the Namakwa Region face a multitude of pressures that are or can lead to the outright loss or degradation of the natural environment thereby undermining societies' ability to achieve sustainable development goals. When assessing the impact of any development it is important to understand the current status of biodiversity and the anthropogenic pressures driving trends in natural systems, and how the development will interact with these threats.

Significant threats currently facing biodiversity in the region are summarised in Table 2-3. There are many other threats facing biodiversity in the region that are not discussed here. That is because they are either not considered a significant driver of biodiversity loss within the regional context (e.g., alien invasive species), or the threats have a local impact that is not considered significant (e.g., off road driving, hunting, urban development). Threats that lead to permanent loss of natural habitat, especially over large areas, and loss or decline in populations of species of conservation concern are consider highly significant threats. Ecosystem degradation threats such as livestock grazing, whilst impacting large areas, are potentially reversible therefore are considered significant.

It is very important to have some perspective on novel or developing economic activities, and where and how they may impact the biodiversity. These can present potentially significant threat to biodiversity. This perspective can help prioritise where conservation action should focus to minimise the impact of new threats. Good spatial planning will be critical for ensuring that novel land uses develop in an appropriate and environmentally sustainable manner.

Largescale developments that are on the horizon for the Namakwa Region include:

- The hydrogen economy, the motivation behind this study, and the expansion of renewable energy to meet the energy demand for this industry is highly likely. This industry has the potential to impact very large areas and will possibly be the largest driver of habitat loss in the short term.

- There are still extensive reserves of mineral sands throughout the Sandveld, and it is only a matter of time until these resources are exploited. The open-cast moving-pit mining model used by current mineral sand operations along the coast target whole landscapes or ecosystems and have the potential to destroy significantly more habitat than what the diamond miners have achieved. For example, the current mineral sand mine at Namakwa Sands stretches the entire width of the Sandveld and the pit area is currently 20 000 ha in extent and growing. The sheer spatial scale of this type of operation dwarfs that of the diamond mines.

- It is also likely that with the advent of cheap or surplus electricity in the region, the cost of desalinating sea water will become cost effective for the developing tunnel agriculture. It is not unreasonable to envision large swaths of the Sand being covered in poly-tunnels.

The impact of climate change is discussed separately in the following section.

Table 2-3: A summary of the major threats currently facing biodiversity in the Namakwa Region.

Activity	Description of Impact	Biodiversity Impact	Potential area of impact	Notes
Livestock grazing	Livestock eating natural vegetation	Loss of ecosystem function (reduction in plant cover and species diversity, increased soil erosion and runoff)	Widespread impacting the whole region	Livestock grazing is the most widespread land use activity in the region. The impact is strongly dependent on land tenure, i.e., impact varies across properties. Within the context of climate change and promoting ecosystem resilience managing livestock grazing is the single most important threat to manage given the wide spatial extent.
Current mining	Construction and operation of mine	Outright loss of habitat at mine site. Degradation of ecosystems in neighbourhood (dust and runoff)	Restricted to mine site and local neighbourhood	Underground pit mining activities tend to be focussed on specific sites. These can have significant species or habitat-level impacts especially where they coincide with biodiversity features of conservation concern. These impacts need to be managed on a case-by-case basis. Future open-cast mining for mineral sands in the Sandveld is an emerging threat that will impact very large areas (>100 000ha)
Historic mining at Alexander Bay	Legacy mining impacts continuing to self-propagate and expand area of impact.	Loss of habitat as a direct result of wind erosion and sand deposition	Neighbourhood to region	Along the Port Nolloth to Alexander Bay coast the historic impacts of legacy mining operation are continuing to self-propagate. This is currently South Africa's largest mining-related environmental disaster. This impact will continue to grow without significant intervention.
Renewable energy - solar	Construction of solar farms	Loss of habitat due to site clearing	Widespread	The construction of solar farms will be the largest driver of habitat loss in this region in the short term. This magnitude of this loss will be directly related to the development of green hydrogen activities South Africa.
Renewable energy - wind	Operation of wind farms	Reduction in bird and bat populations due to turbine strikes	Widespread	Reduction in the size of wild populations increases the risk of species extinction as smaller, more fragmented populations are less resilient to stochastic events. It is highly likely that we will see the extinction of certain bird or bat species in the region if wind energy facilities are scaled to support the hydrogen economy. As bats are apex predators controlling insect populations, the loss of bats form ecosystems can have catastrophic cascading ecosystem-level
Aerial Linear infrastructure	Operation of transmission lines	Reduction in bird populations due to collisions and electrocutions	Widespread	As previous point.
Poaching of biodiversity	Illegal collecting of plant and animal species from wild populations	Reduction in population sizes doe to collecting	Widespread impacting all areas	Possibly the most important threat is currently facing biodiversity in the region as we are seeing extinction of species in real time. Reduction in the size of wild populations increases the risk of species extinction as smaller, more fragmented populations are less resilient to stochastic events.

2.3.2.1 Climate Change and Ecosystem Degradation

Climate change is the most important short-, medium- and long-term threat to biodiversity and society in the region. The most recent climate change Succulent Karoo biome response analysis (Guo et al. 2017) indicates, as in previous assessments, that the Desert biome is expected to increase in extent in Namaqualand by 2070 (Figure 2-2) implying significantly hotter and drier conditions becoming the norm within the next 50 years.

This prediction appears to be confirmed by looking at actual vegetation productivity trend data for the region.

A vegetation productivity trend analysis was conducted using Landsat derived enhanced vegetation index (EVI) comparing two 34-year time series Figure 2-3). Time series one, 1984 to 2018, coincides with the end of a large drought event in the region. Time series two, 1990 to 2024, coincides with a period of recovery following the drought. For each time series a linear regression is fitted to annual EVI data (Venter et al. 2020) and the trend result is expressed here as a % change (slope) in EVI relative to the baseline (intercept) EVI value.

Comparing the two trend maps in Figure 2-3 one can see considerable recovery in vegetation post the drought that ended in 2018 whilst in other areas the browning (degrading) trend observed in the first time series continues post drought.

The two time series outputs were combined and re-classified into different vegetation trend categories to reflect degrading, static or greening of vegetation.

1984-2018 Trend	1990-2024 Trend	Combined Trend Category
Negative	Negative	Degraded
Greening	Negative	Degrading
No change	Negative	Degrading
Negative	Greening	Recovering
Negative	No change	Recovering
No change	No change	Static
Greening	No change	Static
No change	Greening	Greening
Greening	Greening	Greening

At the regional level it is clearly apparent the arid zone of South Africa is experiencing significant and widespread browning of vegetation Figure 2-4). This is interpreted here as being representative of degraded or degrading ecosystems (i.e., reduction in long term vegetation productivity). Within the region, the most sever degrading trends are concentrated in the northwest of the region in the Richtersveld bioregionFigure 2-5). The largescale degradation of ecosystems observed in this analysis is confirmed by on the ground observation (Jürgens et al. 2025). The trends differ across vegetation types (ecosystems) suggesting that the underlying ecological characteristics of vegetation types also play a role in how vegetation is responding to climate change (Figure 2-6 and Table 2-4).

Land use, specifically livestock grazing, does impact the trend in vegetation productivity. Whilst the EVI trend dataset has not been analysed to specifically differentiate the climate change vs land use impact, there are some inferences we can make from the current analysis. Vegetation productivity trends are compared between a long term protected area with low stock rates (Namaqua National Park) and the surrounding areas. Very clear fence-line contrasts can be observed between the park and surrounding areas (Figure 2-7). A pairwise comparison between vegetation types shared between the park and neighbouring areas show on average 50% less (22% of vegetation type extent inside versus 42% outside)

degraded area compared to outside the park (Table 2-5). The Namaqua National Park is the only large area in northern Namaqualand showing a net neutral EVI trend. This suggests that livestock grazing is a very important factor mediating the impact of climate change.

Some important observation from the vegetation trend analysis include:

- Climate change is a reality for Namaqualand. Most vegetation types show negative productivity trends with the most extreme values observed in the northwest of the region.

- Trends differ between vegetation types. Whilst climate change and land use are probably the two most important factors determining trend, underlying ecological characteristics of each ecosystem (vegetation type) are also an important variable. For example, Bushmanland arid grasslands on sand appear to be much more resilient than neighbouring Bushmanland vloere shrubland on rocky substrates.

- Land use specifically livestock grazing appears to be a very important mediator of climate change impact on vegetation productivity trend. Possibly the most important climate change adaptation intervention that can be made in this region is to manage livestock impacts. This observation also highlights the role that well managed protected areas can play in mitigating climate change impacts. Significantly more protected areas are required in the region if this mitigation impacts are to be scaled to deliver benefits the whole ecosystem.

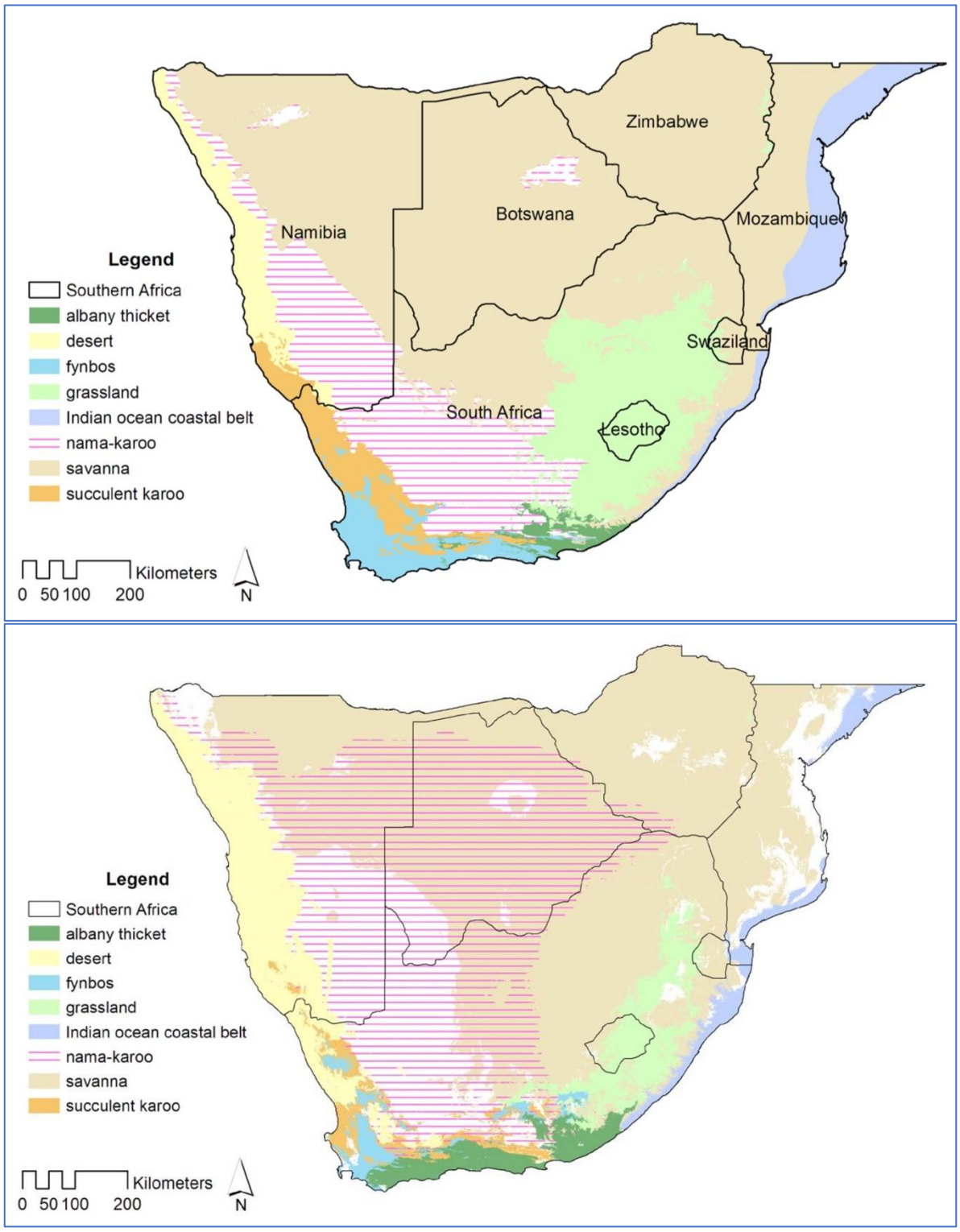


Figure 2-2: Extent of southern African biomes under current (top) and future (2070, bottom) climate scenarios (from Guo et al. 2017).

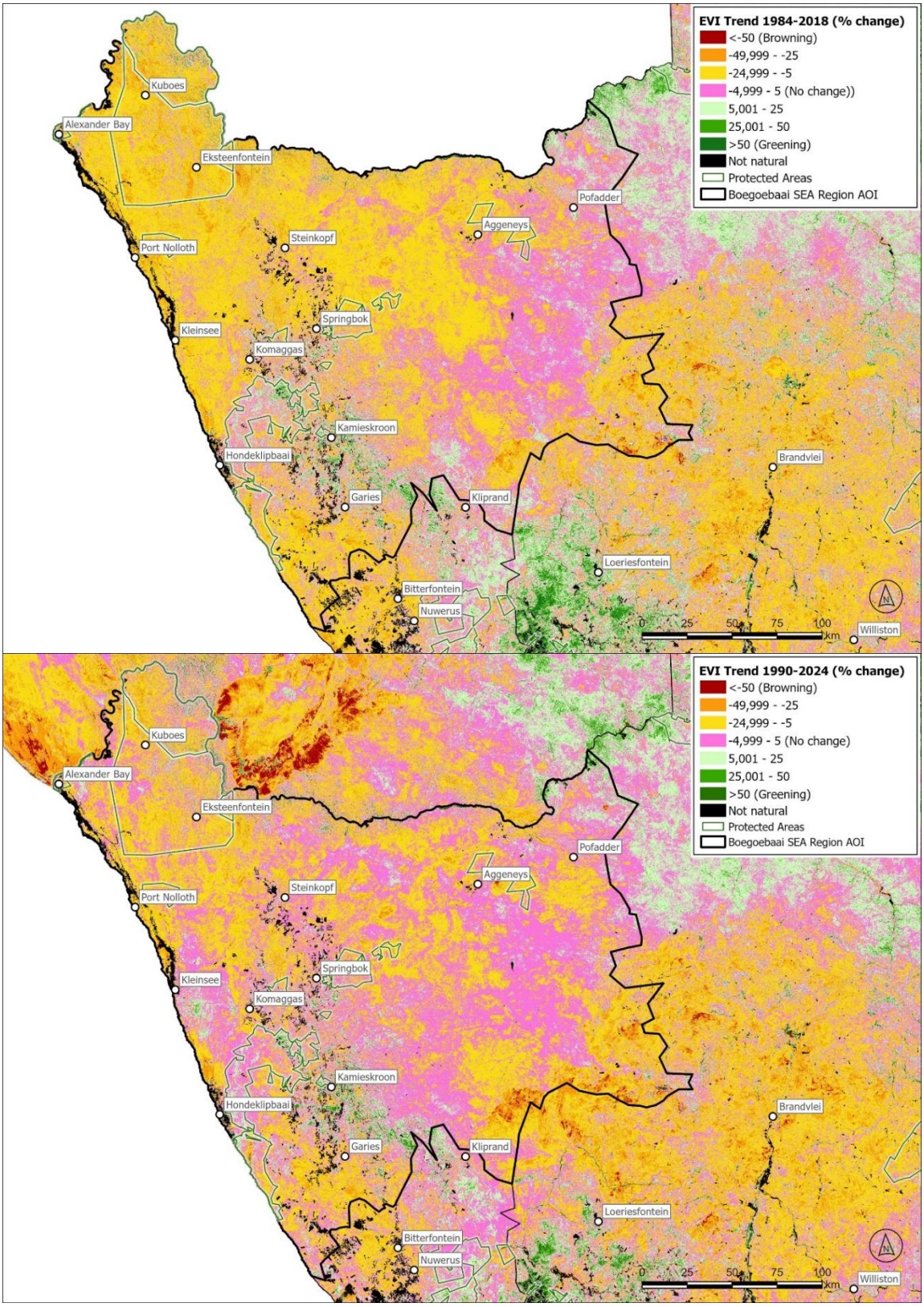


Figure 2-3: Trend in vegetation productivity in the Namakwa Region for two 34-year trend periods.

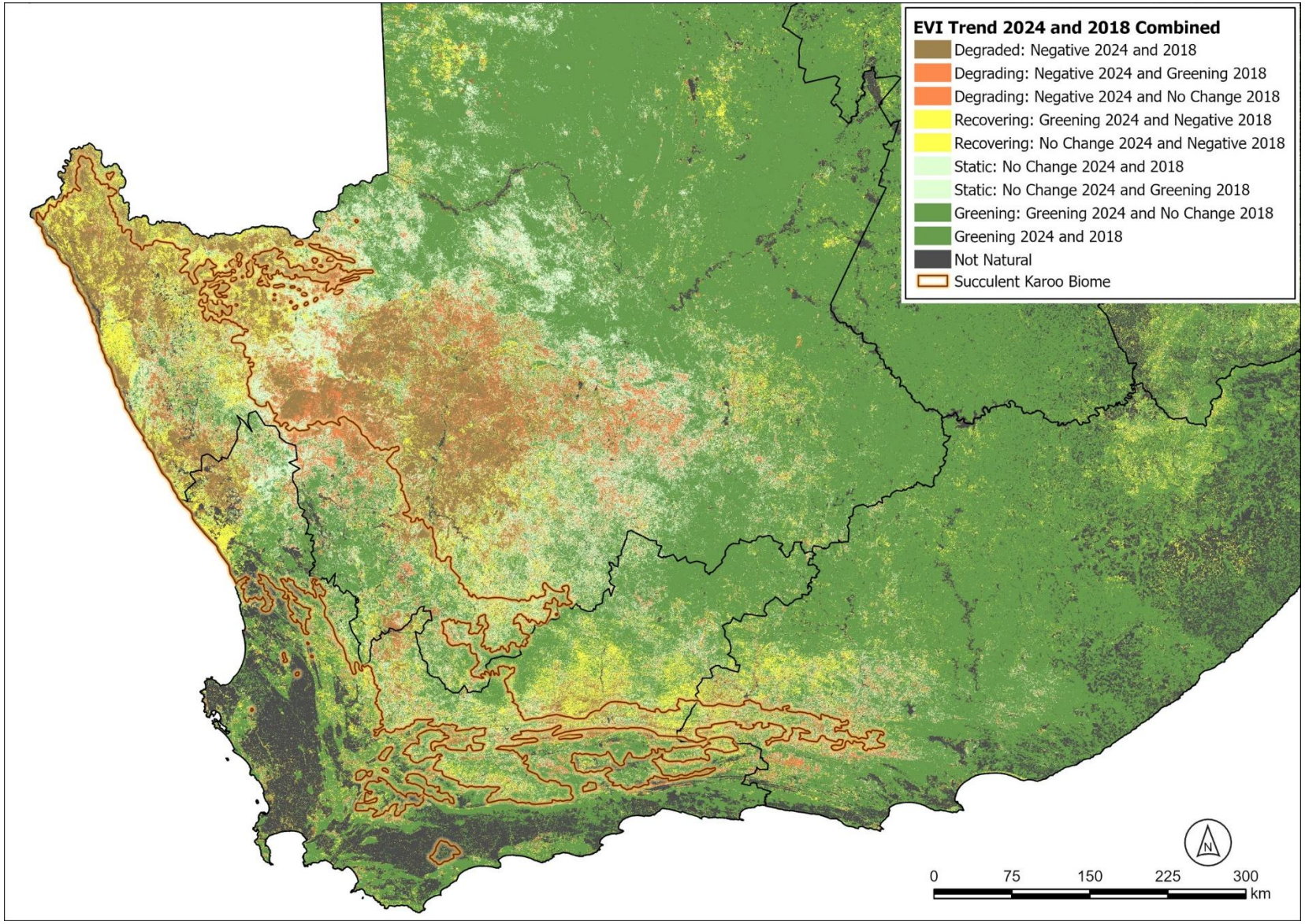


Figure 2-4: The vegetation productivity trend for the arid zone of South Africa based on a combination of the trend analysis for two 34-year time series (1984-2018 and 1990-2024).

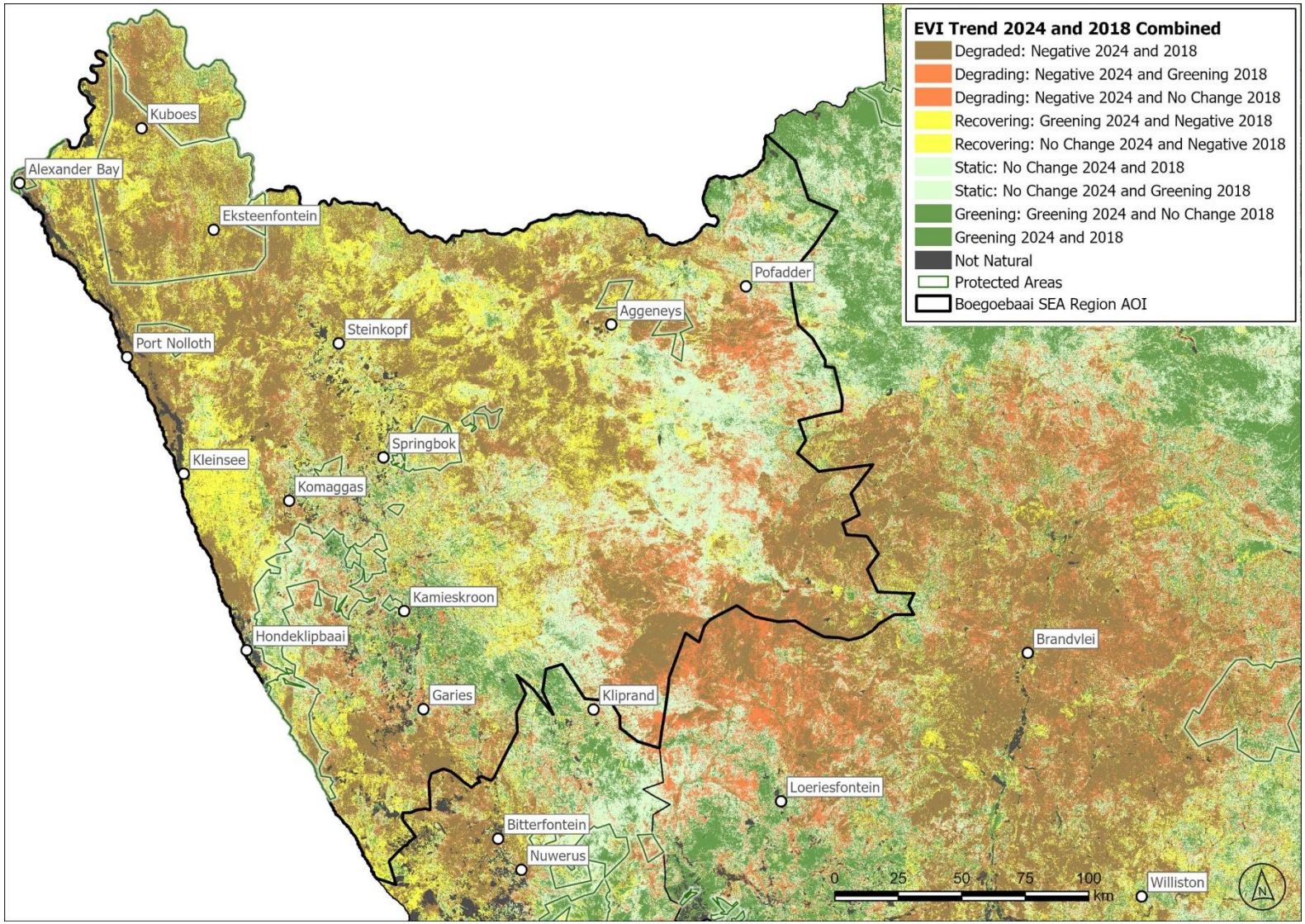


Figure 2-5: The vegetation productivity trend for the Namakwa Region based on a combination of the trend analysis for two 34-year time series (1984-2018 and 1990-2024).

Table 2-4: A summary of vegetation productivity trends within vegetation types. Table is sorted from most degraded to least degraded.

VEGETATION TYPE	EVI Trend 1990 to 2024								EVI Trend 1984 to 2018								Combined EVI Trend 2024 vs 2018								
	< -50 Strong Browning	-50 - -25 Browning	-25 - -5 Some Browning	-5 - 5 No Change	5 - 25 Some Greening	25 - 50 Greening	>50 Strong greening	2024 Sum of Browning	< -50 Strong Browning	-50 - -25 Browning	-25 - -5 Some Browning	-5 - 5 No Change	5 - 25 Some Greening	25 - 50 Greening	>50 Strong greening	2018 Sum of Browning	Degraded: Negative 2024 & 2018	Degrading: Negative 2024 & Greening 2018	Degrading: Negative 2024 & No Change 2018	Recovering: Greening 2024 & Negative 2018	Recovering: No Change 2024 & Negative 2018	Static: No Change 2024 & 2018	Static: No Change 2024 & Greening 2018	Greening: Greening 2024 & No Change 2018	Greening 2024 & 2018	Sum of Degrading
Vyftienmyl se Berge Succulent Shrubland	-	17	79	4	-	-	-	96	-	11	78	8	3	-	-	88	86	7	3	2	1	1	-	-	-	96
Bushmanland Inselberg Shrubland	-	18	63	18	-	-	-	81	-	13	69	14	3	-	-	82	82	10	2	1	1	2	1	1	1	94
Alexander Bay Coastal Duneveld	9	31	49	8	3	-	-	89	12	68	16	2	2	-	-	95	87	1	-	6	-	1	2	-	1	89
Lekkersing Succulent Shrubland	-	7	91	-	2	-	-	98	-	13	74	11	2	-	-	87	80	7	1	3	6	1	1	1	-	88
Richtersveld Sandy Coastal Scorpionstailveld	-	7	76	17	-	-	-	83	-	15	79	5	-	-	-	94	82	3	-	14	-	-	-	-	-	85
Richtersveld Coastal Duneveld	1	19	61	17	3	-	-	80	-	28	65	5	2	-	-	93	77	2	1	14	2	1	2	1	1	80
Namib Seashore Vegetation	-	32	48	18	-	2	-	80	-	42	46	2	2	6	2	88	78	2	-	13	-	4	-	-	2	80
Kosiesberg Succulent Shrubland	-	11	17	64	7	1	-	28	-	-	76	19	5	1	-	76	65	11	-	18	1	2	1	1	1	76
Aggeneys Gravel Vygieveld	-	1	73	25	1	-	-	74	-	3	65	27	5	-	-	68	55	18	2	13	9	2	-	1	-	75
Rooiberg Quartz Vygieveld	-	2	73	24	1	-	-	75	-	17	78	4	-	-	-	95	73	2	-	22	2	-	-	-	-	75
Western Gariep Hills Desert	1	9	60	27	3	-	-	70	1	30	59	6	2	1	1	90	67	3	1	23	-	1	2	1	1	71
Southern Richtersveld Yellow Duneveld	-	6	91	-	2	-	-	97	-	17	78	5	-	-	-	95	68	2	-	26	3	-	1	-	-	70
Southern Richtersveld Inselberg Shrubland	-	5	64	30	1	-	-	69	-	4	74	19	3	-	-	78	58	9	2	19	9	2	-	1	-	69
Western Bushmanland Klipveld	-	5	63	30	1	-	-	68	-	-	24	47	28	1	-	25	23	33	12	2	13	15	-	-	1	68
Namaqualand Shale Shrubland	-	10	60	24	5	1	-	70	-	19	64	15	1	1	-	83	66	1	2	16	6	3	2	2	2	68
Namaqualand Seashore Vegetation	5	29	35	18	6	3	4	69	1	24	47	10	8	4	6	72	57	6	4	12	3	4	2	2	10	67
Noms Mountain Desert	-	9	58	25	6	1	1	67	-	10	64	18	1	3	3	75	52	9	5	14	6	5	3	2	4	67
Bushmanland Vloere	1	1	39	36	15	4	4	41	1	18	11	6	43	12	8	31	50	12	5	2	17	-	5	7	2	67
Bushmanland Basin Shrubland	1	14	49	24	10	2	1	63	-	9	55	3	25	6	1	65	45	15	6	1	9	10	1	2	10	67
Southern Richtersveld Scorpionstailveld	-	5	61	33	1	-	-	66	-	13	78	8	1	-	-	92	62	3	-	28	5	-	1	-	-	66
Rosyntjieberg Succulent Shrubland	-	7	58	20	7	4	3	65	-	26	55	7	6	3	4	81	59	3	3	16	2	2	6	2	7	65
Central Richtersveld Mountain Shrubland	-	9	55	26	7	2	1	64	-	20	64	14	1	1	1	84	56	6	2	19	5	2	4	3	2	64

VEGETATION TYPE	EVI Trend 1990 to 2024								EVI Trend 1984 to 2018								Combined EVI Trend 2024 vs 2018									
Southern Nababiepsberge Mountain Desert	-	13	50	25	9	1	1	63	1	25	58	10	4	1	1	84	60	3	1	19	4	1	5	3	3	63
Northern Richtersveld Scorpionstailveld	-	1	62	34	3	-	-	63	-	14	75	10	1	-	-	89	59	4	-	28	5	1	2	-	-	63
Platbakkies Succulent Shrubland	-	1	8	89	3	-	-	9	-	1	91	4	4	-	-	92	52	10	-	4	29	3	1	1	1	62
Stinkfonteinberge Eastern Apron Shrubland	-	4	58	36	2	-	-	62	-	35	62	2	-	-	-	97	61	1	-	35	1	-	1	-	-	62
Stinkfonteinberge Quartzite Fynbos	-	12	23	11	41	11	2	35	-	15	65	14	5	1	-	80	54	4	1	21	5	2	6	4	3	60
Namaqualand Heuweltjieveld	-	6	55	37	1	1	-	61	-	1	11	58	30	-	-	12	43	10	2	13	13	7	2	3	5	56
Northern Richtersveld Yellow Duneveld	-	2	53	40	4	-	-	55	-	9	83	7	1	-	-	92	53	2	-	36	4	-	3	1	-	55
Eastern Gariep Plains Desert	-	1	39	49	10	1	-	40	-	1	63	28	7	-	-	64	44	9	1	4	24	4	4	5	5	55
Oograbies Plains Sandy Grassland	-	1	51	47	1	-	-	52	-	5	89	5	-	-	-	95	51	1	-	43	4	-	-	-	-	52
Richtersveld Red Duneveld	-	1	48	49	2	-	-	48	-	5	86	9	-	-	-	91	50	2	-	45	1	-	1	1	-	51
Kwaggarug Mountain Desert	-	5	46	34	12	1	1	51	-	2	67	18	8	2	3	69	46	3	2	23	8	4	5	5	5	51
Kahams Mountain Desert	-	4	72	1	16	4	3	76	-	11	64	15	8	3	-	75	43	4	2	25	7	4	5	3	7	49
Southern Namaqualand Quartzite Klipkoppe Shrubland	-	4	45	33	15	3	-	49	-	6	44	28	19	3	-	50	35	11	4	12	12	9	3	5	9	49
Eenriet Plains Succulent Shrubland	-	-	49	48	3	-	-	49	-	2	97	1	-	-	-	99	47	2	-	40	7	-	2	1	-	49
Eastern Gariep Rocky Desert	-	3	48	44	1	2	2	52	-	6	54	25	12	2	1	59	37	7	2	19	14	6	3	4	7	46
Umdaus Mountains Succulent Shrubland	-	1	45	50	3	-	-	46	-	3	80	14	2	-	-	83	42	3	-	40	10	1	2	1	1	46
Goariep Mountain Succulent Shrubland	-	2	50	44	1	2	-	52	-	16	75	2	6	1	-	91	41	4	1	30	7	2	8	4	3	46
Northern Nababiepsberge Mountain Desert	-	3	42	40	10	2	2	46	1	24	61	9	3	1	2	85	43	2	1	35	4	2	7	3	4	46
Anenous Plateau Shrubland	-	1	40	47	11	1	-	41	-	4	60	27	8	1	-	64	32	8	1	28	15	4	4	5	3	41
Richtersveld Sheet Wash Desert	-	1	39	49	9	1	-	41	-	12	83	1	3	-	-	95	39	2	-	43	6	1	4	4	2	41
Richtersberg Mountain Desert	-	2	34	40	18	4	2	36	-	6	51	21	13	5	4	57	30	5	3	24	11	7	5	1	14	38
Namaqualand Riviere	1	5	31	33	18	6	6	37	-	4	32	3	37	14	10	36	18	9	10	8	10	16	2	5	23	37
Tatasberg Mountain Succulent Shrubland	-	-	35	45	14	3	2	36	-	1	37	26	19	10	7	37	20	9	7	15	13	17	2	4	13	36
Western Gariep Lowland Desert	-	1	34	56	8	-	-	35	1	58	36	3	2	-	-	94	35	1	-	52	4	-	6	2	-	35
Namaqualand Klipkoppe Shrubland	-	-	32	44	19	4	1	32	-	4	8	69	5	11	2	12	22	9	3	16	18	12	3	1	16	35
Hantam Karoo	-	6	25	29	27	11	3	31	-	2	2	27	44	20	5	4	15	9	8	5	9	16	1	-	35	33
Namaqualand Strandveld	-	1	22	48	23	5	1	22	-	-	64	25	9	1	-	65	31	-	-	5	18	-	18	15	11	32
Namaqualand Granite Renosterveld	-	2	28	35	27	7	2	29	-	2	29	29	32	7	1	31	18	7	4	10	14	11	3	8	25	29
Riethuis-Wallekraal Quartz Vygieveld	-	-	28	66	6	-	-	28	-	-	22	52	25	1	-	23	11	14	3	11	36	19	-	2	3	28
Namaqualand Blomveld	-	1	26	58	14	1	-	27	-	-	60	38	2	1	-	60	22	5	1	29	22	7	3	6	7	27
Namaqualand Sand Fynbos	-	1	23	47	25	3	1	24	-	4	52	29	14	1	-	56	21	4	1	28	16	6	12	10	1	26
Namaqualand Heuweltjie Strandveld	-	1	23	45	26	5	1	24	-	9	68	18	5	-	-	77	24	2	-	38	-	2	22	8	3	26
Helskloof Canyon Desert	-	1	24	55	19	-	-	25	-	22	68	8	1	-	-	91	25	-	-	51	4	-	15	4	1	25
Namaqualand Inland Duneveld	-	1	24	52	21	2	-	25	-	7	65	22	6	-	-	71	22	2	-	36	13	3	13	7	4	25
Bushmanland Arid Grassland West	-	1	42	53	4	-	-	43	-	-	48	43	8	-	-	49	4	17	2	26	37	8	1	3	2	23
Upper Annisvlakte Succulent Shrubland	-	-	47	51	2	-	-	47	-	6	89	5	-	-	-	95	7	14	1	7	47	1	20	3	1	21
Die Plate Succulent Shrubland	-	2	61	35	1	-	-	64	-	29	63	8	1	-	-	92	13	6	1	66	10	1	2	1	-	20
Namaqualand Coastal Duneveld	1	14	43	28	13	1	1	57	1	38	16	32	10	2	2	54	10	8	2	39	10	3	15	7	6	20
Non-terrestrial (estuarine habitat)	8	4	9	18	18	17	27	20	9	8	13	26	21	2	23	29	8	3	6	5	-	10	6	9	52	18

VEGETATION TYPE	EVI Trend 1990 to 2024								EVI Trend 1984 to 2018								Combined EVI Trend 2024 vs 2018									
Lower Gariep Alluvial Vegetation	5	4	9	18	16	16	32	18	2	6	12	9	17	17	37	19	10	2	5	5	3	9	5	5	56	17
Namib Lichen Fields	-	1	16	36	40	7	-	17	-	2	25	39	35	-	-	27	14	2	-	10	17	9	2	20	25	17
Kamiesberg Mountains Shrubland	-	1	12	27	34	17	8	14	-	1	16	23	38	16	6	17	8	4	3	1	10	11	4	10	49	15
Kamiesberg Granite Fynbos	-	1	15	45	5	22	11	16	-	-	13	25	40	15	5	14	5	4	2	6	12	13	3	10	45	11
Western Gariep Plains Desert	1	5	34	37	23	-	-	40	1	2	73	20	1	2	-	76	5	4	2	40	9	6	17	10	8	11
Lower Gariep Broken Veld	-	1	8	25	39	20	7	9	-	-	7	17	42	23	11	8	4	3	3	3	1	16	1	7	63	10
Bushmanland Sandy Grassland	-	-	17	81	2	1	-	17	-	-	27	52	18	1	2	27	1	6	2	19	45	16	1	-	10	8
Northern Knersvlakte Vygieveld	-	-	11	63	25	1	-	11	-	-	10	68	11	10	-	10	2	-	5	-	25	39	-	7	21	8
Namaqualand Arid Grassland	-	-	6	49	40	5	-	6	-	-	1	42	52	4	-	1	2	3	1	5	24	20	1	12	31	6
Bushmanland Arid Grassland East	-	-	3	31	50	14	2	4	-	-	3	22	54	18	3	3	1	2	1	1	11	18	1	9	56	3
Blouputs Karroid Thornveld	-	-	6	79	12	2	2	6	-	-	4	27	56	11	1	4	1	1	1	2	14	19	1	11	49	3

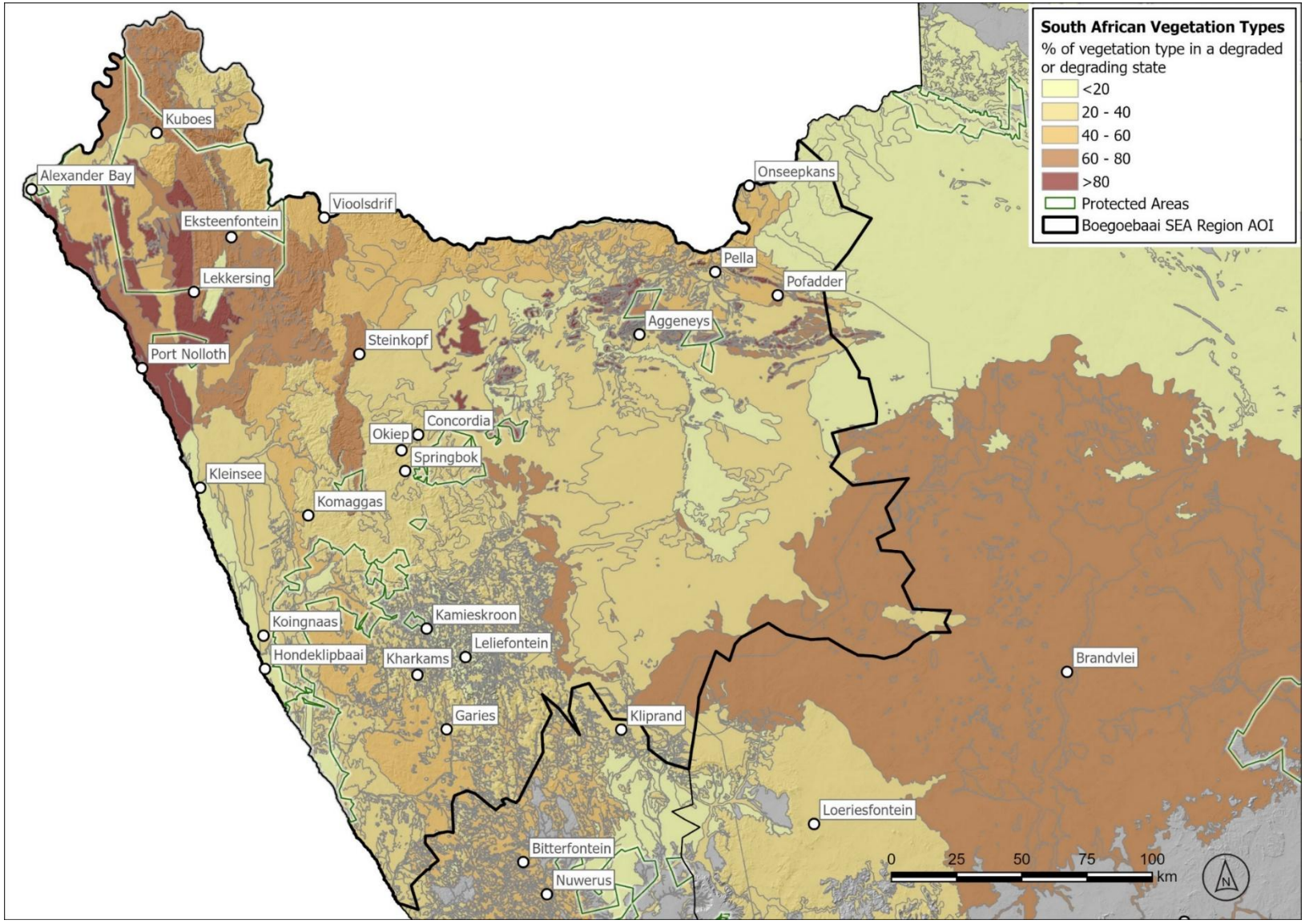


Figure 2-6: The extent of degradation across vegetation types in the Namakwa Region (The proportion of a vegetation considered to be degraded or in a degrading state).

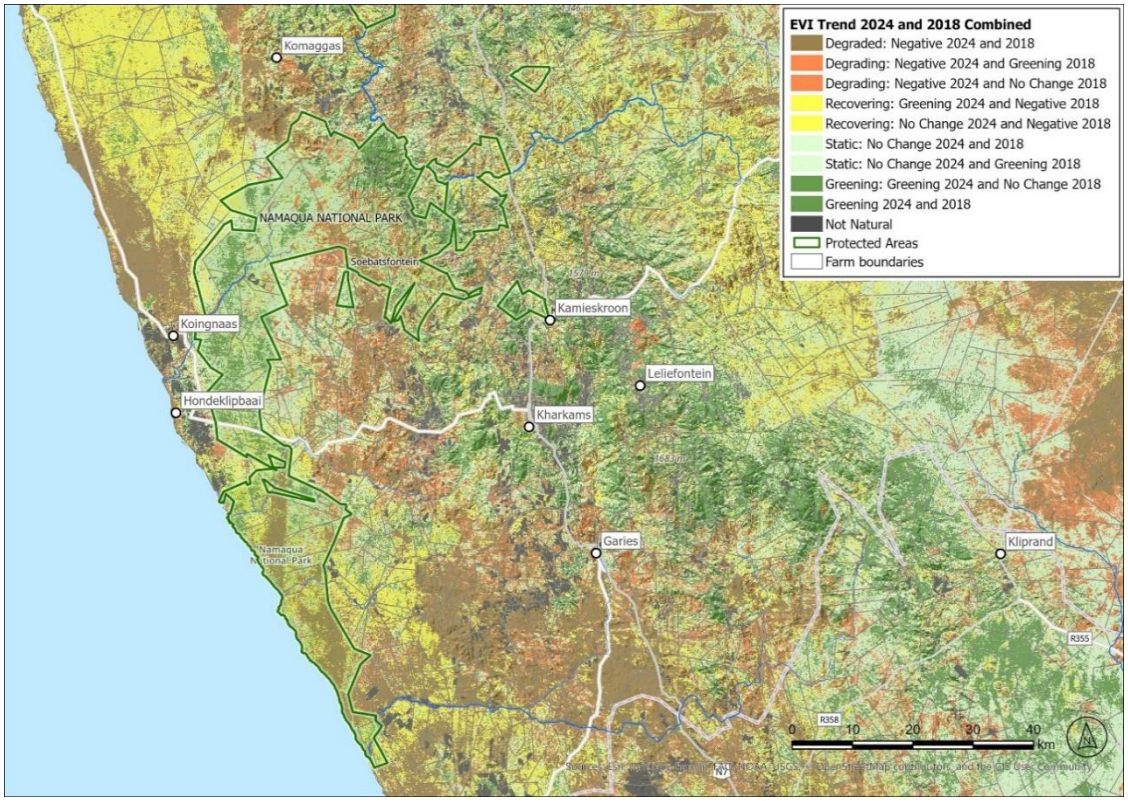


Figure 2-7: Trend in vegetation primary productivity (EVI) comparing the Namaqua National Park to surrounding areas (see Table 2-5 for an area summary of trends within vegetation types inside and outside the park).

Table 2-5: A comparison of vegetation productivity trends in vegetation types between the Namakwa National Park and surrounding areas.

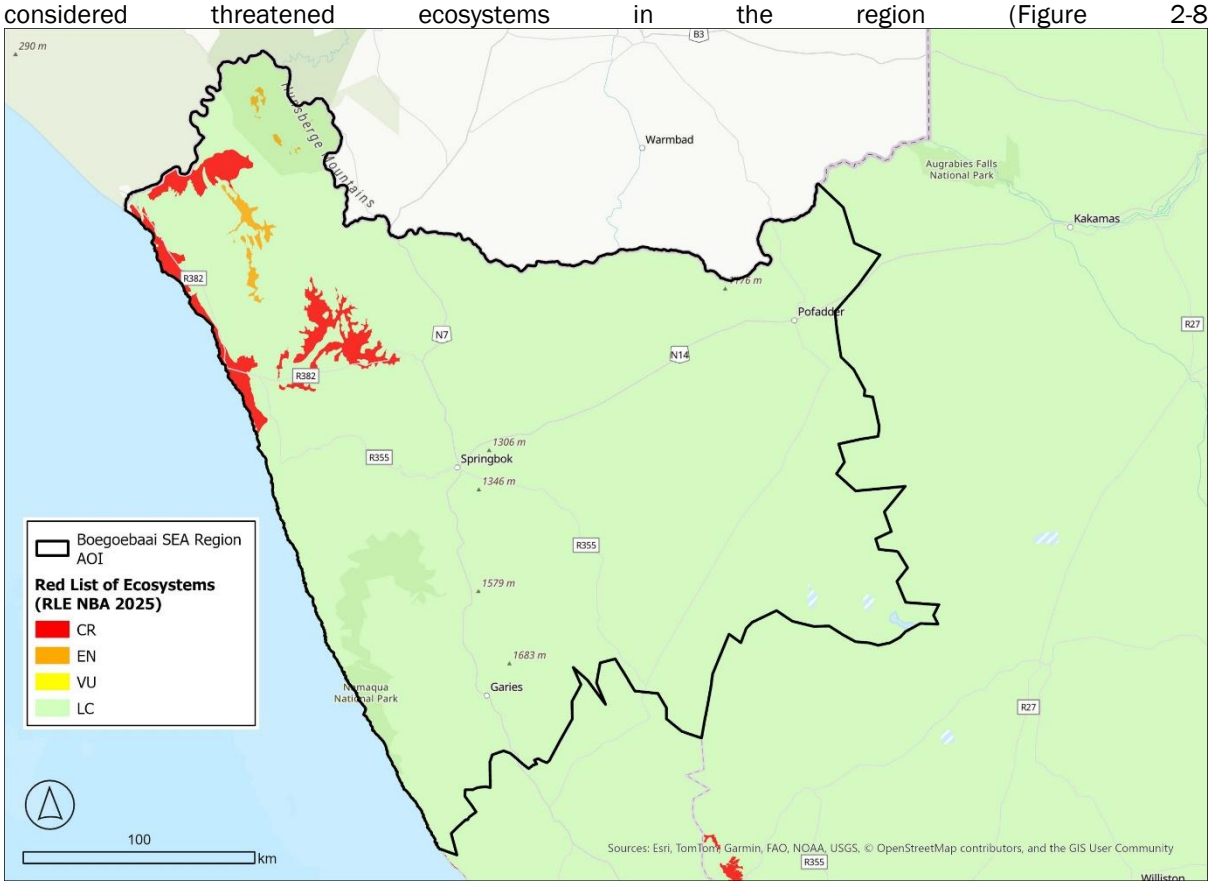
Namakwa National Park:	Outside of park										Inside park										
Vegetation Type	Degraded: Negative 2024 and 2018	Degrading: Negative 2024 and No Change 2018	Degrading: Negative 2024 and Greening 2018	Recovering: No Change 2024 and Negative 2018	Recovering: Greening 2024 and Negative 2018	Static: No Change 2024 and 2018	Static: No Change 2024 and Greening 2018	Greening: Greening 2024 and No Change 2018	Greening 2024 and 2018	Sum of degraded classes	Degraded: Negative 2024 and 2018	Degrading: Negative 2024 and No Change 2018	Degrading: Negative 2024 and Greening 2018	Recovering: No Change 2024 and Negative 2018	Recovering: Greening 2024 and Negative 2018	Static: No Change 2024 and 2018	Static: No Change 2024 and Greening 2018	Greening: Greening 2024 and No Change 2018	Greening 2024 and 2018	Sum of degraded classes	% Difference in extent of degraded vegetation IN versus OUTSIDE the park
Kamiesberg Mountains Shrubland	5,4	3,6	2,9	5,1	3,5	9,2	11,6	9,4	49,2	11,9	0,3	1,7	1,2	0,9	1,5	7,6	10,5	12,2	64,2	3,2	73,1
Namaqualand Arid Grassland	0,0	0,0	0,1	5,7	1,0	24,0	14,6	26,6	28,1	0,1	1,8	5,6	1,7	5,2	0,3	33,7	26,8	6,0	18,9	9,1	
Namaqualand Blomveld	21,5	8,3	2,5	22,8	5,2	17,2	6,9	7,4	8,0	32,3	7,3	5,9	2,7	15,2	5,0	19,2	11,6	11,7	21,5	15,9	50,8
Namaqualand Coastal Duneveld	58,8	6,3	1,6	11,7	2,4	7,3	3,5	3,1	5,4	66,7	57,0	6,3	1,6	14,8	2,9	7,5	2,3	4,0	3,7	64,9	2,7
Namaqualand Granite Renosterveld	17,0	9,2	4,8	7,9	2,3	14,8	13,3	6,9	23,8	31,0	0,0	0,4	0,4	3,5	1,4	14,8	10,9	16,5	52,1	0,8	97,4
Namaqualand Heuweltjie Strandveld	39,5	3,2	0,2	39,5	4,9	8,2	1,1	2,6	0,9	42,9	20,0	5,9	1,2	27,0	6,8	20,6	7,8	7,3	3,5	27,1	36,8
Namaqualand Heuweltjieveld	38,6	14,7	3,7	11,4	1,3	16,3	8,4	2,3	3,3	57,0	15,2	12,9	5,7	7,3	0,6	22,8	25,0	2,5	8,0	33,8	40,7
Namaqualand Inland Duneveld	35,4	3,7	0,6	32,5	4,7	13,4	2,6	4,4	2,6	39,7	6,2	3,2	0,6	19,3	4,0	28,9	12,3	12,3	13,3	10,0	74,8
Namaqualand Klipkoppe Shrubland	19,0	9,9	3,5	14,1	3,0	18,5	11,4	6,8	13,8	32,4	12,6	9,3	4,5	9,9	2,0	16,0	15,1	6,2	24,4	26,4	18,5
Namaqualand Riviere	47,2	12,0	5,3	12,8	3,2	8,9	5,1	2,7	2,9	64,5	21,8	12,8	4,8	12,9	1,7	21,3	14,9	3,2	6,7	39,4	38,9
Namaqualand Sand Fynbos	27,1	6,7	1,9	24,7	3,1	18,6	7,4	5,3	5,1	35,7	2,7	1,5	0,7	13,1	2,3	30,5	16,5	14,0	18,7	4,9	86,3
Namaqualand Seashore Vegetation	66,3	8,1	5,8	4,7	1,2	3,5	4,7	0,0	5,8	80,2	42,0	4,2	4,2	10,9	0,8	1,7	2,5	3,4	30,3	50,4	37,2
Namaqualand Strandveld	31,0	3,9	0,4	35,2	4,9	15,1	2,7	4,2	2,5	35,3	5,4	2,9	0,9	14,3	7,3	25,2	10,7	17,7	15,6	9,2	73,9
Riethuis-Wallekraal Quartz Vygieveld	21,1	26,5	6,8	6,1	0,1	23,6	15,3	0,2	0,3	54,4	6,8	8,7	2,1	13,4	0,4	41,1	20,2	2,4	4,8	17,6	67,6
Average	30,6	8,3	2,9	16,7	2,9	14,2	7,8	5,9	10,8	41,7	14,2	5,8	2,3	12,0	2,6	20,8	13,4	8,5	20,4	22,3	53,8

2.3.2.2 Ecosystem Status

The International Union for Conservation of Nature (IUCN) Red List of Ecosystems (RLE) framework has been adopted and adapted by South African National Biodiversity Institute (SANBI), within the National Biodiversity Assessment (NBA) process, as the standards to assess the risk of collapse for its ecosystems. The SANBI uses the RLE framework as part of its periodic National Biodiversity Assessment (NBA), the country's primary tool for monitoring and reporting on the state of its biodiversity to inform national policy and conservation decisions. The NBA is a collaborative project that synthesizes scientific data on South Africa's biodiversity. The assessments, which have been conducted since 2004, cover all realms: terrestrial, freshwater, estuarine, and marine. The RLE framework is a critical component of the NBA, providing the scientific foundation for assessing the status of South Africa's ecosystems.

The RLE is a key informant of policy and decision-making across various sectors, such as water, agriculture, and mining. Within land use planning and decision making RLEs influence the nature and extent of acceptable land use activities and where and how biodiversity offsets should be applied.

The current 2025 RLE status of ecosystems indicates only a 9 (12%) out of 71 vegetation types are considered threatened ecosystems in the region (Figure 2-8 Table 2-6). This assessment, however, only considers degradation process (criterion D) for a few selected ecosystems in the Richtersveld and not widely across the region. So, whilst the NBA 2025 analysis reflects the best available published data sources in its assessment, it does not consider current trends in degradation across the region. In the light of the data presented in Section 2.3.2.1 this is perhaps not an accurate reflection of the actual status of ecosystems in the region.



RLE criterion D1 is applied here using the data in Table 2-4, specifically the combined 2024 and 2018 data and only the degraded class (negative trend in 2024 and 2018). Criterion D1 assesses the disruption of biotic processes or interactions that occurred over the past 50 years. It evaluates the change in a specific biotic variable across a fraction of the ecosystem's extent and with a relative severity, using quantitative thresholds to determine the risk category.

An ecosystem is listed in a threatened category under Criterion D1 if the combination of the extent of the ecosystem affected and the relative severity of the change in a key biotic variable meets or exceeds the thresholds of >80% = Critically Endangered (CR), 50-80% = Endangered (EN) and 30-50% = Vulnerable (VU). The variable used in this analysis is the extent of an ecosystem considered in a degraded state defined here as areas with a significantly negative trend (<-25%) in EVI in both 2018 and 2024 trend analysis. Both trend analyses are 34 years duration so partially overlapping. The period from 2018 to 2024 is a recovery periods after a major drought ending in 2018. Whilst many areas show significant recovery after this drought many areas also show continued negative EVI trends, and therefore the conclusion that these areas are degraded.

The RLE analysis including the D1 criterion indicates that 44 (62%) of the 71 vegetation types in the region are considered threatened (**Error! Reference source not found.**,Table 2-6). When combined with the NBA 2025 assessment, the total number of RLE increases to 46 (65%) of vegetation types considered threatened (Figure 2-10, Table 2-6).

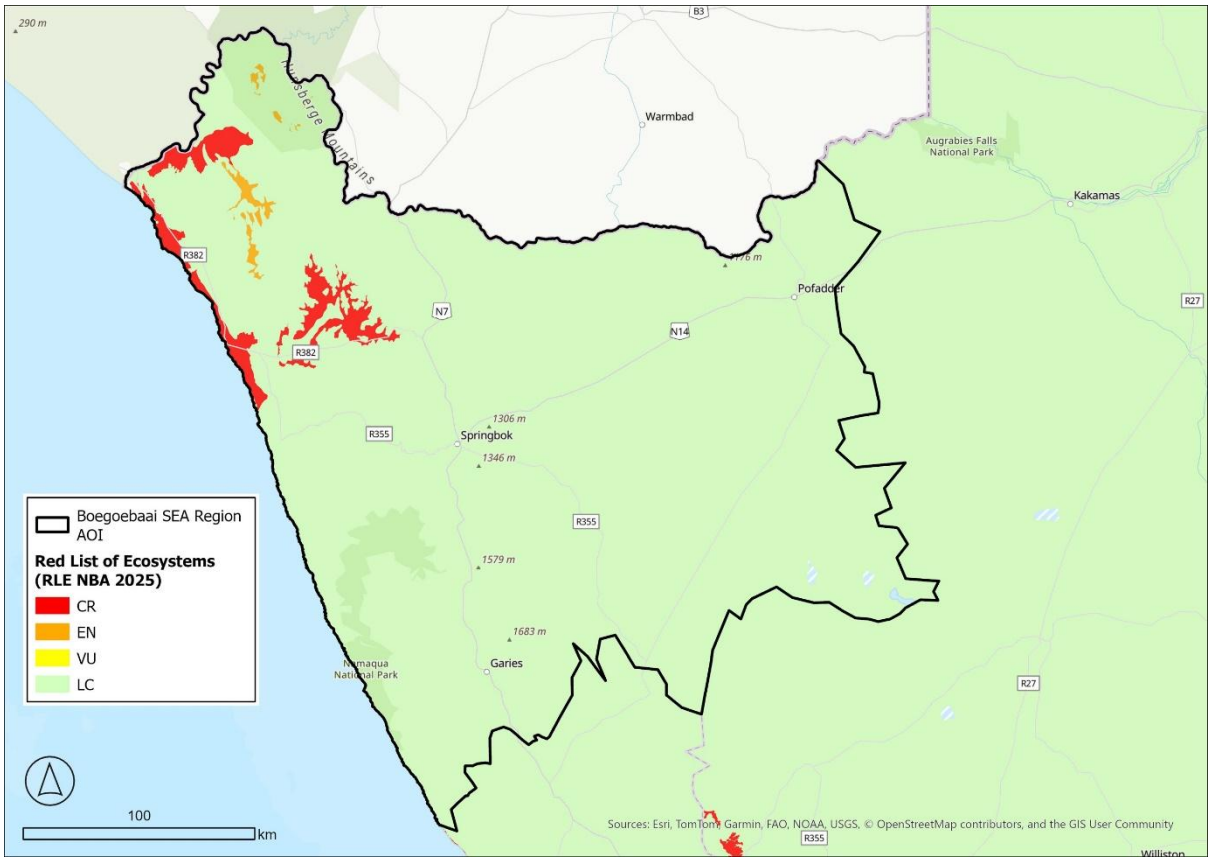


Figure 2-8: The Red List of Ecosystems (RLE) according to the NBA 2025.

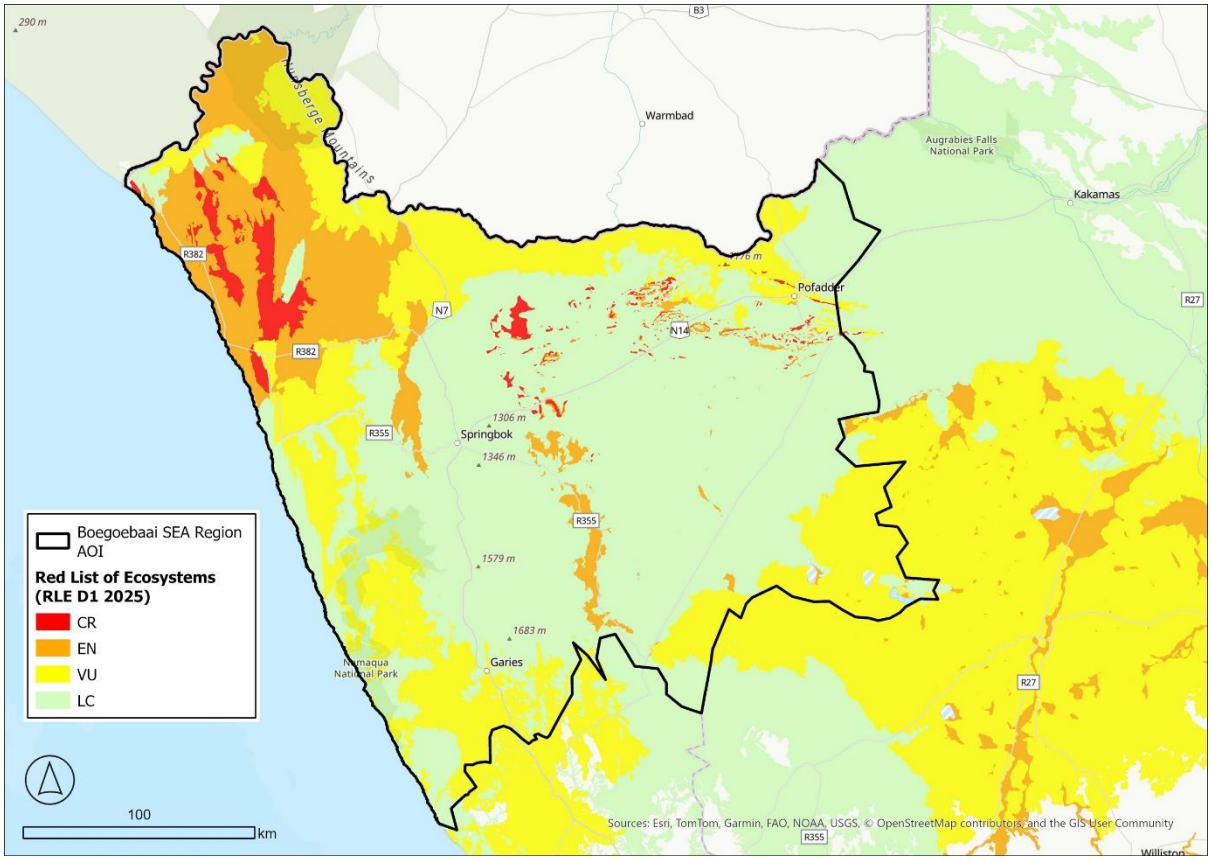


Figure 2-9: The combined NBA 2025 and D1 Red List of Ecosystems (RLE).

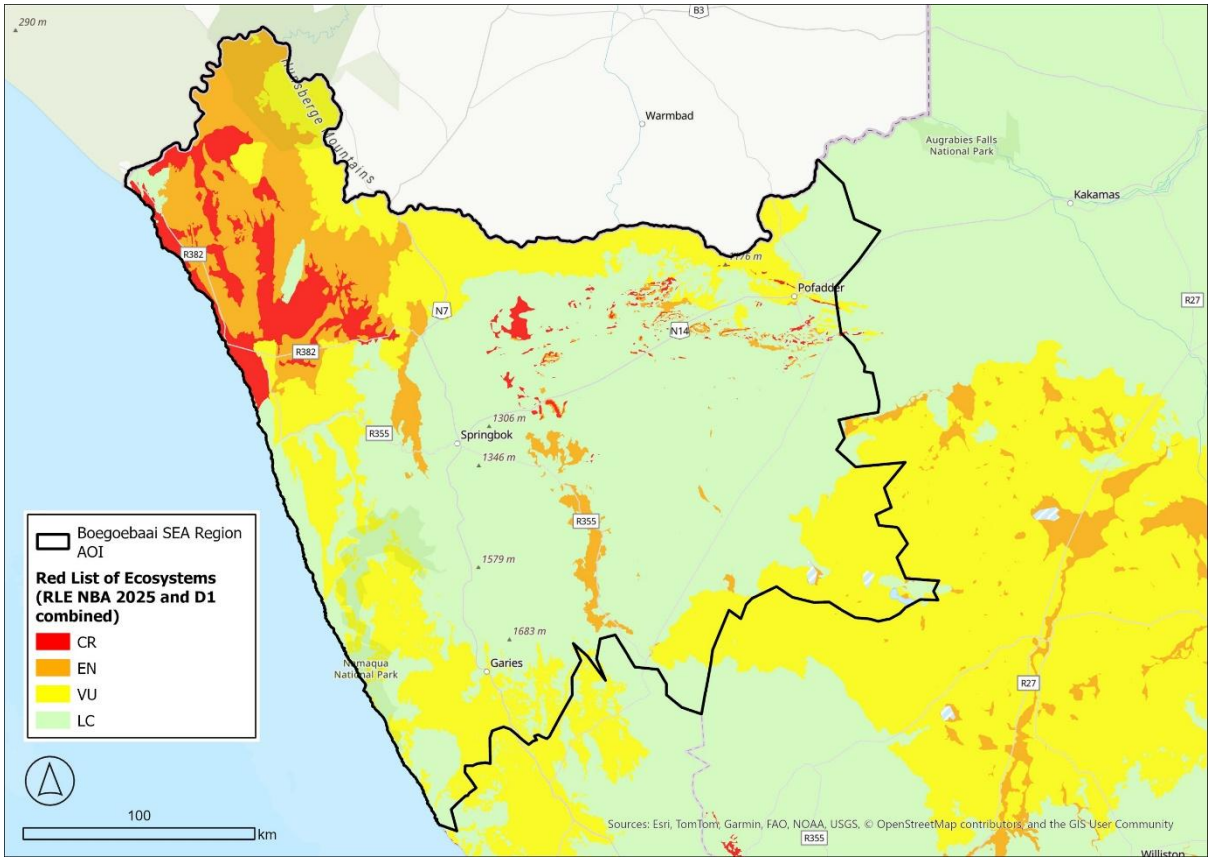


Figure 2-10: The combined NBA 2025 and D1 Red List of Ecosystems (RLE).

Table 2-6: The Red List of Ecosystems (RLE) status of vegetation types in the SEA region. The extent degraded the % of vegetation type area with negative EVI (<-25%) trend in both 2024 and 2018. Ecosystem Protection Level (EPL) value is WP = well protected, MP = mostly protected, PP = Partially protected and NP = Not protected.

Vegetation Type	Extent Degraded	RLE (D1)	RLE (NBA 2025)	EPL (NBA 2025)
Aggeneys Gravel Vygieveld	55,06	EN	LC	WP
Alexander Bay Coastal Duneveld	86,96	CR	CR	NP
Anenous Plateau Shrubland	32,34	VU	LC	NP
Blouputs Karroid Thornveld	0,71	LC	LC	WP
Bushmanland Arid Grassland East	0,83	LC	LC	PP
Bushmanland Arid Grassland West	3,82	LC	LC	PP
Bushmanland Basin Shrubland	45,47	VU	LC	PP
Bushmanland Inselberg Shrubland	82,43	CR	LC	PP
Bushmanland Sandy Grassland	0,91	LC	LC	NP
Bushmanland Vloere	50,07	EN	LC	PP
Central Richtersveld Mountain Shrubland	56,09	EN	LC	WP
Die Plate Succulent Shrubland	13,44	LC	LC	NP
Eastern Gariep Plains Desert	44,25	VU	LC	PP
Eastern Gariep Rocky Desert	36,76	VU	LC	NP
Eenriet Plains Succulent Shrubland	46,95	VU	LC	NP
Goariep Mountain Succulent Shrubland	41,46	VU	LC	WP

Vegetation Type	Extent Degraded	RLE (D1)	RLE (NBA 2025)	EPL (NBA 2025)
Hantam Karoo	14,85	LC	LC	NP
Helskloof Canyon Desert	25,15	LC	LC	WP
Kahams Mountain Desert	43,16	VU	LC	WP
Kamiesberg Granite Fynbos	5,17	LC	LC	NP
Kamiesberg Mountains Shrubland	8	LC	LC	NP
Kosiesberg Succulent Shrubland	65,18	EN	LC	NP
Kwaggarug Mountain Desert	45,66	VU	LC	WP
Lekkersing Succulent Shrubland	80,17	CR	LC	MP
Lower Gariep Alluvial Vegetation	9,54	LC	LC	PP
Lower Gariep Broken Veld	4,19	LC	LC	PP
Namaqualand Arid Grassland	2,08	LC	LC	WP
Namaqualand Blomveld	21,51	LC	LC	PP
Namaqualand Coastal Duneveld	9,88	LC	LC	MP
Namaqualand Granite Renosterveld	18,21	LC	LC	NP
Namaqualand Heuweltjie Strandveld	23,6	LC	LC	PP
Namaqualand Heuweltjieveld	42,69	VU	LC	PP
Namaqualand Inland Duneveld	22,35	LC	LC	PP
Namaqualand Klipkoppe Shrubland	22,48	LC	LC	PP
Namaqualand Riviere	17,76	LC	LC	PP
Namaqualand Sand Fynbos	20,8	LC	LC	PP
Namaqualand Seashore Vegetation	57,41	EN	CR	PP
Namaqualand Shale Shrubland	65,54	EN	LC	NP
Namaqualand Strandveld	30,74	VU	LC	PP
Namib Lichen Fields	14,17	LC	CR	WP
Namib Seashore Vegetation	77,78	EN	CR	NP
Noms Mountain Desert	52,05	EN	LC	WP
Northern Knersvlakte Vygieveld	1,78	LC	LC	MP
Northern Nababiepsberge Mountain Desert	43,26	VU	LC	NP
Northern Richtersveld Scorpionstailveld	58,5	EN	EN	WP
Northern Richtersveld Yellow Duneveld	53,32	EN	LC	NP
Oograbies Plains Sandy Grassland	51,19	EN	LC	NP
Platbakkies Succulent Shrubland	51,7	EN	LC	NP
Richtersberg Mountain Desert	30,16	VU	LC	WP
Richtersveld Coastal Duneveld	77,23	EN	CR	NP
Richtersveld Red Duneveld	49,66	EN	LC	NP
Richtersveld Sandy Coastal Scorpionstailveld	81,64	CR	LC	NP
Richtersveld Sheet Wash Desert	38,94	VU	LC	WP
Riethuis-Wallekraal Quartz Vygieveld	10,87	LC	LC	WP
Rooiberg Quartz Vygieveld	73,14	EN	LC	WP
Rosyntjieberg Succulent Shrubland	59,49	EN	LC	WP
Southern Nababiepsberge Mountain Desert	59,8	EN	LC	NP
Southern Namaqualand Quartzite Klipkoppe Shrubland	34,78	VU	LC	PP
Southern Richtersveld Inselberg Shrubland	58,29	EN	LC	NP
Southern Richtersveld Scorpionstailveld	62,43	EN	CR	NP

Vegetation Type	Extent Degraded	RLE (D1)	RLE (NBA 2025)	EPL (NBA 2025)
Southern Richtersveld Yellow Duneveld	67,65	EN	LC	NP
Stinkfonteinberge Eastern Apron Shrubland	60,88	EN	LC	WP
Stinkfonteinberge Quartzite Fynbos	54,29	EN	LC	WP
Tatasberg Mountain Succulent Shrubland	20,25	LC	LC	WP
Umdaus Mountains Succulent Shrubland	42,3	VU	LC	NP
Upper Annisvlakte Succulent Shrubland	6,53	LC	CR	MP
Vyftienmyl se Berge Succulent Shrubland	86,03	CR	LC	WP
Western Bushmanland Klipveld	22,9	LC	LC	NP
Western Gariep Hills Desert	66,99	EN	LC	PP
Western Gariep Lowland Desert	34,55	VU	CR	NP
Western Gariep Plains Desert	5,25	LC	LC	PP

2.3.2.3 Levels of Protection

Site-based biodiversity management efforts are among the most effective means to reduce global biodiversity loss with a well-designed and managed network of statutory protected areas being regarded as the most effective management tool for conserving biodiversity (DEA, 2008). Emanating from the recognition of the Succulent Karoo as a region of global biodiversity importance, there has been a dedicated effort to develop the protected area estate in the biome since the 1990's. This effort has proceeded together with the development of systematic conservation planning in South Africa. Therefore, all the current protected area expansion strategies across agencies and role players are informed by systematic planning and are implemented within the context of the National Protected Area Expansion Strategy. Thus, implementation is aligned across agencies and is striving to achieve a national set of biodiversity conservation targets in line with international best practice. Currently, South Africa is aiming to achieve the 30x30 target implying that by 2030 the protected area estate will cover 30% or more of the region.

Much of this effort is witnessed in the current protected area network (Figure 2-11). Currently protected areas cover less than 8% of the region (Table 2-7). Ecosystem Protection Level (EPL) is another headline indicator from the National Biodiversity Assessment that gives an indication of how well we are achieving our biodiversity conservation targets. EPL is the amount of each ecosystem represented within the protected area network relative to the conservation target for that ecosystem. Only 20 (28%) of the regions ecosystems are well protected) compared to 47 (66%) that are poorly or not protected (Figure 2-13, Table 2-6). Notwithstanding the massive strides in growing protected areas over the past three decades there is still a considerable way to go if we are to meet the 30x30 targets in the region.

With regards the extent of protected areas represented in Figure 2-11 and Table 2-7, these provide an approximate extent of the PA estate. The protected area estate is continually evolving due to additional of new areas and clarification of statutory status and boundaries of existing areas. Consequently, no one data source accurately reflects the entire *de facto* protected area estate. The data presented here is sourced from various datasets including the DFFE PACA database (https://www.dffe.gov.za/egis), SANBI National Biodiversity Assessment data (https://bgis.sanbi.org/Projects/Detail/221) and Leslie Hill succulent Karoo Trust (WWF) datasets. The objective of this section is to provide a narrative of the developing PA estate and not an accurate account of this estate. Therefore, there will be minor discrepancies between what is reported here and what is currently observed on the ground.

Table 2-7: A summary of the protected area estate in the Namakwa Region.

Protected Area Type	% of Namakwa Region
National Park – National Park	3,13%
National Park – Contractual Park	2,92%
Provincial Nature Reserve	0,89%
Nature Reserve Stewardship Programme	0,03%
Private Nature Reserve (ORDINANCE)	0,65%
Total PA	7,62%
World Heritage Site BUFFER only	3,80%
World Heritage Site CORE only	2,48%
Total PA and WHS	13,89%

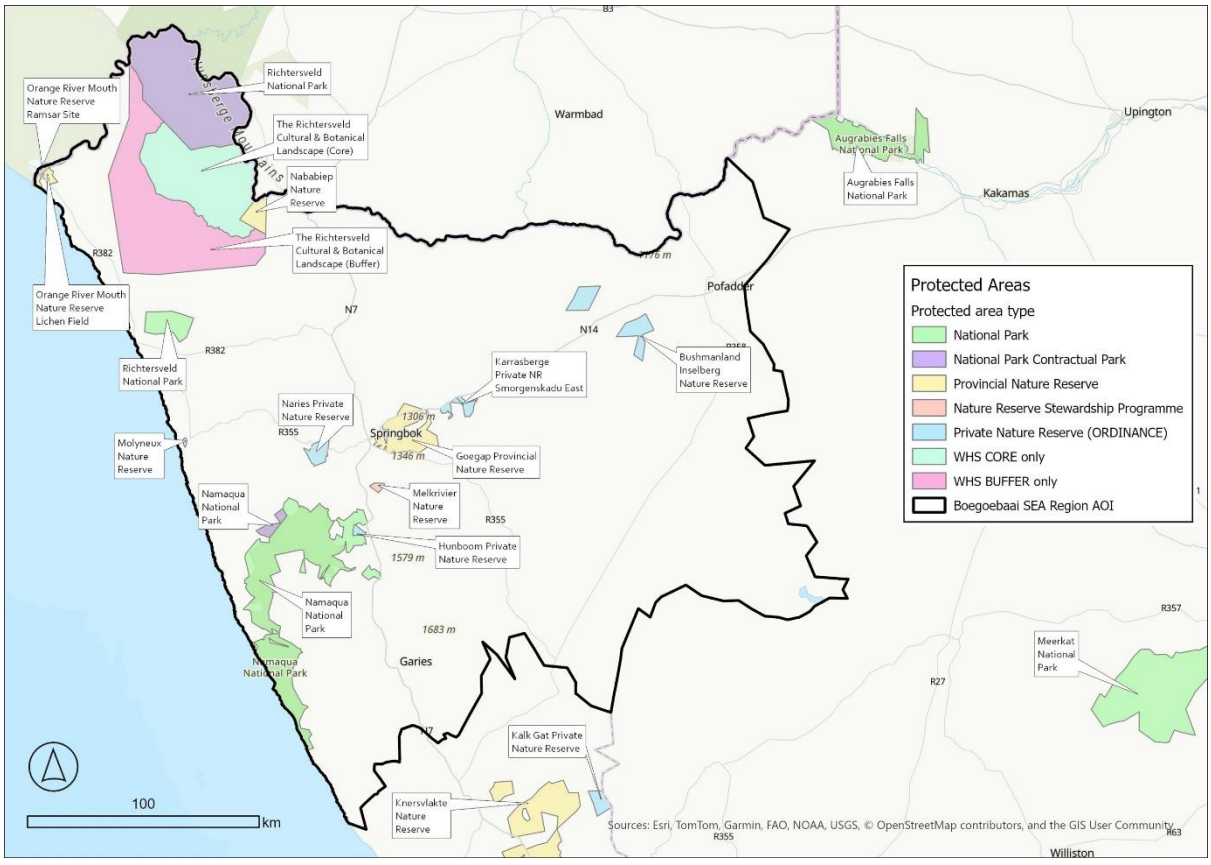


Figure 2-11: The approximate 2024 extent of protected areas in the Namakwa Region.

There are two state agencies responsible for developing the protected area estate in the region:

1. Northern Cape Department of Environmental and Nature Conservation (DENC) now Northern Cape Department of Agriculture, Environmental Affairs, Rural Development and Land Reform (DAERL)

2. South African National Park (SANParks)

Each of these agencies have their own protected area expansion strategies that are aligned to one another and with the National Protected Areas Expansion Strategy (NPAES), and more recently the SANParks 2040

Mega-Living Landscape vision. These agency plans provide the necessary spatial resolution for on-the-ground implementation of protected areas relative to the national PAES.

In the Namakwa Region these agencies are actively supported in their protected area expansion efforts by several NGOs. These include:

1. Leslie Hill Succulent Karoo Trust administered by WWF South Africa who has provided the bulk of funds with which to purchase properties for conservation.

2. Wilderness Foundation Africa working with landowners to signup stewardship sites.

3. The Nature Conservancy working with landowners to signup stewardship sites.

4. Conservation South Africa mostly stewardship with local communities.

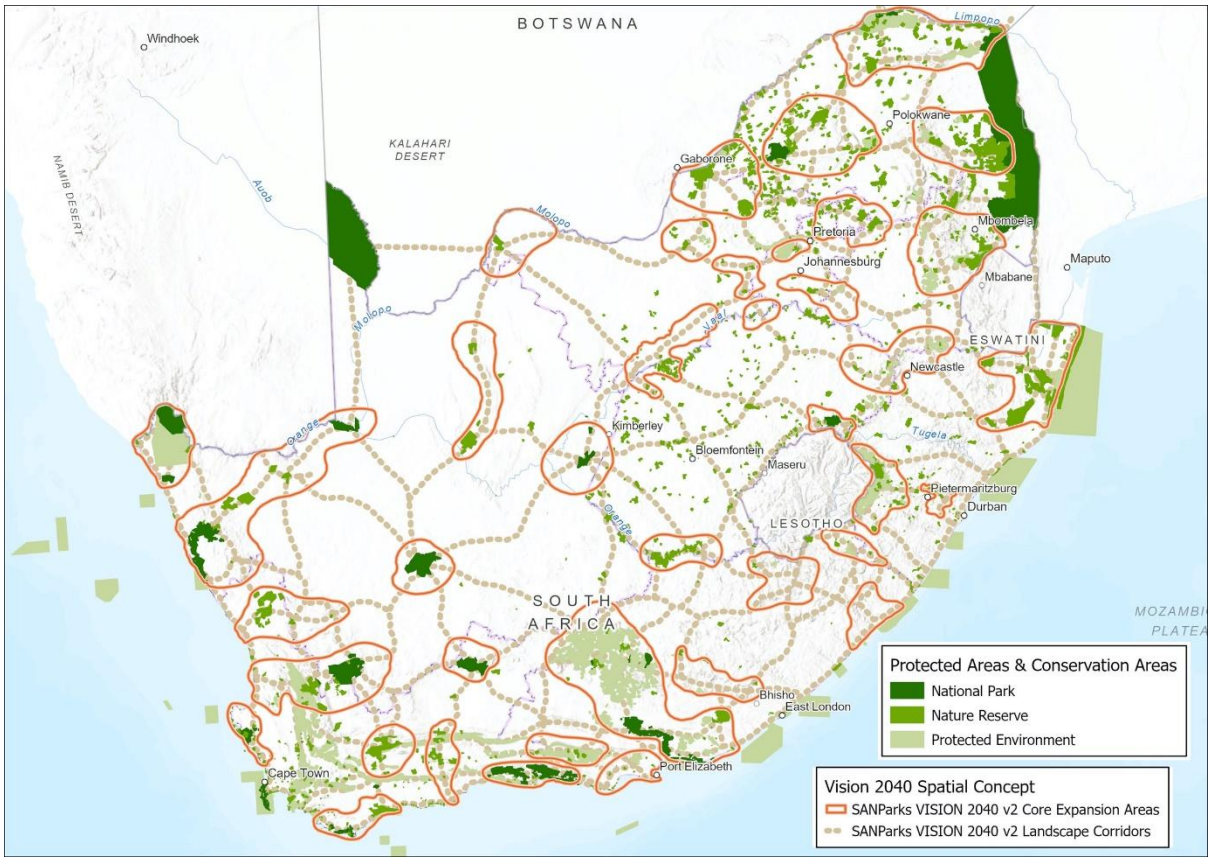


Figure 2-12: The Vision 2040 spatial concept summarising the mega-living landscape vision for protected area development in South Africa where core biodiversity conservation landscapes connected to each other via a network of landscape ecological corridors.

An important spatial planning concept currently informing all protected area development in South Africa is SANParks **Vision 2040** (Figure 2-12). This vision proposes a much larger landscape-level vision for biodiversity conservation in South Africa. This national plan envisages a national network of mega-living landscapes / biodiversity economy landscapes centred around biodiversity conservation, people and biodiversity-based economic development. At the core of these landscapes are protected areas, and the linkages between these core areas give expression to the ecological process landscape linkages and climate change adaptation principles implemented in our spatial biodiversity plans. In the Namakwa Region there are two mega-living landscapes:

1. The Greater Richtersveld; and,

2. The Namaqualand Mega-Reserve that stretches from the Namaqua National Park on the coast inland to Augrabies Fall National Park.

A very important aspect of implementing a protected area expansion strategy is that it takes time. It happens slowly over time and not in one day. Sourcing funds, finding suitable properties and negotiating stewardship or purchase agreements all takes considerable time. Hence achieving a conservation vision for a protected area network can take decades to realise. Whilst we may have a good indication now of where we would like protected areas to develop in the future, it is vitally important in the short term to manage risk or likelihood of losing these areas to competing land use thereby compromising out conservation goals. This is where land use planning and particularly this SEA can help circumvent these conflicts from arising by planning to avoid target areas for conservation.

The current protected area expansion plans for the Namakwa Region when combined cover 72% of the region (Figure 2-14). In addition to the 2 mega-living landscapes, there are three core protected area development nodes in this map: Richtersveld, Namaqua National Park and Bushmanland Inselberg Region.

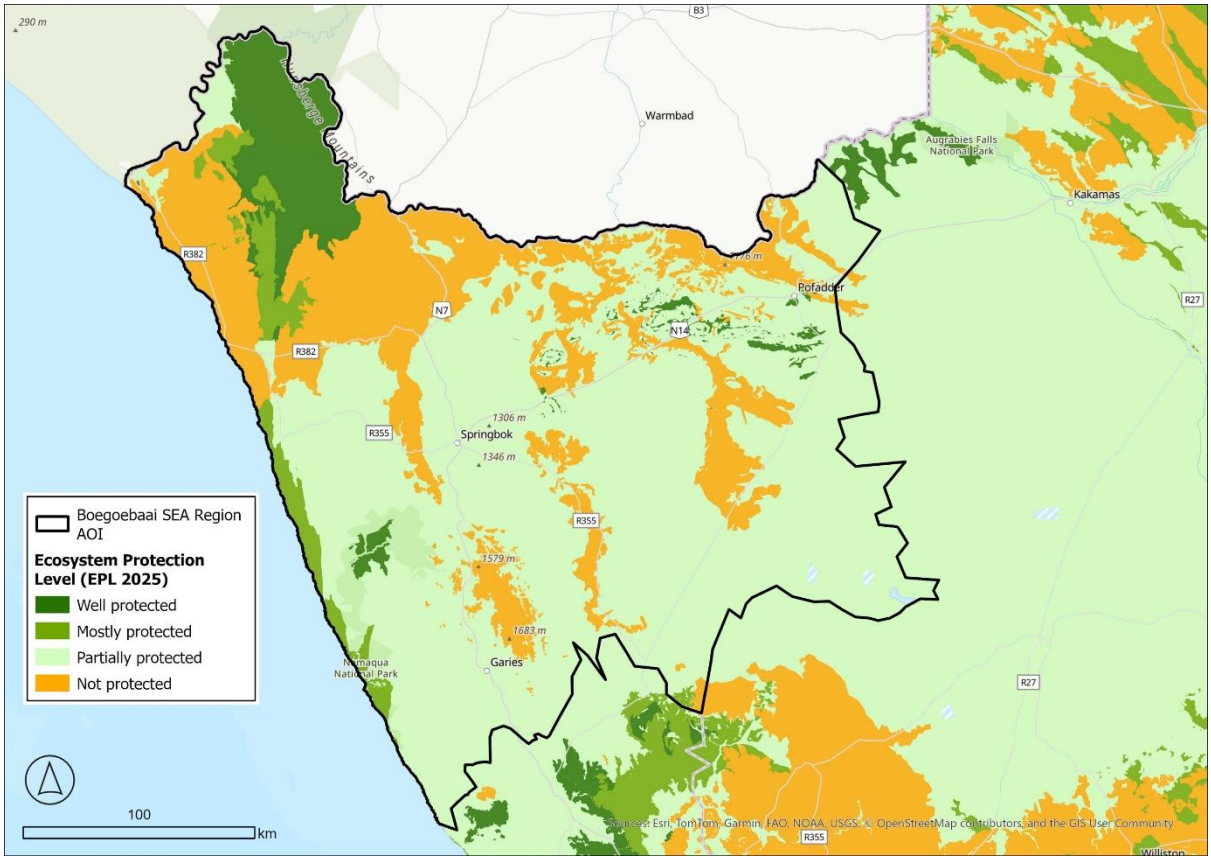


Figure 2-13: Ecosystem Protection Levels (EPL) for vegetation types in the SEA region.

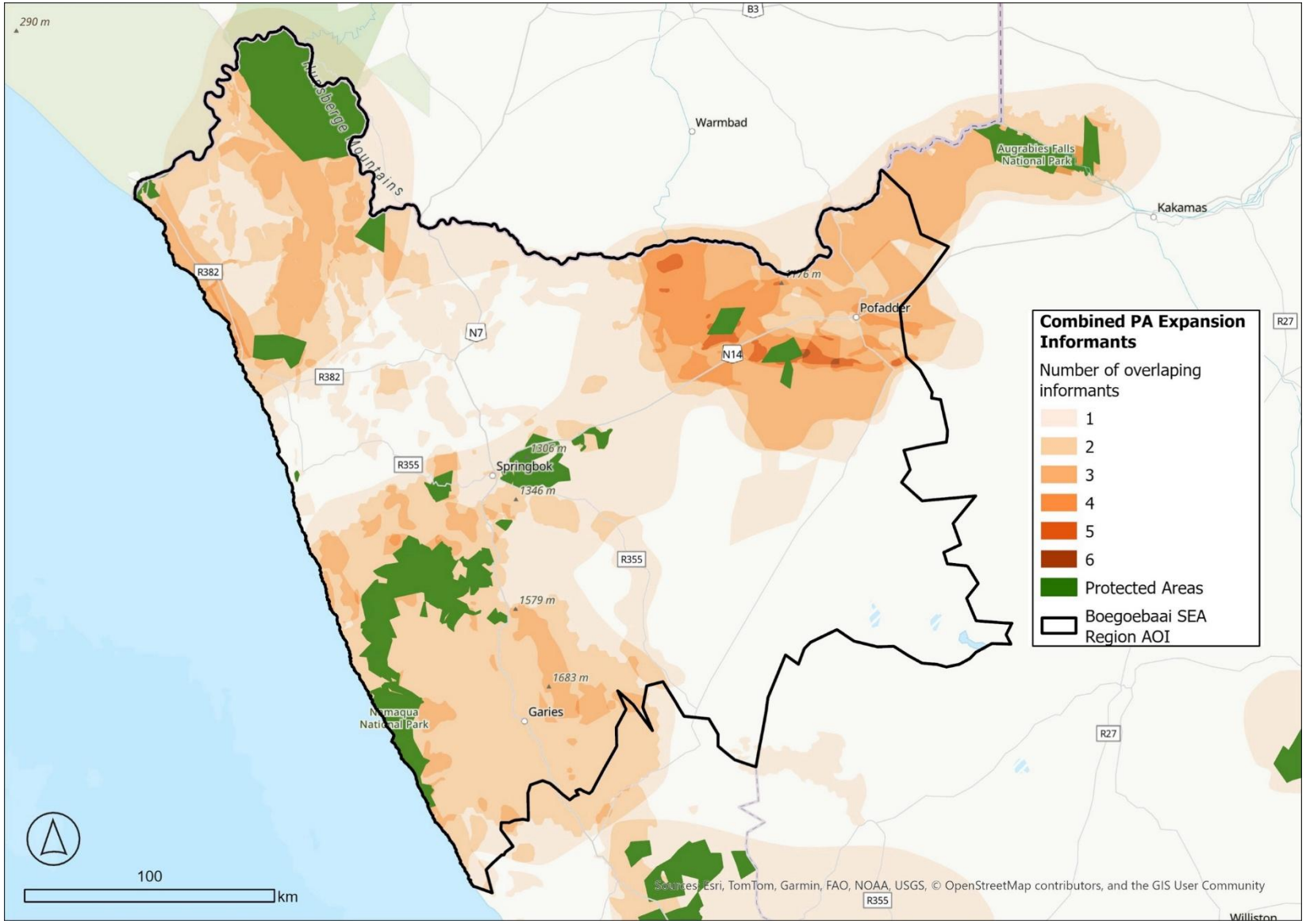


Figure 2-14: The combined protected area expansion focus areas for the Namakwa Region.

2.4 BIODIVERSITY SENSITIVITY ANALYSIS

To provide a perspective on known biodiversity sensitives, existing biodiversity planning informants and biodiversity sensitivity assessments conducted as part of this SEA process are integrated into a single regional **biodiversity sensitivity map**. There is a wealth of biodiversity-related datasets for the region that provide insights to the relative importance or sensitivity of the receiving environment and deciding on which datasets should be used to inform planning is non-trivial. Also, biodiversity sensitives for different components of biodiversity (e.g. plants vs birds vs animals) are not correlated across the region such that a sensitive area for one group will not necessarily reflect spatial sensitivities for other groups. It is therefore prudent and necessary to combine all available datasets into a single integrated sensitivity map for the region rather than attempting to select subset with which to assess the relative biodiversity sensitives of areas. This section briefly summarises the available informants and describes how these are combined to product an integrated biodiversity sensitivity map for the WP2 region.

In South Africa, there is a well-developed framework for incorporating biodiversity into land use planning and decision making in the form of Bioregional Plans. The maps of critical biodiversity areas and ecological support areas, referred to as a CBA Map, associated with these plans provide a standardised set of biodiversity importance values (CBA map categories) with which to assess the impact of land use planning and development decisions. Bioregional plans prepared for a region use a systematic conservation planning approach to develop a map with areas being earmark as important or necessary to achieve our national conservation goals (DEA, 2009). An advantage of CBA maps is that the production of these maps follows a standardised approach across all regions in South Africa that adheres to a set of national technical guidelines (SANBI, 2017). The biodiversity spatial planning products form the first group of informants included in the sensitivity assessment.

A second group of informants is provided by protected area expansion plans. The WP2 region is in the Succulent Karoo biome, a global biodiversity hotspot and as such the biodiversity economy is viewed as an important economic driver with biodiversity conservation and the development of the region's protected area network (PAN) forming the cornerstone of this economy. Nationally, the National Protected Area Expansion Strategy (NPAES) (DEA, 2016) is the national-level policy framework guiding protected area development within the provinces. On-the-ground protected area implementation is guided by provincial, regional or local-level protected area expansion strategies or development plans produced by the statutory agencies or conservation NGOs that identify in more detail specific areas earmarked for inclusion in the PAN. These plans provide another important source of biodiversity sensitivity information as industrial-type development is mostly not compatible with protected area development either directly through loss of areas within the expansion zone or indirectly such as through pollution of viewsheds or disruption of ecological processes (e.g. loss of corridors) adjacent to and between these PAN development zones.

A third group of informants is provided by the specialist studies group (birds, bats, animals and aquatic) sensitivity analyses conducted as part of the SEA process. Each of these assessments provide an interpretation of biodiversity sensitives with specific reference to the specialist group in question. Most of the data used in these assessments has not been used to inform bioregional plans or protected area expansion strategies and therefore this data compliments the above informants.

The following section describes these biodiversity sensitivity informants in more detail. Step one of the analysis process involved combining the raw data inputs to create 4-class high-low sensitivity maps where the resultant map depicts the maximum value from of inputs. This resulted in six sensitivity maps: group 1 biodiversity planning, group 2 protected area expansion, and group 3 specialist studies sensitivity (birds, animals, bats and aquatic ecosystems). Step two of the analysis combined these six intermediate sensitivity maps into a single biodiversity sensitivity map that depicts the combined sensitivity ranks of the inputs and also ranks based on the maximum of inputs.

2.4.1 Biodiversity Sensitivity Informants Group 1: Biodiversity Planning

Available biodiversity spatial planning informants are combined into a single biodiversity planning sensitivity map (Figure 2-15. Datasets informing this map are described in the sections that follow. The technical details on how inputs datasets are combined to create the 4-class high-low map are described in Appendix 2 Biodiversity Sensitivity Analysis Technical Notes.

In the combined biodiversity planning sensitivity map, the extent of high to very-high sensitivity categories cover 50% of the region, and medium to very-high covers 71% of the region (Table 2-9). This is very much to be expected as this is a global biodiversity hotspot and is in keeping with our understanding of the unique patterns of diversity that we see in this landscape. Generally, in South Africa CBA Maps earmark up in the region of 60% of the landscape as CBA and ESA.

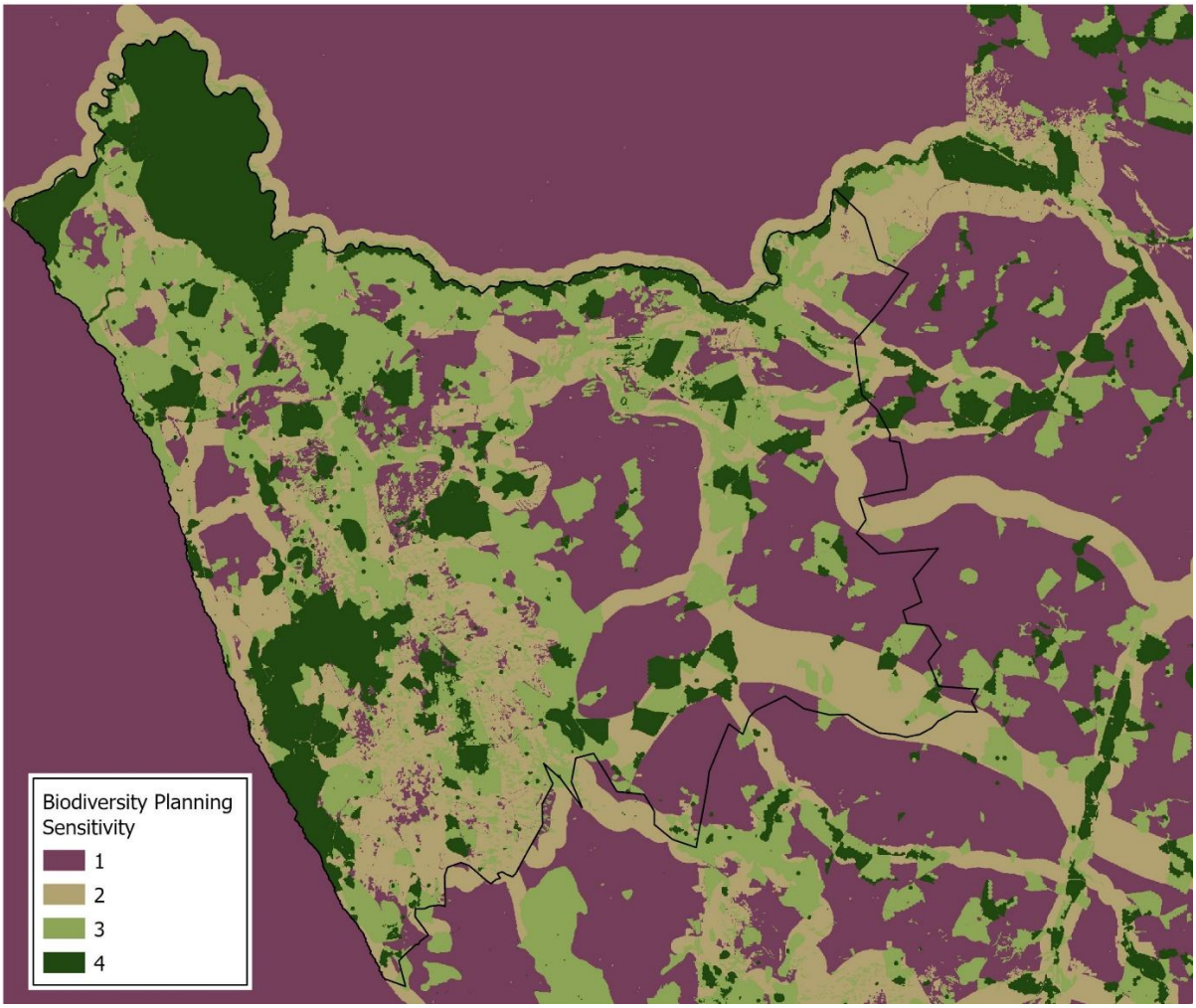


Figure 2-15: Map of combined biodiversity spatial planning sensitives. Sensitivity categories are 1=low, 2=medium, 3=high and 4=very high.

Table 2-8: An interpretation of what the biodiversity planning sensitivity map categories mean in terms of biodiversity importance and land use planning. The binary code is used in step two of the analysis to combine the six intermediate sensitivity maps into the overall biodiversity sensitivity map.

Sensitivity Rank	Map Code	Binary Code	Description
Very High	4	1000	Declared protected areas and conservation areas
Very High	4	1000	Irreplaceable sites. These are sites that are mandatory if we are to achieve our conservation goals targets. These are areas that contain extremely sensitive features, such as key habitat for rare, endemic or threatened species, or features that perform critical ecological functions. These sites are irreplaceable (i.e., no ecologically equivalent sites exist and there is no exchangeability between sites) or contain the necessary habitat to support the continued survival of species of conservation concern. Extensive GH2 activities should be avoided in these areas, as impacts of GH2 in these areas would undermine the ecological integrity of the region and our ability to achieve our conservation goals. Ideally these areas should be secured through appropriate zoning (e.g., CBA map, SDF), development controls, or protected area expansion.
High	3	100	Important and necessary sites. A selection of available sites that collectively contribute and meet a conservation goal or target. Areas that contain highly sensitive features and/or features that are important for achieving targets for representing biodiversity and/or maintaining ecological processes. These areas

Sensitivity Rank	Map Code	Binary Code	Description
			represent the optimal configuration for securing the species, ecosystems and ecological processes of the Karoo. Impacts of GH2 in these areas are undesirable, and any impact would need to be offset and ecologically equivalent sites identified to represent the same suite of biodiversity features that were impacted.
Moderate	2	10	Areas necessary to maintain ecological processes. Areas containing natural or semi-natural areas identified as being important for maintaining ecological processes such as the area required to main populations (e.g., foraging areas), protected populations from impacts (e.g., buffer zones) or to connect parts of the landscape (i.e., ecological corridor network). Any GH2 activity that has the potential to reduce habitat quality or lead to fragmentation of habitat through the loss of habitat or erection of barriers to species movement should be avoided and where unavoidable, then offset and strongly mitigated.
Low	1	1	Other areas of natural habitat not earmarked for achieving a biodiversity conservation outcome. These are areas that do not contain currently known sensitive or important features and are not required for meeting targets for representing biodiversity or maintaining ecological processes. Provided that category 2-4 areas are secured, loss of habitat here should not compromise our ability to achieve conservation targets provided the impacts here do not extend into adjacent areas of higher importance or sensitivity. If development is extensive, then offsets may still apply. However, if any impacts occur in category 2 and 3 areas, additional sites from this category may be required as alternatives for representing biodiversity and maintaining ecological processes. *Note that this category also includes areas that are no longer natural, however, this category is not indicated on the map.*

Table 2-9: Summary of the extent of categories in the biodiversity planning sensitivity map.

	Biodiversity Sensitivity Category	% of Namakwa Region
4	Very High (protected areas)	9,7
4	Very high	11,4
3	High	28.4
	Total area of 3 and 4	**49,5**
2	Medium	21.8
	Total area of 2, 3 and 4	**71,2**
1	Low	28,8
	Total	**100**

2.4.1.1 Northern Cape Critical Biodiversity Areas 2024

Maps of Criticval Biodiversity Areas and Ecological Support Areas, or CBA Maps, are spatial plans for conserving biodiversity and maintaining a well-functioning landscape or seascape (SANBI 2017). They show priority areas for retaining ecosystems and species and maintaining ecological functioning. CBA Maps are developed using scientific methods that combine a wide range of biodiversity data into one map that shows the most important places for biodiversity. The development of CBA maps gives effect to the requirements of the National Environment Management Act (NEMA) 107 of 1998 that obligates all organs of state to take biodiversity considerations into account and to ensure decisions are informed by the most up to date information. The Biodiversity Act (10 of 2004) provides for the management and conservation of

biological diversity in South Africa and has introduced several tools to help achieve this. One of these tools is the development and publishing of bioregional plans (DEA, 2009). Bioregional plans inform land-use planning, environmental authorisations and natural resource management outside of protected areas. The bioregional plan serves as the primary source of biodiversity information informing land-use planning and decision-making processes. SANBI has developed a set of national guidelines for developing bioregional plans (SANBI 2017).

The 2024 Northern Cape Critical Biodiversity Area Map (Figure 2-16, Oosthuysen and Geldenhuys 2024) builds on previous biodiversity spatial plans in the province. This 2024 version is the first revision of the original 2016 provincial CBA Map. An artefact of this provincial-scale CBA Map is the relatively coarse spatial resolution of the plan, something that proves limiting for on-the-ground site-level applications. Also, the nuances of finer-scale biodiversity plans are lost at this coarser resolution. A third aspect of the provincial is that it uses rivers and mountain ranges as a spatial surrogates for ecological corridors and not a designed ecological corridor network. Within the context of landscape-wide development proposals identifying and retaining landscape ecological connectivity is an essential mitigation activity. Therefore, for this SEA assessment the provincial product is used in conjunction with other the finer-scale Namakwa District Municipality (NDM) Biodiversity Sector Plan.

2.4.1.2 Namakwa District Biodiversity Sector Plan 2009

The Namakwa District Biodiversity Sector Plan (http://bgis.sanbi.org/Projects/Detail/52, Marsh *et al.*, 2009, Figure 2-17) predates the development of the provincial CBA products. This plan covers the entire SEA area and has several attributes that complement the provincial product, namely, the finer spatial resolution, the inclusions of datasets not used in the provincial plan, and the inclusion of a designed, albeit expert mapped, ecological corridor network.

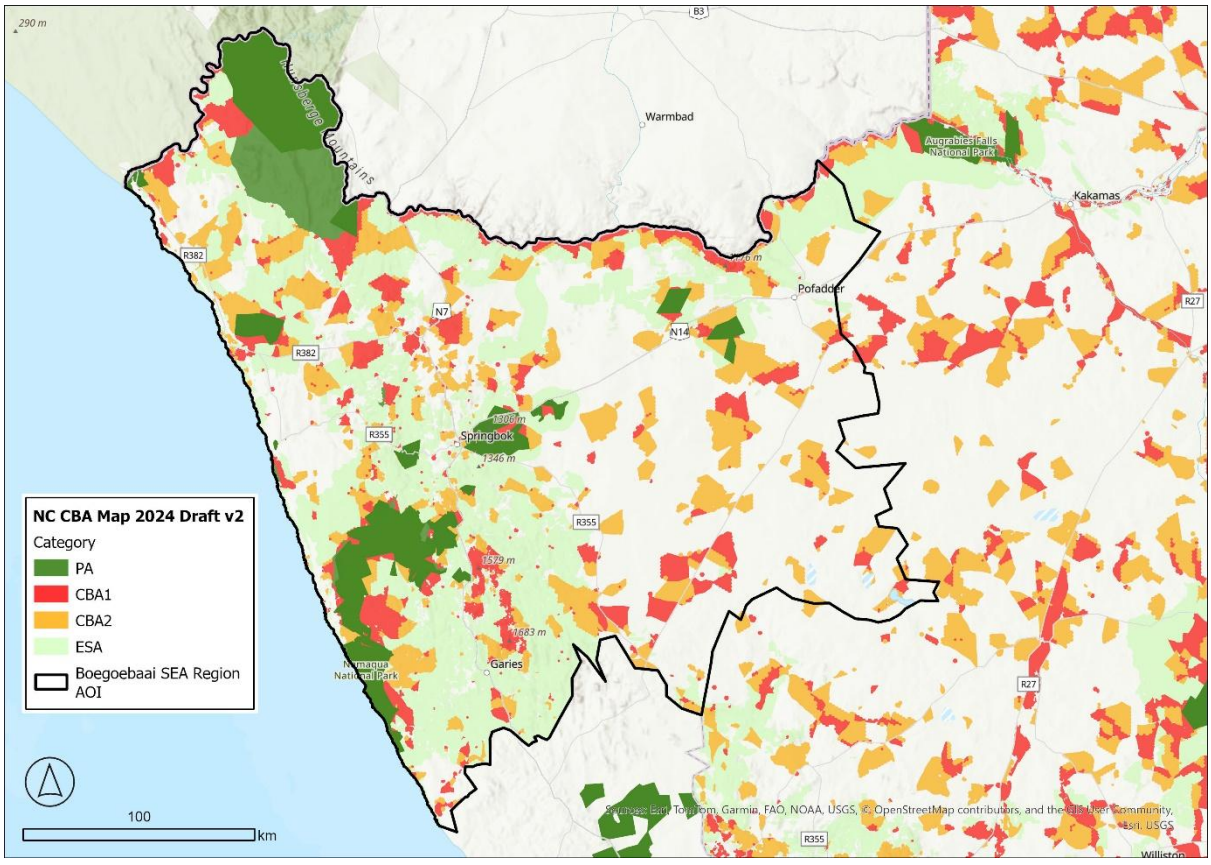


Figure 2-16: The Northern Cape Map of Critical Biodiversity Areas and Ecological Support Areas (2024 Draft v2, Oosthuysen and Geldenhuys 2024).

2.4.1.3 Plants Species of Conservation Concern

Plant species of conservation concern (SCCs) include threatened and rare plants that have been assessed SANBI's Threatened Species Programme (http://redlist.sanbi.org). this point-locality data is used to provide a fine filter observation-based planning informant (Figure 2-18). Threatened plant species are already considered in the Northern Cape 2024 CBA Map, however, rare species are included here as they are also an important indicator of biodiversity sensitivity.

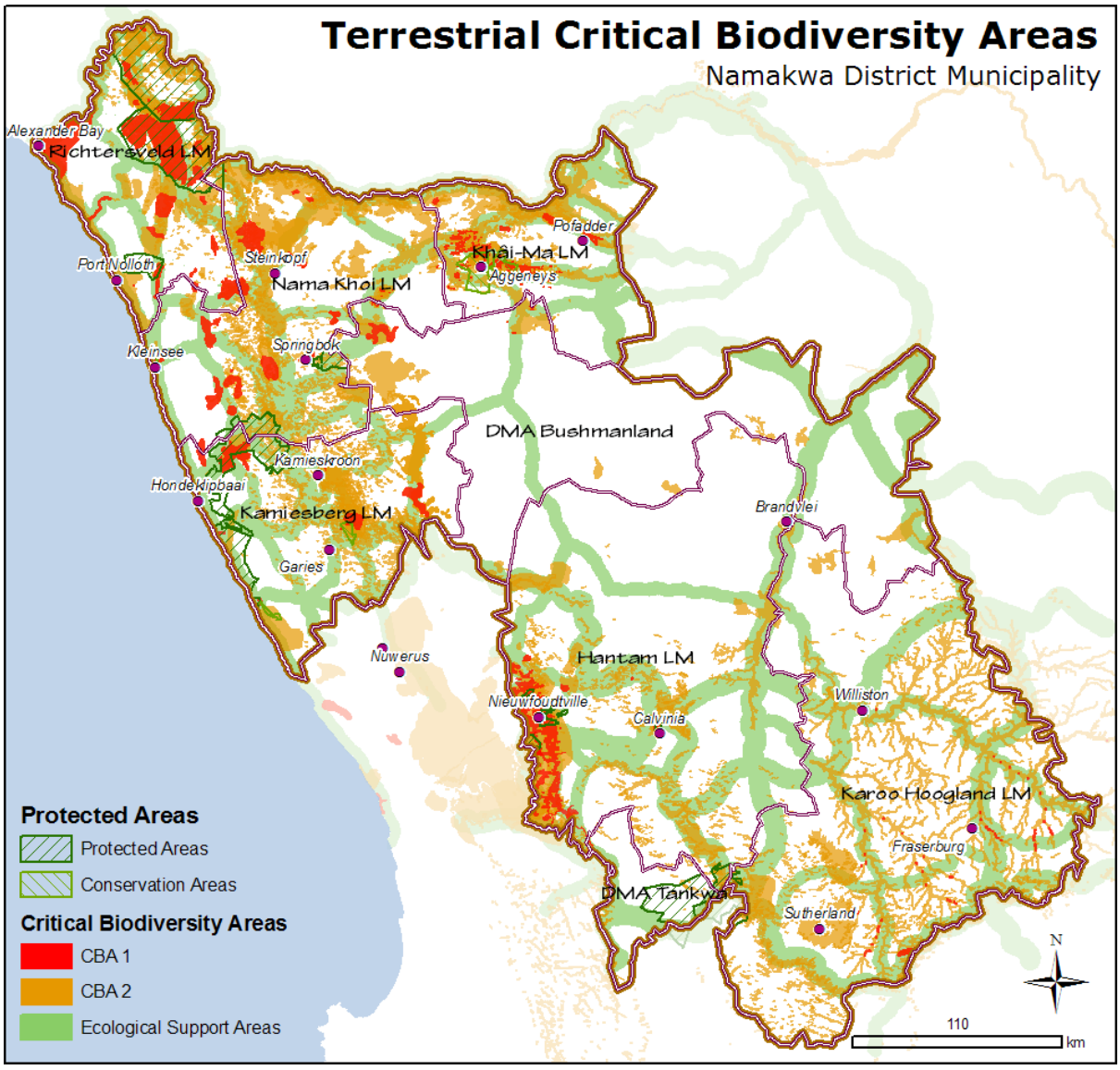


Figure 2-17: The Namakwa District Map of Critical Biodiversity Areas and Ecological Support Areas (map from Marsh et al. 2009).

2.4.1.4 Key Biodiversity Areas (KBAs)

Key Biodiversity Areas (Figure 2-19) are 'sites that contribute significantly to the global persistence of biodiversity', which means they are the most important places in the world for species and their habitats – whether these be in terrestrial, freshwater, estuarine or marine ecosystems. KBAs provide a global currency for identifying the most biologically significant sites, which helps focus our collective efforts on conserving the places that matter most. The KBA initiative is a global partnership to identify, map, monitor,

and conserve areas to help safeguard the most critical sites for nature. SANBI and BirdLife South Africa lead this initiative in South Africa. South Africa re-assessed KBAs in 2017 becoming the first country to apply all 11 KBA criteria. In 2024, the KBA Secretariat approved 263 terrestrial KBA sites underpinned by 3598 species triggers and 309 ecosystem triggers. The large number of terrestrial sites that qualify as global KBAs demonstrates the megadiverse and rich heritage of South Africa. (https://www.sanbi.org/biodiversity/building-knowledge/biodiversity-monitoring-assessment/key-biodiversity-areas-in-south-africa/)

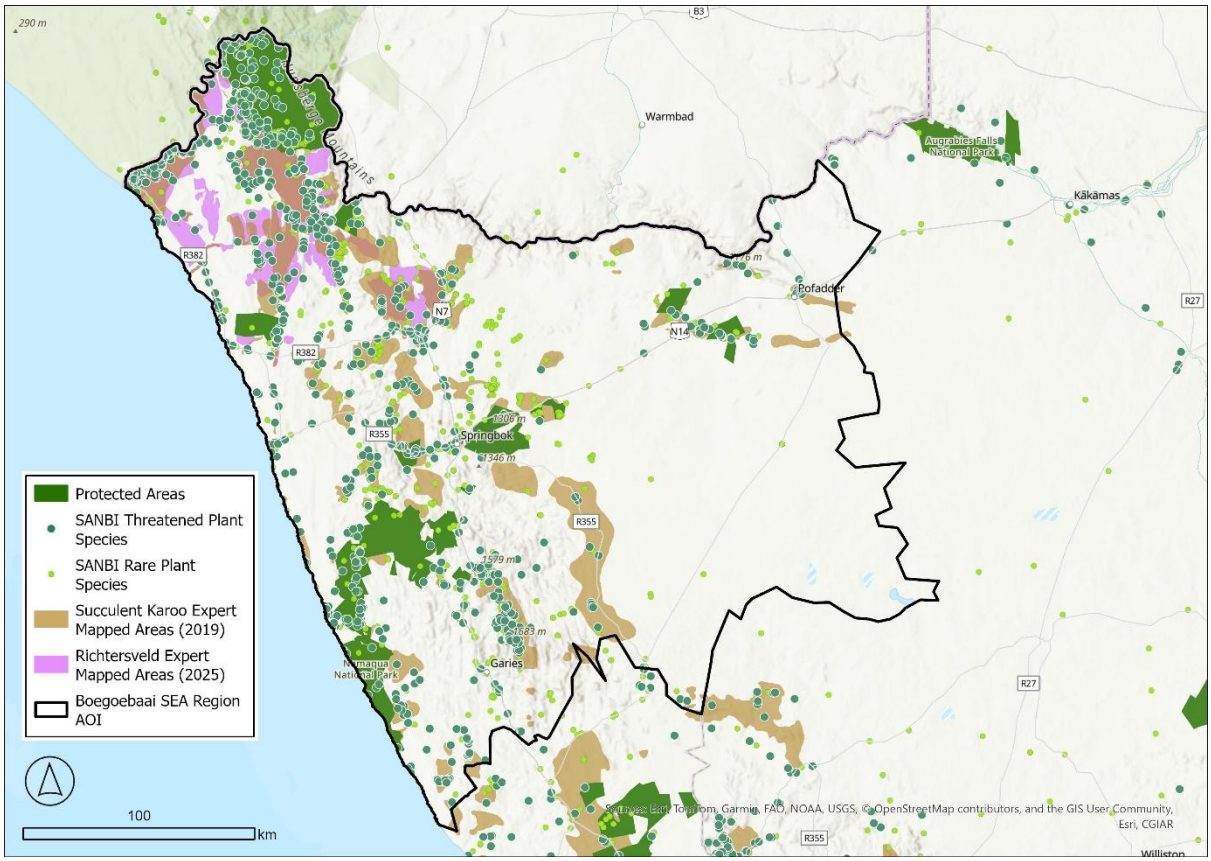


Figure 2-18: Expert mapped important areas for plants and SANBI species locality data.

KBAs are not use in this assessment. In the Namakwa Region there are 16 KBAs that cover 82% of the region. This large extent of KBAs viewed in context of the national KBAs network reiterates the global significance of the Greater Cape Floristic Region and the Namakwa Region as a global biodiversity hotspot. Whilst the KBAs are useful for focusing international attention on the Succulent Karoo and Namaqwa Region, the extensive coverage of KBAs mean that they have limited value for informing fine-scale or on-the-ground spatial planning and development decision making within the region. In this SEA analysis the Important Bird Area information is extracted from the KBAs data to compliments the bird sensitivity analysis (see following section).

2.4.1.5 Biodiversity Planning Sensitivity

Whilst the wealth of spatial planning informants provides useful tools for informing and guiding development planning, deciding on where to apply or how to interpret the various products can be a challenge. The inputs described above each provide different perspectives on biodiversity priorities or sensitivities based on the underlying information or approach used to identify areas. Thus, objective of this integration exercise is to combine the selected informants into a single map biodiversity sensitivity map (a) without necessarily re-interpreting the original results of the original studies, and (b) broadly keeping in line with the bioregional plan CBA Map framework that is the standard tool informing land use planning in South Africa. The CBA map and map categories are well understood in land use planning in South Africa, and it is therefore useful to keep within this framework of thinking for the integration of input. Whilst the

integration approach aligns broadly with that used to develop CBA maps, the product is not intended to replace any existing CBA maps, therefore the resultant map should be interpreted as a map of biodiversity sensitivities (Table 2-8).

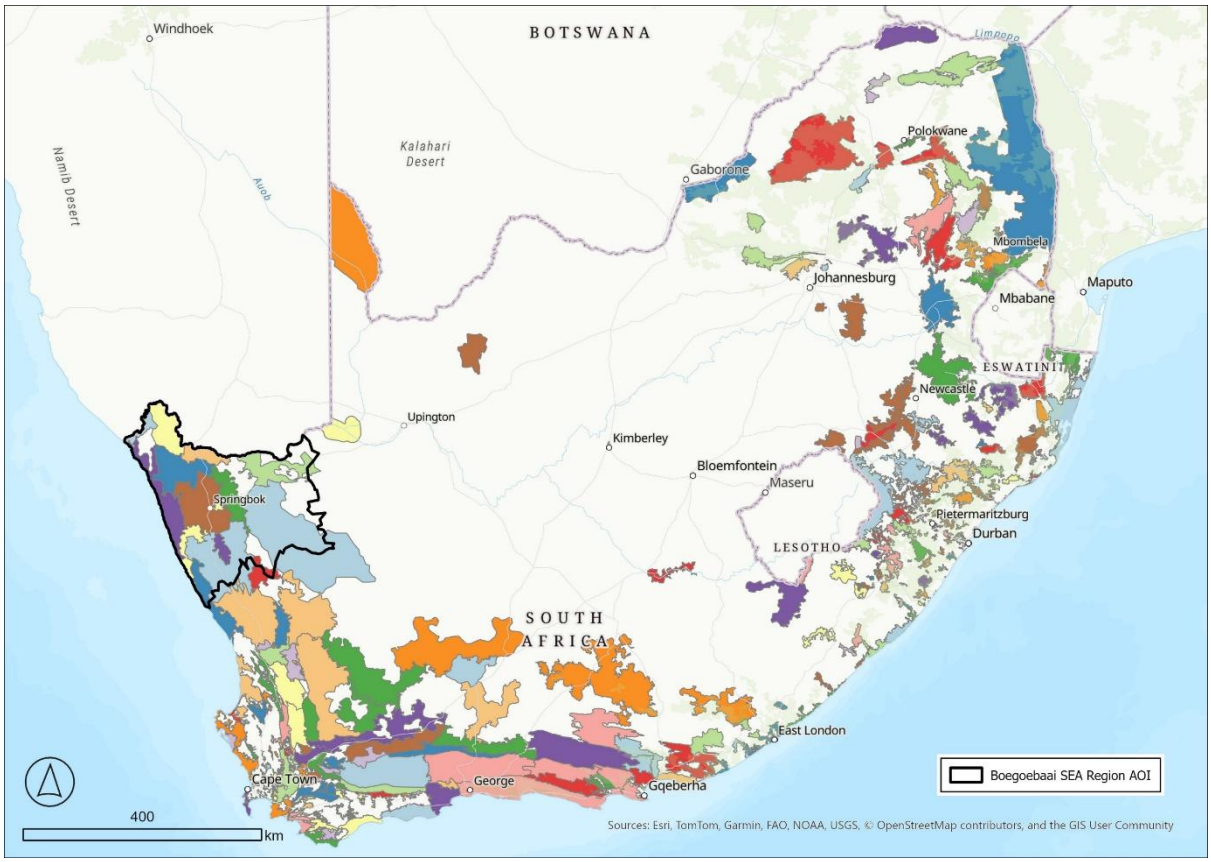


Figure 2-19: The extent of 16 the KBAs in the Namakwa Region in relation to the national network of 263 KBAs.

2.4.2 Biodiversity Sensitivity Informants Group 2: Protected Area Expansion Plans

The National Protected Area Expansion Strategy (NPAES) (DEA, 2016) is the national-level policy framework guiding protected area development within the provinces. It provides the necessary scientific, policy, and planning tools to ensure that protected area expansion contributes to sustainable development and international biodiversity commitments. The NPAES serves as a 20-year framework to accelerate the cost-effective expansion of protected areas. It aims to improve ecosystem representation, ecological sustainability, and climate change resilience by identifying priority areas, setting targets, and providing mechanisms for land-based and marine expansion. The primary focus is to protect a representative sample of all South Africa's ecosystems, particularly focusing on under-represented biomes such as grasslands, Nama Karoo, Succulent Karoo, and specific marine, river, and wetland ecosystems.

The strategy identifies 42 focus areas for land-based expansion, which are large, intact, and unfragmented areas suitable for protection. Whilst the NPAES is a spatial assessment it is not a protected area development plan in that it gives broad guidance as to protected area development spatial priorities across the country and it does not identify specific sites earmarked for inclusion in the PAN. At the level of this SEA it is more informative to consider local-level protected area development plans and other spatial plans that have been adopted by the agencies and NGO's that are being used for on-the-ground PAN development (Table 2-10, Figure 2-20). These informants were combined into a 4-class high-low sensitivity map where the sensitivity rating reflects the number of times a site is earmarked by the combined

informants (Figure 2-21, Appendix 2 Biodiversity Sensitivity Analysis Technical Notes Biodiversity Sensitivity Analysis technical Notes).

Table 2-10: List of spatial inputs used to inform protected area expansion sensitivity.

	Name of Dataset	Source
1.	Northern Cape PAES 2017	Northern Cape DAERL
2.	Succulent Karoo expert mapped areas 2019	Leslie Hill Succulent Karoo Trust / WWF. Includes Richtersveld expert areas by Pieter van Wyk mapped as part of WP1. (See Appendix 3)
3.	KBA 2021 (IBA areas only) and IBA 2015	SANBI and Birdlife
4.	SANParks buffer zones 2025 and Augrabies Falls NP expansion plan 2025	SANParks
5.	SANParks Vision 2040	SANParks
6.	Bushmanland Protected Area Development Zone 2013	Bushmanland Conservation Initiative

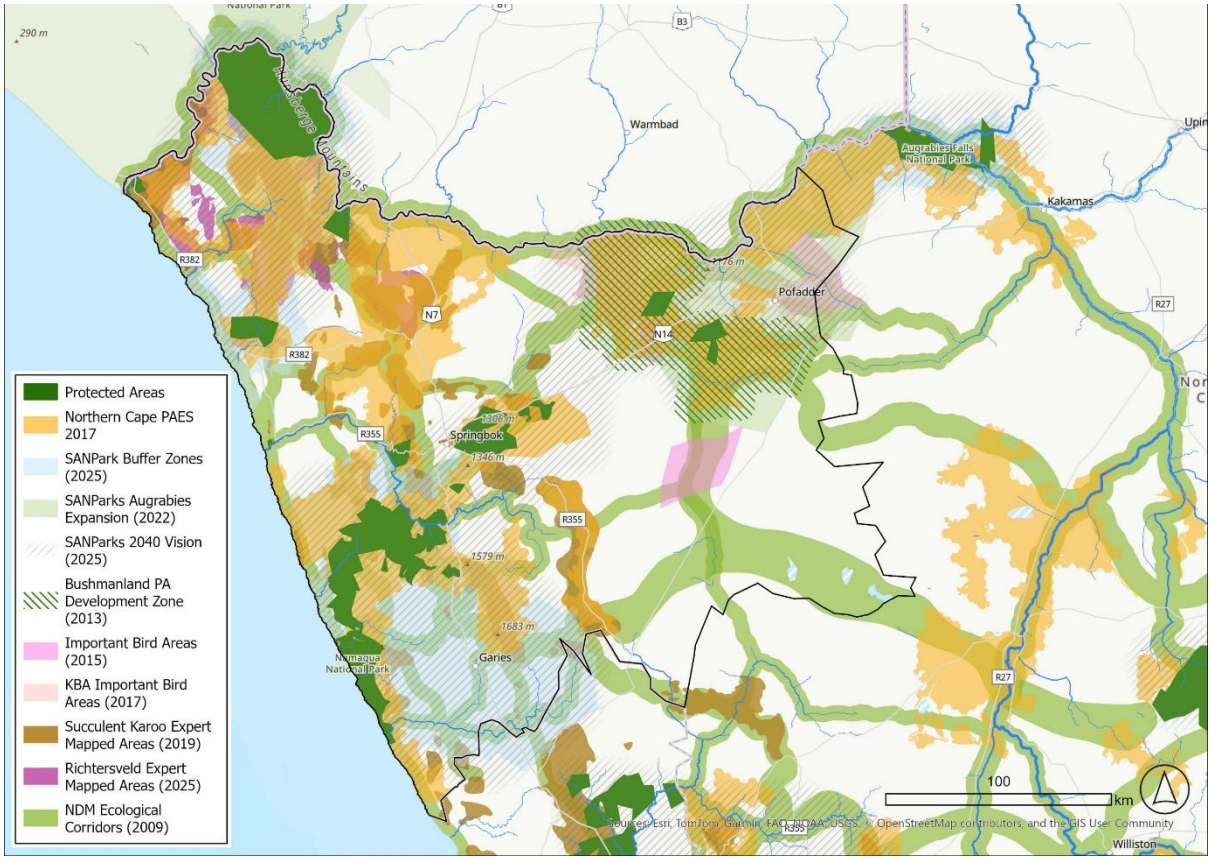


Figure 2-20: Inputs included in the protected area expansion sensitivity analysis. Note that the NDM corridor network is included here for context only. The ecological corridor network that links protected areas is included in the biodiversity planning analysis.

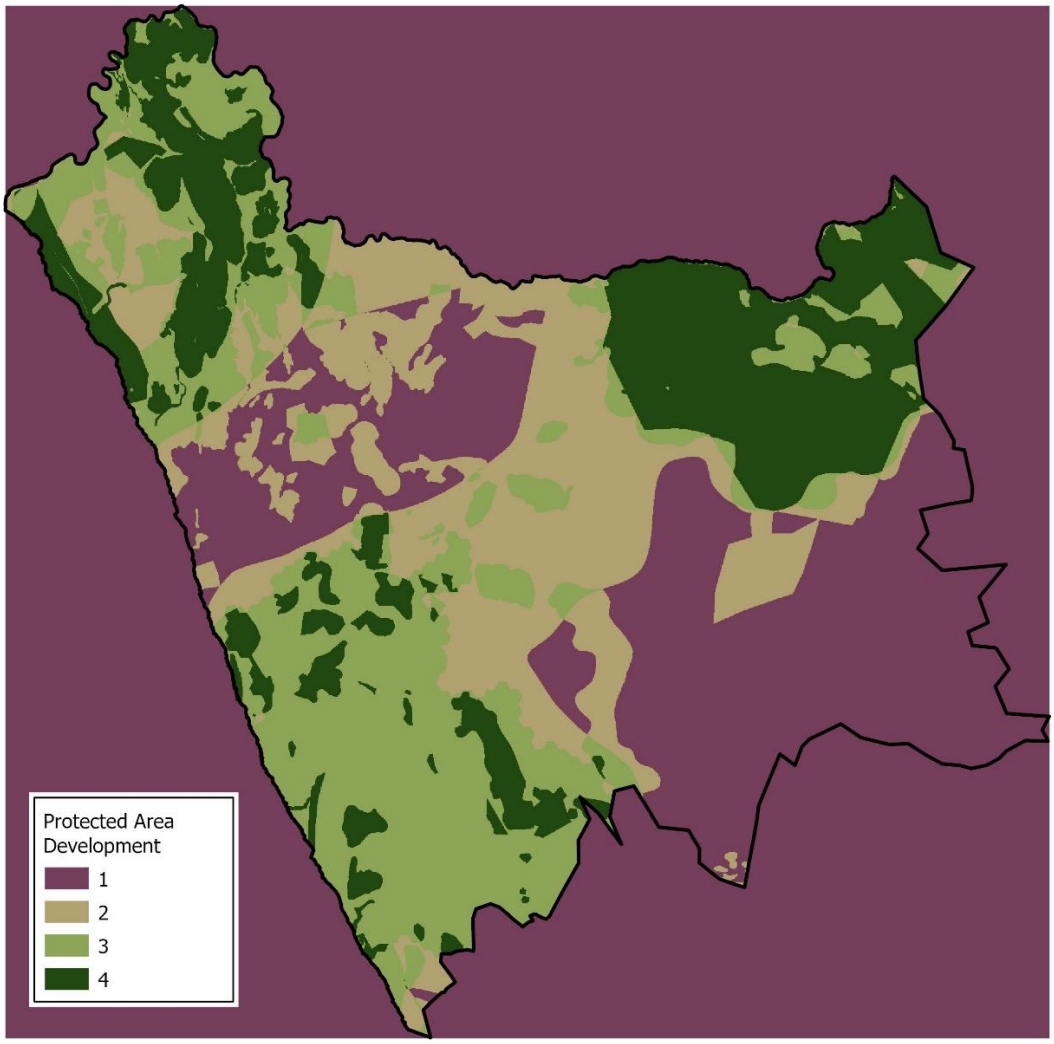


Figure 2-21: Map of protected area expansion sensitivities. Notes that this map does not include existing protected areas as these are already included in the biodiversity planning sensitivity map.

2.4.3 Biodiversity Sensitivity Informants Group 3: Specialist Assessments

As part of the SEA regional assessment, specialist studies were undertaken with each study conducting a sensitivity analysis that is relevant to the taxonomic group in question. These assessments, summarised below, are incorporated into the overall biodiversity sensitivity assessment.

2.4.3.1 Bird Sensitivity Assessment

Kellerman et al. 2026 developed a regional bird risk assessment as part of the SEA regional work package. This assessment considers the risks to avifauna from four key development impacts: (1) displacement due to disturbance from noise, lighting, and human activity; (2) habitat loss and fragmentation; (3) collisions with wind turbines and transmission lines; and (4) electrocutions from transmission lines. Multiyear bird atlas data, species distribution modelling, and habitat mapping is integrated in a weighted risk assessment for 44 bird species of conservation concern. The four input risk maps were combined to create the bird sensitivity map with the highest sensitivity category of the inputs (i.e. maximum of inputs) becoming the overall sensitivity value (Figure 2-23).

The bird spatial risk assessment identifies areas of relative threat to bird species in relation to specific development-related impacts. This assessment does not highlight important habitats or areas for birds based on contribution to achieving a conservation goal. Therefore, the bird risk maps cannot be compared to, for example, the CBA or KBA maps discussed above.

Currently, there is no systematic planning spatial product for birds that identifies important and necessary for areas for bird conservation such as critical habitats, minimum habitat requirements, breeding sites, flyways/corridors, etc. It is possible, however, to draw on the Important Bird Areas (IBAs) that are used as one of the triggers for a KBAs (Figure 2-22). IBAs provide some spatial resolution in terms if important bird habitats in the Namakwa Region. As birds of conservation concern in the arid zone of South Africa are relatively agnostic in terms of habitat preference, and range widely throughout the entire arid zone in response to seasons and rainfall events it is difficult to determine important and necessary areas for the arid zone avifauna. To consider the area and ecological requirements for birds more effectively in development planning it is necessary that this is done. This is an important recommendation from the Kellerman et al. (2026) regional risk assessment study is the motivation for improved spatial planning for birds.

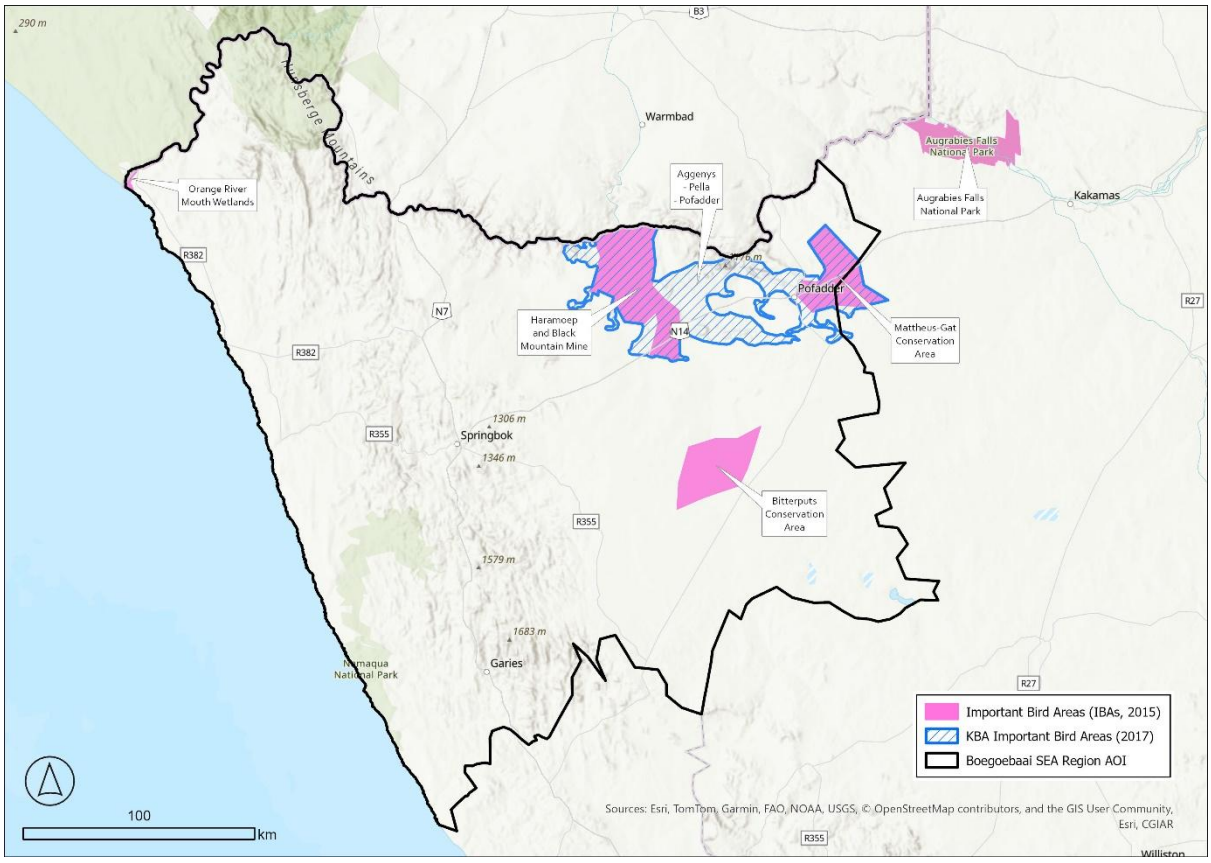


Figure 2-22: The extent of Important Bird Areas (IBAs) in the Namakwa Region.

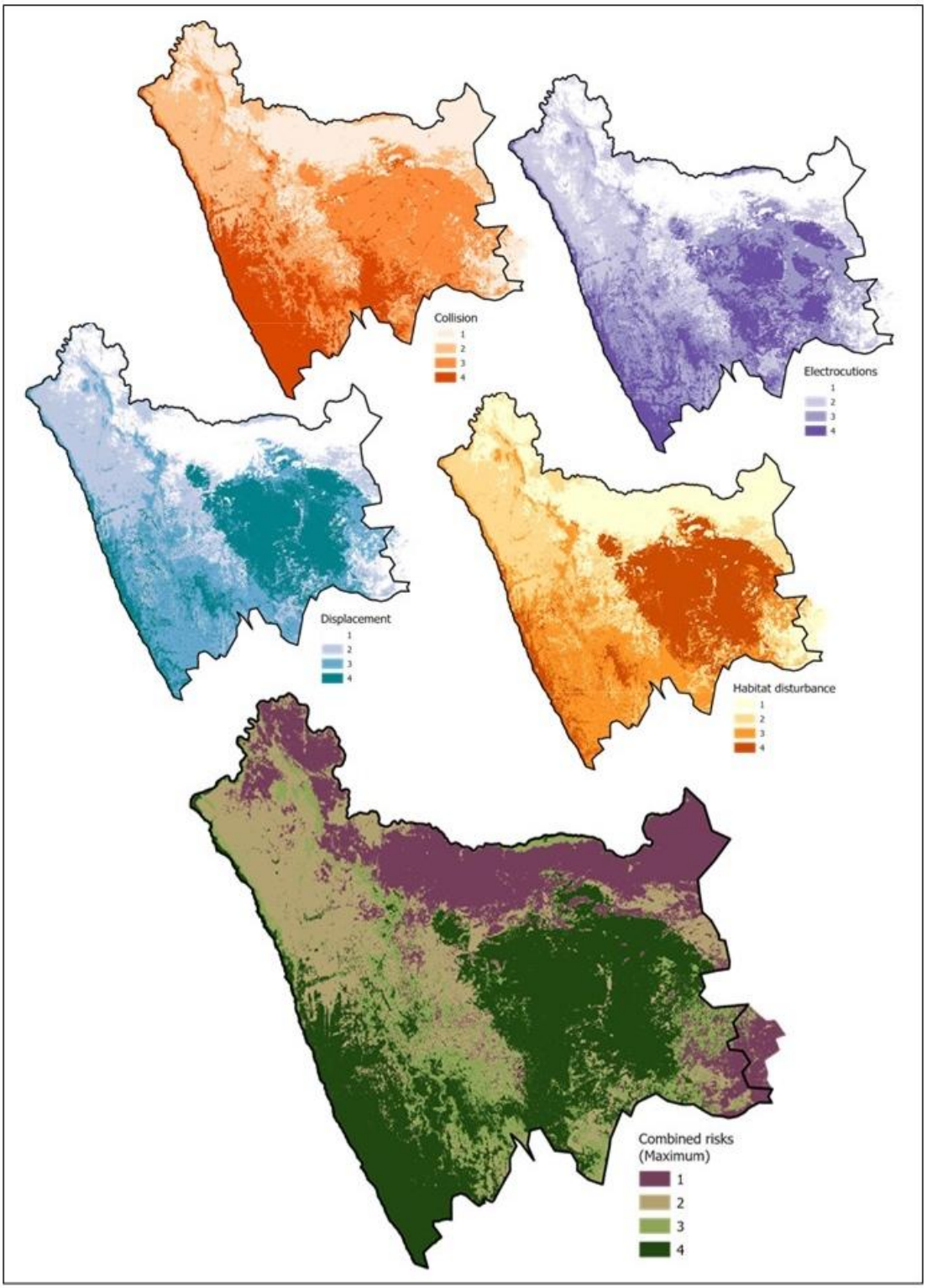


Figure 2-23: The regional bird risk (sensitivity) assessment in relation four key development impacts. The final sensitivity map combines the four individual layers with the maximum value from the four inputs becoming the final sensitivity value.

2.4.3.2 Bat Sensitivity Assessment

Werner and Welch (2026) developed a regional bat risk assessment as part of the SEA regional work package. The bat sensitivity analysis assesses the risk to bats populations to development based the relative importance of roosting, foraging, and conservation value areas (Figure 2-24):

- Very High sensitivity areas are characterised by exceptional roosting or foraging potential, very high levels of bat activity, and/or the possible presence of species of conservation concern (e.g., Vulnerable, Endangered, or Data Deficient). From a bat conservation perspective, such areas are generally unsuitable for development of GH2 and associated renewable energy because of the significant risks they pose to bat populations.

- High sensitivity areas include habitats with strong roosting or foraging potential and consistently high levels of bat activity. These areas are likely to present considerable risks to bats, and renewable energy development within them is generally discouraged.

- Medium sensitivity areas are associated with moderate roosting or foraging potential, moderate or uncertain levels of bat activity, and/or the potential presence of Near Threatened or Rare species. While development may be possible, site-specific assessments during the EIA phase of a renewable energy facility remain essential to confirm impacts and identify robust mitigation measures.

- Low sensitivity areas are characterised by limited roosting or foraging opportunities, low bat activity, and the absence of conservation-important species. These areas are considered more compatible with renewable energy development, though sensitivity mapping will still be refined at the EIA stage to confirm site-level risks.

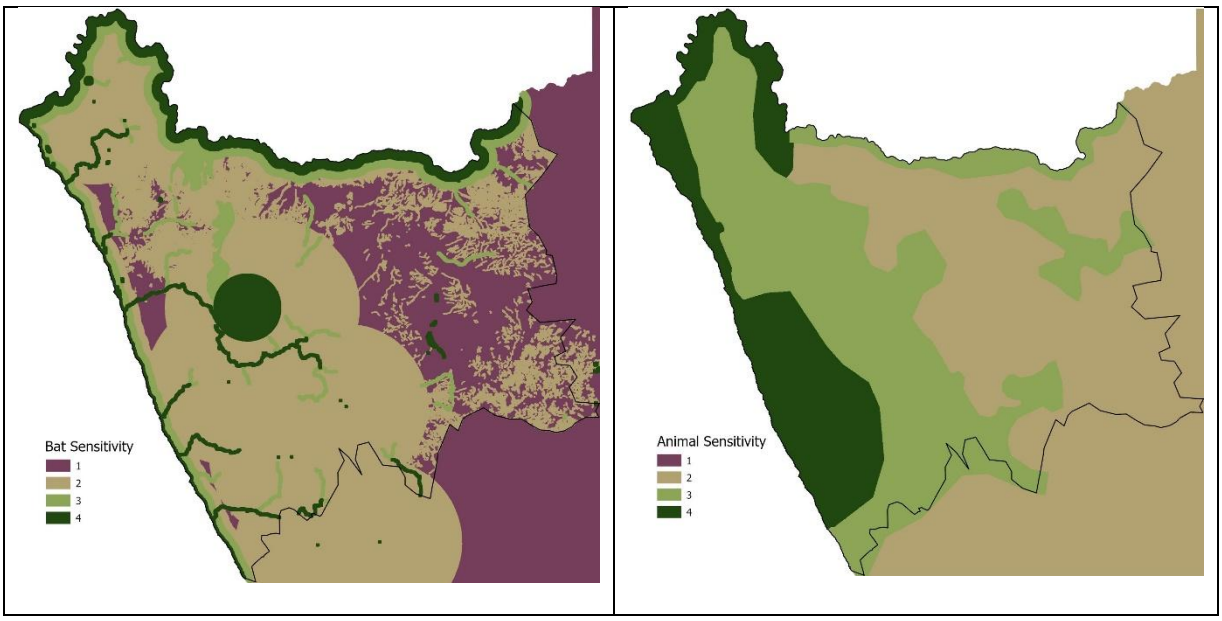


Figure 2-24: The regional sensitivity assessment for bats (left) and animals (right).

2.4.3.3 Animal Sensitivity Assessment

Niemandt (2026) developed a regional animal (fauna) risk assessment as part of the SEA regional work package. The faunal sensitivity of the Namakwa Region reflects the intersection of exceptional endemism, highly specialised habitat requirements, and intensifying development pressures characteristic of the Succulent Karoo biodiversity hotspot. The faunal sensitivity map is based on the distribution and relative importance of range-restricted, endemic, threatened, rare and habitat-dependent reptiles, amphibians, invertebrate and mammals Figure 2-24):

- **Very High Sensitivity** Areas predominately the coastal belt that coincides with the core habitat for several narrowly endemic and threatened species, particularly those associated with loose aeolian sands and fog-dependent dune ecosystems. Species include De Winton's golden mole (*Cryptochloris wintoni*, Critically Endangered), Grant's Golden Mole (*Eremitalpa granti granti*, Vulnerable), Desert rain frog (*Breviceps macrops*, Vulnerable (IUCN); Near Threatened (National)), Branch's rain frog (*Breviceps branchi*, narrow-endemic), and Namaqua dune mole-rat (*Bathyergus Janetta*, Uplisted to Endangered A4(a))

- **High Sensitivity** areas extend inland across Namaqualand Hardeveld, succulent shrublands, and rocky inselbergs, where important faunal species of conservation concern and ecological processes occur. Important species include Speckled padloper tortoise (*Chersobius signatus*, Endangered (IUCN)), Girdled lizards (*Namazonurus* and *Karusasaurus spp.*), Namaqua sand frog (*Tomopterna* branchi, Endemic). Important ecological processes underpinning High Sensitivity include high pollinator activity in flower-rich shrublands; soil engineering by ants, termites and rodents; seasonal amphibian breeding in natural pans; and, critical refugia on koppies for reptiles and small mammals.

- **Medium Sensitivity** areas cover much of the interior plains where faunal diversity, while still significant, comprise more disturbance-tolerant assemblages. These species have broader distributions in the region and have better tolerance of moderate habitat modification. Species include arid-zone toads, widespread sand lizards and skinks, mammalian generalists such as steenbok, hares and generalist rodents, and generalist invertebrate assemblages.

- No **Low Sensitivity** areas are identified.

2.4.3.4 Aquatic Sensitivity Assessment

Day *et al.* (2026) developed a regional aquatic risk assessment as part of the SEA regional work package. The aquatic assessment comprises three separate analyses each relating to a different spatial, physical and biological aquatic receptors. Only those components of the aquatic assessment that directly relate to biodiversity sensitivity have been included in this assessment, namely, the (1) surface water and (2) inland aquatic and estuary assessments. The groundwater sensitivity assessment is not considered here as no groundwater dependent ecosystems or species are specifically identified or discussed by Day *et al.* (2026).

Surface water sensitivity has been assessed for linear and distributed criteria. Linear features subject to impacts are the drainage network (river system) and the Orange River abstraction and reticulation network. Distributed features include aridity levels and the density of farm dams, all mapped at a quaternary level. These features are classified as follows:

- Very High sensitivity areas include the Orange River and buffer area, water supply reticulation pipeline from the Orange River and desalination plants, including towns they supply, or NFEPA river systems.

- High sensitivity areas include areas with more than 50 farm dams per quaternary, areas classified as arid, but with Aridity Index less than 10, or 1:50 000 rivers layer.

- Medium sensitivity areas include areas with fewer than 50 farm dams per quaternary, Aridity Index greater than 10, but in Arid classification (Aridity Index less than 20), or river buffers.

- Low sensitivity areas include areas classified as Hyper-Arid (Aridity Index greater than 20) or no surface water supply or storage.

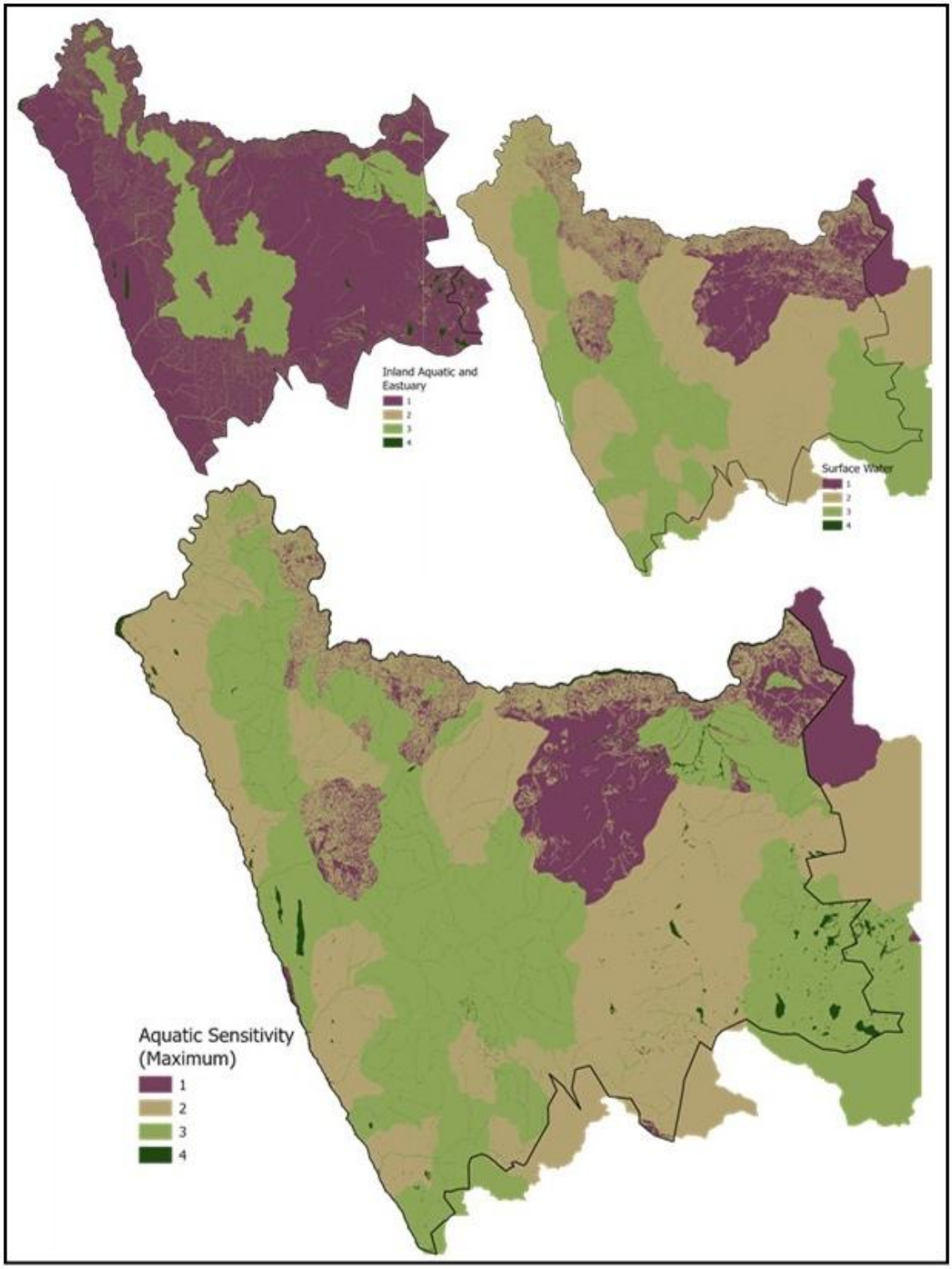


Figure 2-25: The aquatic sensitivity assessment in relation the input sensitivity assessments for surface water and inland aquatic and estuary aquatic receptors.

Aquatic ecosystem sensitivity classification considers inland aquatic and estuarine ecosystems in the context of their sensitivity in terms of (1) the capacity of an aquatic ecosystem to tolerate disturbance, and (2) the ecological importance of the impacted ecosystem.

- Very High sensitivity areas include NBA (2018) Critically Endangered (CR) and Endangered (EN) wetland types, CBA1 and CBA2 wetlands (NWM_5), NFEPA rivers, or Critically Endangered (CR) and Endangered (EN) estuaries (NWM-2).

- High sensitivity areas include all other wetlands included in the NWM 5, FEPA sub-catchments, upstream sub-catchments as identified in the NFEPA programme, all watercourses as mapped in 1:50 000 rivers layer and NFEPA river layer, artificial pans, dams, or all other estuaries (Estuary Functional Zones (EFZ)).

- Medium sensitivity areas include all watercourse buffers / development setback areas (20 m buffer round dams / artificial wetlands, 50 m buffer for 1:50 000 rivers, 50 m buffer for all wetlands, 100 m buffer for NFEPA rivers, EFZ data (NBA 2018)), or micro-outlets into the sea.

- Low sensitivity areas include all other areas not identified above, i.e. terrestrial areas outside of recommended aquatic ecosystem buffer zones.

The surface water and inland aquatic and estuary assessments were combined to create the aquatic sensitivity input with the higher sensitivity category of the two inputs (i.e. maximum of inputs) becoming the overall aquatic sensitivity value.

2.4.4 Integrating Sensitivity Informants

The six individual sensitivity maps described above (Figure 2-26) were equally weighted and combined to create a biodiversity sensitivity map for the SEA region using two integration approaches:

1 A maximum of inputs where the resultant rank is the maximum rank contained in the six inputs (Figure 2-27), and

2 Cumulation of inputs where the resultant numerical value is a binary code that reflects the combined sensitivity rank of all six inputs (Figure 2-28). For example, a combined rank code of 15 means that a site was ranked medium in one input and low in 5 inputs whereas a value of 1122 means a site was ranked very high by 1 input, high in another input, medium in 2 inputs and low in the remaining 2 inputs. The second approach of combining ranks provides a more nuanced integration of the inputs that gives greater spatial discrimination in the result.

The maximum of inputs sensitivity map (Figure 2-27) indicates that 70% of the region is ranked as very high sensitivity (Table 2-11). This is to be expected knowing that Namaqualand is a global biodiversity hotspot. Across almost the entire landscape it is expected that there will be high to very high biodiversity sensitivities in one form or the other.

In contrast the cumulated rank Figure 2-28 indicates that only 11.5% of the region is ranked very high for three or more of the inputs (Table 2-11). This indicates that there is some, but not a high degree of spatial correlation between the sensitivity inputs. In other words, areas important for plants are not necessarily also important for bats or birds. From the development perspective, this map illustrates where there might be more flexibility in the sensitivity map. For example, areas that are very high sensitivity for only one input implies that significant impacts may be lower and the required mitigation less than in an area that is very high for two or three inputs.

Table 2-11: Summary of the extent of biodiversity sensitivity categories in the SEA region. Sensitivity Rank 1 is a maximum of inputs. Sensitivity Rank 2 is a cumulation of inputs that gives an indication of how sites were ranked in the individual inputs.

RANK	% of Region	Cumulated Ranks Binary Code	Sensitivity Rank 1	% of Region	Area (ha)	Sensitivity Rank2	% of Region	Area (ha)
1	3.97	15, 24, 33, 42, 51, 60	Moderate	3.97	228 632	Low - Moderate	3.97	228 632
2	7.88	105, 114, 123, 132, 141, 150	High	26.19	1 508 282	Moderate - High	16.51	950 811
3	8.63	204, 213, 222, 231, 240						
4	5.44	303, 312, 321, 330				High	9.68	557 471
5	4.24	402, 411, 420, 501, 510, 600						
6	11.84	1014, 1023, 1032, 1041, 1050	Very High	69.85	4 022 084	High - Very High	58.33	3 359 224
7	27.95	1104, 1113, 1122, 1131, 1140, 1203, 1212, 1221, 1230, 1302, 1311, 1320, 1401, 1410, 1500						
8	18.54	2004, 2013, 2022, 2031, 2040, 2103, 2112, 2121, 2130, 2202, 2211, 2220, 2301, 2310, 2400						
9	8.95	3003, 3012, 3021, 3030, 3102, 3111, 3120, 3201, 3210, 3300				Very High	11.51	662 860
10	2.56	4002, 4011, 4020, 4101, 4110, 4200, 5001, 5010, 5100, 6000						
SEA Total Area (ha)				**100**	**5 758 998**		**100**	**5 758 998**

The sensitivity analysis is a pragmatic approach to combining a diverse array of datasets into a single map that gives insights on the relative sensitivity of areas in the SEA landscape. It must be remembered that it is a qualitative analysis that relies strongly on the opinion of the experts involved, the datasets available and how these are interpreted relative to the impacts envisaged. Whilst there is always room for improving input datasets (see recommendations) the current analysis is an integration of the best available information that is a "reasonably accurately" reflection of the major biodiversity sensitivities in the landscape.

Changing the assumptions behind the assessment could change or refine the spatial outcomes. This same analysis conducted for PV-only would provide a significantly different result due to the impacts of WEFs specifically on flying animals. Also, weighting sensitivities based on spatial flexibility in the underlying biodiversity feature (e.g. feature range of 10ha vs 100 000ha) or ability to mitigate risk (e.g. outright habitat loss vs degradation of habitat) would provide further insights on the spatial distribution of sensitivities. The current analysis does provide a good regional perspective on the spatial distribution of biodiversity sensitivities and where may be appropriate for large-scale RE developments. Further analysis will provide greater detail or resolution in parts of the map, but it is unlikely to change the broad spatial trends presented here.

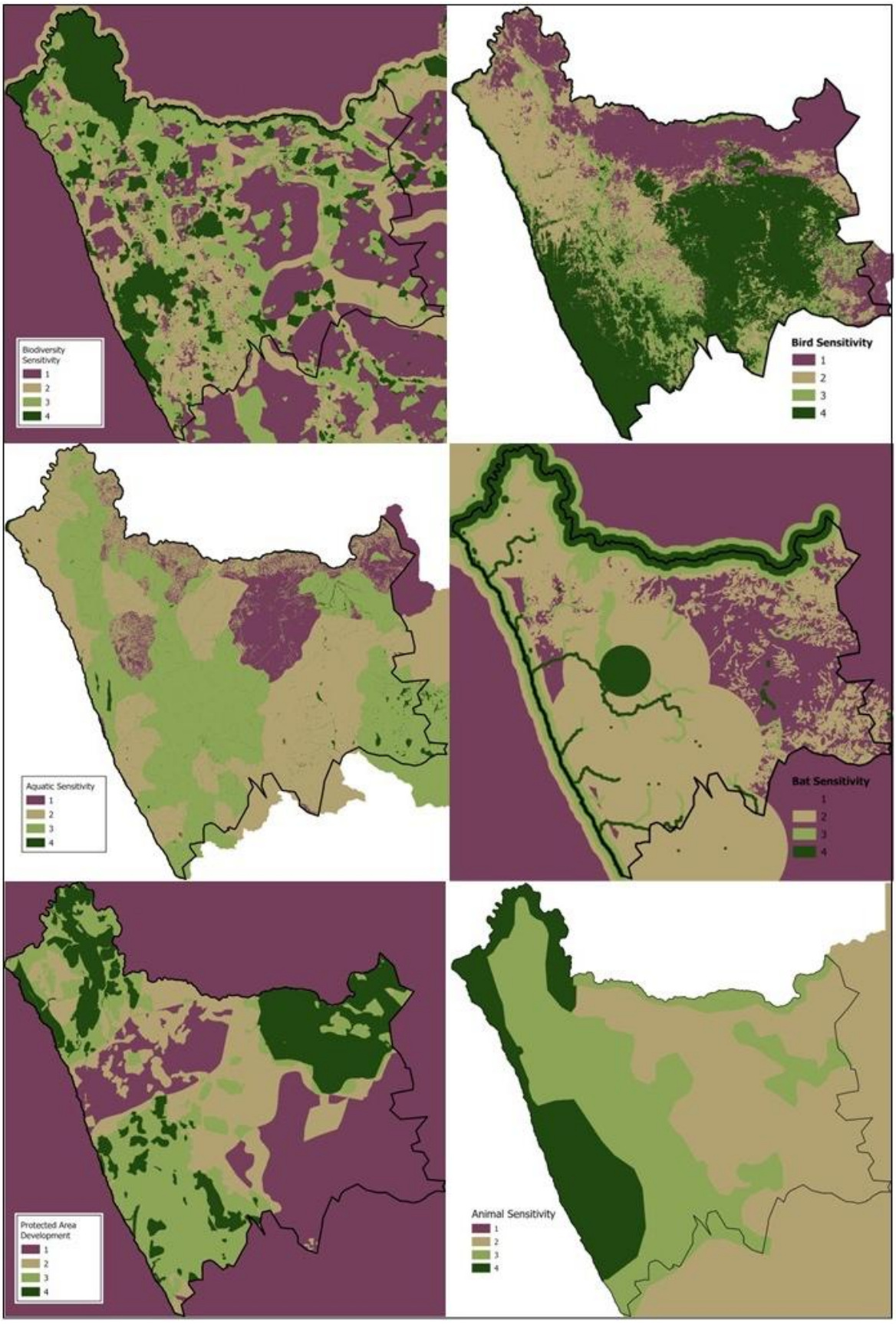


Figure 2-26: The six individual biodiversity sensitivity assessment inputs to the regional biodiversity sensitivity analysis.

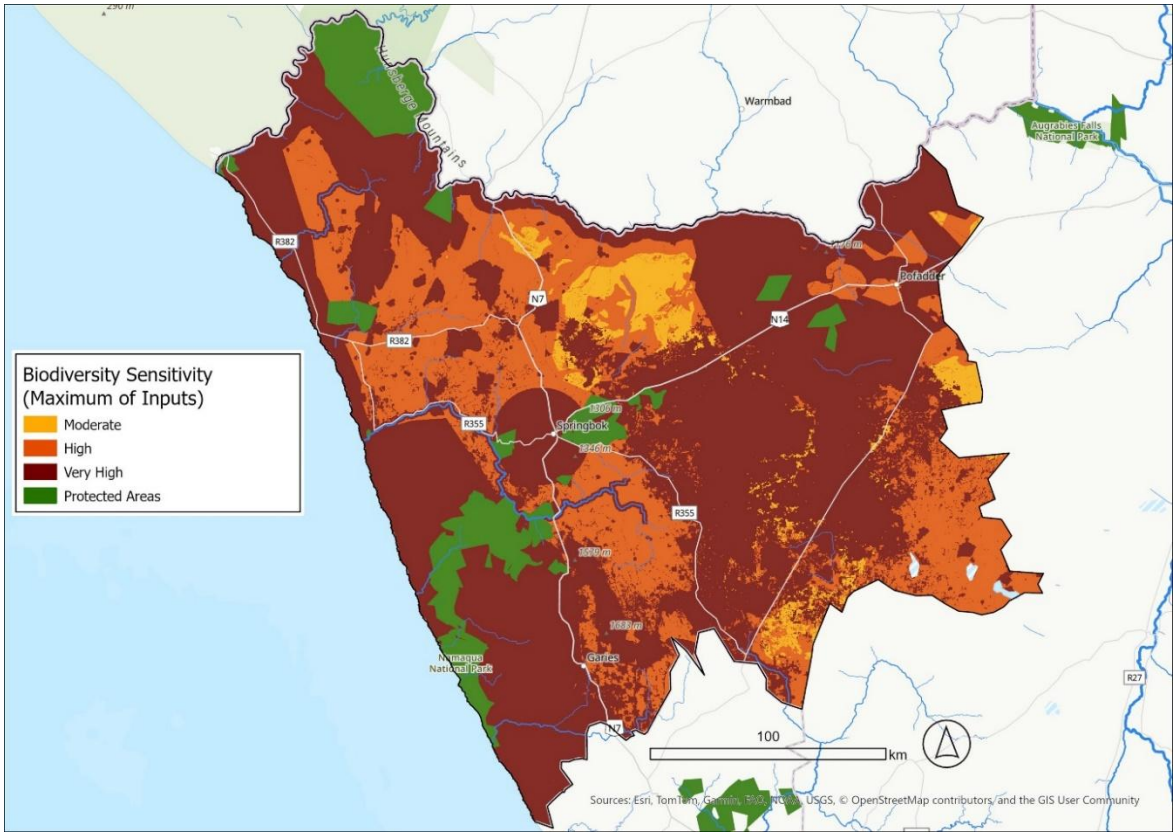


Figure 2-27: Biodiversity sensitivity rank for the SEA region based on the maximum of inputs.

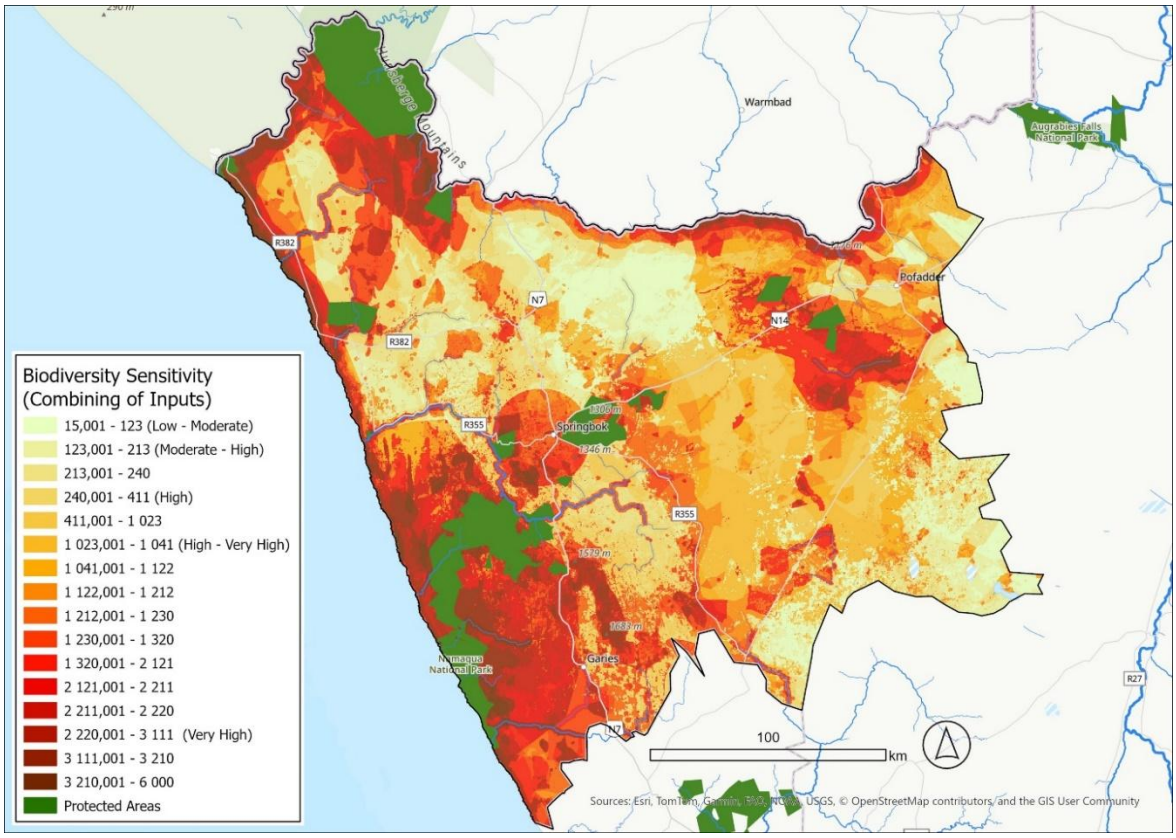


Figure 2-28: Biodiversity sensitivity rank for the SEA region based on the cumulation of inputs.

2.5 RISK ASSESSMENT

2.5.1 Definition of Consequence / Benefit Categories.

For biodiversity and ecological impacts (Table 2-12), risk is measured in terms of disruption of ecological processes, loss or degradation of ecosystems, and/or loss of species. The degree of risk (consequence) is assessed against thresholds for maintaining the functioning of all key ecological processes, maintaining a proportion of each ecosystem in good ecological condition, retaining all threatened species, and retaining a representative sample of all endemic or near-endemic species.

Whilst the regional assessment is aware of the total expected development footprint, there is no detail as to the location of the various development components under each scenario. So rather than attempting to articulate consequence in relation to the entire development scenario, it is considered at the site level in terms of what would the consequence be from a single development perspective. Therefore, thresholds of change are interpreted relative to a site and the consequence that the spatial scale of site-level impact would have on biodiversity in the landscape surrounding the site.

2.5.2 Description of Potential Impacts

Impacts of GH2 development at the regional scale are grouped into two high-level categories:

- Biodiversity pattern impacts. The immediate and direct loss of biodiversity due to the loss of habitat or species populations during the construction phase (e.g., land clearing) or operational phase (e.g., mortality of individuals). Primarily relevant in sensitivity categories 3 and 4.

- Ecological process impacts: The gradual and indirect loss of biodiversity due to the loss, disruption or degradation of ecological processes necessary for supporting species populations (e.g., construction of barriers to species movement, degradation of habitat due to light or noise pollution. Primarily relevant in sensitivity category 2.

2.5.3 Mitigation

There are a host of potential development- or site-specific mitigation actions. Some are discussed in relation to specific receptors in the species specialist regional reports. For the regional biodiversity assessment only high-level mitigation measures are considered in relation to the two high-level impacts considered. Mitigation measures include:

- Biodiversity pattern impacts:
    - Avoidance of development in sensitive landscapes (categories 2-4).
    - Where avoidance is not possible then safeguard regional biodiversity using biodiversity offsets to increase the extent of impacted ecosystems within formal protected areas.
- Ecological process impacts:
    - Avoidance of development in sensitive landscapes (categories 2-4).
    - Development type, site, ecosystem or species-specific mitigation measures to reduce disturbance, prevent imposition of impermeable barriers to movement and eliminate incidental death of individuals.

2.5.4 Risk Assessment Table

Given the spatial scale of both scenarios there is no difference in the assessed consequence and likelihood between with and without mitigation (Table 2-13). Whilst biodiversity offsets do guarantee that a portion of the biodiversity being lost is placed into formal protection, this does not negate the fact that a

significant amount of biodiversity has been permanently lost. The only difference between with and without mitigation comes in the interpretation of the significance of this loss in relation to biodiversity sensitivity categories and their contribution to achieving our biodiversity conservation goals. Areas that that have been identified as being necessary to achieve our conservation goals for biodiversity pattern or ecological processes attract a higher risk rating.

A key aspect of the risk interpretation is the consideration of avoidance. As there is not guarantee that areas will be avoided the consequence and risk assessment is only considering mitigation without avoidance.

Table 2-12: Description of negative consequences as defined for biodiversity based on expert judgement. Consequence categories as per CSIR (2024) requirements.

Negative consequence	Impacts	
	Biodiversity pattern impacts	Ecological process impacts
Slight	• Loss of habitat over a contiguous area of <3ha • <20% reduction in the SEA regional extent of a SCC OR no reduction in size of the meta-populations (i.e., 0 out of 10 populations lost)	No disruption of ecological processes (<20%) • Longest dimension of cleared habitat: <300m • Length of impermeable barriers to species movement: <300m • Longest dimension of high-risk barriers to species movement: 0km • Length of boundary generating ecosystem degrading processes: <1km
Moderate	• Loss of habitat over a contiguous area of 3-10ha • 20-30% reduction in the SEA regional extent of a SCC OR reduction of no more than 10% in size of the meta-population (i.e., 1 out of 10 populations lost)	Some disruption of ecological processes (20-40% • Longest dimension of cleared habitat: 300-500m • Length of impermeable barriers to species movement: 300m-1km • Longest dimension of high-risk barriers to species movement: <300m • Length of boundary generating ecosystem degrading processes: 1-3km
Significant	• Loss of habitat over a contiguous area of 10-100 ha • 30-50% reduction in the SEA regional extent of a SCC OR reduction of no more than 30% in size of the meta-population (i.e., 3 out of 10 populations lost)	Significant disruption of ecological processes (40-60%) • Longest dimension of cleared habitat: 500m-750m • Length of impermeable barriers to species movement: 1-2.5km • Longest dimension of high-risk barriers to species movement: 300m-1km • Length of boundary generating ecosystem degrading processes: 3-5km
Drastic	• Loss of habitat over a contiguous area of 100-1000 ha • 50-80% reduction in the SEA regional extent of a SCC OR reduction of more than 50% in size of the meta-population (i.e., 5 out of 10 populations lost)	Very significant disruption of ecological processes (60-80%) • Longest dimension of cleared habitat: 750m-1km • Length of impermeable barriers to species movement: 2.5-5km • Longest dimension of high-risk barriers to species movement: 1-5km • Length of boundary generating ecosystem degrading processes: 5-10km
Extreme	• Loss of habitat over a contiguous area of 1000 ha or more • >80% reduction in the SEA regional extent of a SCC OR reduction of more than 80% in number of meta-populations (i.e., 8 out of 10 populations lost)	Highly significant disruption of ecological processes (>80%) • Longest dimension of cleared habitat: >1km • Length of impermeable barriers to species movement: >5km • Longest dimension of high-risk barriers to species movement: >5km • Length of boundary generating ecosystem degrading processes: >10km

Table 2-13: Assessment of risks associated with the negative impacts of GH2 on biodiversity. Risk with mitigation is assumed to be mitigation without avoidance.

Negative Impact	Scenario	Spatial receiving environment (Biodiversity sensitivity category)	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Biodiversity pattern impacts	S0: Baseline	4 Very High	Moderate	More Likely	MODERATE	Moderate	More Likely	MODERATE
	S1: Small GH_2		Drastic	Definite	VERY HIGH	Drastic	Definite	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	3 High	Moderate	More Likely	MODERATE	Moderate	More Likely	MODERATE
	S1: Small GH_2		Drastic	Definite	VERY HIGH	Drastic	Definite	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	2 Medium	Moderate	More Likely	MODERATE	Moderate	More Likely	LOW
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	1 Low	Moderate	More Likely	MODERATE	Moderate	More Likely	LOW
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	MODERATE

Negative Impact	Scenario	Spatial receiving environment (Biodiversity sensitivity category)	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Ecological process impacts	S0: Baseline	4 Very High	Moderate	More Likely	MODERATE	Moderate	More Likely	MODERATE
	S1: Small GH_2		Drastic	Definite	VERY HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	3 High	Moderate	More Likely	MODERATE	Moderate	More Likely	MODERATE
	S1: Small GH_2		Drastic	Definite	VERY HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	2 Medium	Moderate	More Likely	MODERATE	Moderate	More Likely	LOW
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	MODERATE
	S0: Baseline	1 Low	Moderate	More Likely	MODERATE	Moderate	More Likely	LOW
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	Definite	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	MODERATE

2.6 RECOMMENDATIONS FOR BEST-PRACTICE MANAGEMENT

2.6.1 General Guidelines

There is a wealth of information in South Africa dealing with best practice management guidelines for various types of land use and development that are the logical starting point for determining best practice guidelines for RE development. The most important guidelines are bioregional plans and the land use guidelines therein that relate to the various CBA map categories and the land use activities permissible in each map category. These guidelines are high-level guidelines that do not necessarily contain the level of detail necessary to fully mitigate impacts related to a specific development type (e.g. solar or wind energy facilities or powerlines) or impacts affecting specific taxa or ecosystems. The Namakwa District Biodiversity Sector Plan (Marsh et al. 2009) is the only bioregional plan with detailed land use guidelines covering the SEA regional area. In addition to covering terrestrial ecosystems, this document also has detailed management guidelines for aquatic ecosystems.

Further afield, related documents such as ecosystem guidelines and land use planning handbooks do contain more detailed information of best practices covering a variety of land use activities. These include:

- Ecosystem guidelines for the savanna biome (SANBI 2021), Western Cape including fynbos and succulent karoo biomes (Fynbos Forum 2016, Pool-Stanvliet et al. 2017) and grassland biome (SANBI 2013). These guidelines documents cover both terrestrial and aquatic ecosystems in these biomes.

- There is no succulent or nama karoo-specific ecosystem guidelines other than what is contained in the Western Cape guidelines, however, Todd et al. (2009) and Wilderness Foundation (2018) cover rangeland management best practice. Whilst these deal with livestock farming and veld management and are not directly applicable to renewable energy, as discussed below, these guidelines are directly relevant to the indirect impacts of renewable energy facilities.

- Wetland and aquatic ecosystem-specific guidelines are covered in the biome guideline document as well as some detailed wetland guideline documents (Edwards et al. 2018 and Lloyd et al. 2025). All these guidelines have a focus on more mesic ecosystems and the absence of a detailed guideline document dealing with aquatic ecosystems in the arid zone is perhaps a gap in the South African ecosystem guideline literature.

- Currently, there are no handbooks or guides tailored specifically to terrestrial ecosystems in the context of renewable energy development. Most impacts associated with renewable energy projects—such as linear infrastructure, powerlines, and land clearing—are comprehensively addressed in existing guidelines listed above. Nevertheless, because wind energy facilities uniquely affect flying animals, South Africa has developed several best practice guidelines focused on specific animal groups, namely birds (Jenkins et al. 2015; Simmons et al. 2020; Pfeiffer and Ralston-Paton 2018) and bats (MacEwan et al. 2020a; MacEwan et al. 2020b).

- The IUCN guidelines dealing with mitigation of environmental impact assessment associated with renewable energy projects (Bennun et al. 2021, Bennun *et al.* 2024, Jobson et al. 2024) provide valuable international perspectives and best practices that should be applied locally in relation to the development of RE in South Africa.

2.6.2 Development Specific Guidelines

Best practice guidelines can be grouped according to three categories of mitigation interventions: avoid impacts, reduce impacts (avoid degradation) and restore ecosystems.

2.6.2.1 Avoid sensitive habitat

All WP2 regional ecological studies highlight avoiding high sensitivity landscapes or habitats at the project planning phase as being the most important mitigation action. Renewable projects need to consider the

wealth of spatial biodiversity data more rigorously at the project inception phase to avoid known sensitivities before the EIA stage.

The sensitivity analysis conducted here compliments CBA maps in that it considers information that is not necessarily used to inform CBA maps. They should therefore be used in conjunction to inform planning. There are, however, some important knowledge gaps relating to ecological corridors and migratory pathways that needs to be addressed to improve the sensitivity analysis.

Regional sensitivity mapping can be complimented at the site planning scale by detailed ecological mapping of proposed development sites before infrastructure planning has commences. This can significantly reduce project implementation time and expense by avoiding biodiversity constraints and high environmental risk area *a-priori*. Ecological mapping that "fine-scales" the region planning informants to site-level can identifying sensitive areas, no-go areas and ecological buffers or setbacks at a spatial resolution that is relevant to development planning thus providing a least-cost or environmental constraint temple that can be used by developers to design projects.

2.6.2.2 Minimise impacts on site and reduce degradation of the surrounding landscape

There is a wealth of best practice recommendations discussed in the documents listed above as well as the WP2 ecological report that detail technical standards for the design and operation of renewable energy facility aimed at reducing the impact of the activity both on site as well as impact propagation into the surrounding landscape. These include:

- The placement of sites in the landscape (i.e. avoid sensitive areas)
- General site design considerations to reduce attracting species to sites (e.g. minimise the creation of roosting and foraging habitat)
- General site design innovations to reduce physical footprint (e.g. raised PV installations to avoid/reduce clearing of PV sites).
- Reduce degrading surrounding landscape (e.g. reduce noise, eliminate fugitive light, control alien invasive species, etc.).
- Design specifications for individual infrastructure components to reduce or deter animal interaction (e.g. powerline visibility, pylon bird perches and insulators)
- Operational management to avoid operation during peak animal activity periods (e.g. diurnal cycles and seasonal migration).

Currently, best practice information is spread across multiple information sources. It is advisable that a comprehensive set of renewable energy guidelines be developed in South Africa to integrate available recommendations into a single document to support developers to minimise and mitigate their impacts. Having a single national standard will improve implementation success by containing key information in a single source and improve biodiversity outcomes as all operators would be working towards a common set of outcomes

2.6.2.3 Improve the ecological condition of ecosystems

Improving habitat quality and reducing ecological fragmentation of natural habitat surrounding developed areas is identified as one of the best mitigation measures available to help species buffer the loss of habitat and species mortality due to RE development. This includes the design and creation of corridors and core biodiversity areas (viz. protected areas), active restoration of degraded areas, and working with landowners to improve the ecological condition of their veld. Investing in improving habitat quality

increases forage availability and quality for impacted species and improves ecological connectedness by maintaining high quality habitat for species movement.

Since livestock grazing is the most widespread land use activity that directly determines the health of ecosystems across almost the entire SEA area, working with this industry to improve livestock management for improved ecosystem health outcomes could be an effective mechanism to mitigate the ecosystem-level impacts of GH2.

For example, Todd et al. 2009 identify that removal of livestock from veld during drought periods is critical for maintaining rangeland condition through drought cycles. Current drought relief programs that enable livestock to remain on the veld through droughts via means of supplemental feeding is possibly the single most detrimental intervention farmers or the state can make. This intervention supports farmers in the short term to maintain herd size but in the medium to long term this leads to degradation of ecosystems in Namaqualand (Samuels et al. 2007, Todd et al. 2009, Letsoalo et al. 2025). As the impacts of GH2 will be at the whole ecosystem level, there is an opportunity for GH2 and agriculture to create a partnership to support local farmers through providing innovative solutions to circumvent the drought degradation trap. Incentives or mechanisms that support farmers to improve ecosystem condition within GH2 impact areas could also be viewed as an OECM and linked a wider biodiversity offset scheme through, for example, a biodiversity stewardship program.

2.7 RECOMMENDED STRATEGIC MANAGEMENT ACTIONS

2.7.1 Invest in the biodiversity knowledge base.

There is always a need for more foundation biodiversity distribution data to inform spatial planning, biodiversity management and development planning and management. The accuracy and detail of the sensitivity analyses is directly related to the quality of biodiversity data available. It is essential that biodiversity distribution data collected though EIAs and RE monitoring programs be captured and integrated with national datasets. Improved foundational datasets on the occurrence and distribution of species that is then used to improve sensitivity maps and CBA maps. This data can also be used to quantify ecological buffers around RE sites and during the operational phase of developments this data feeds into the adaptative management strategy of operations to identify, manage and mitigate environmental risks and impacts.

An urgent data collection / research question is the identification and mapping of migratory routes and roosts for cave dwelling bats and birds. This is a research priority. As part of the mitigation measures linked to GH2, it is recommended to initiate a dedicated region-wide biodiversity inventory and research program that can address this question as well as other knowledge gaps related to the impact and mitigation of GH2 in the region.

Monitoring of the impacts RE is essential. It is critical that observed impacts, particularly, mortality due to WEFs be related to species populations status and trends. Mortality rates must be used to inform population viability models for species of conservation concern for all regions in South Africa where WEFs operate to determine thresholds of potential concern (TCPs) for species. TCPs define species-, site- or region-specific trigger levels (e.g. population size, collision risk rates, displacement indices, breeding success, fatality thresholds) that mandate corrective/ adaptive management actions during construction and operations (Kellerman et al. 2026). More importantly, TCPs should be used to scientifically determine the maximum allowable WEF density or development cap per region so as not to reach the set TCPs. This should be conducted as a matter of urgency considering the rate and extent of WEF development in South Africa.

Monitoring data, especially mortality monitoring reports, from operational WEFs must be shared with DFFE and be made publicly available. Only if this data is made publicly available can it be rigorously used to improve mitigation measures at WEFs. The current lack of publicly available monitoring data has been identified as a key knowledge gap for birds and bats informing the sensitivity analyses.

All renewable energy facilities should have mandatory monitoring plans that are publicly available and independently audited. This should be a mandatory condition for GH2 development. The requirement for mandatory monitoring programs should be included in the set of best practice guidelines along with detailed technical specifications for the design and operation of the program. Also, all individual RE facility monitoring program should be integrated in the regional research program.

2.7.2 Mandatory GH2 best practice guidelines

Set mandatory GH2 minimum standards that detail best practice guidelines for planning, designing, constructing and operating renewable energy projects (Botha 2026). These should include innovative mitigation measures to reduce clearing of land for solar (e.g. pole-mounted PV), eliminating animal mortality during operation (e.g. blade and transmission line collisions and electrocutions), maintaining landscape connectivity (e.g. maximising linear infrastructure permeability to wildlife), reduce or eliminate propagation of impacts leading to degradation of surrounding (e.g. sound and light abatement, road crossings and hard surface flood water management). Guidelines must explicitly include measures for sustainable water management. Namaqualand is an arid area, however, there is still a great diversity and abundance of aquatic ecosystems that are generally all sensitive ecosystems with high ecological importance.

The GH2 best practice guidelines should cover all aspects best practice discussed in Section 2.6, and ideally should become the **mandatory minimum standard operation procedures (SOP)** necessary for any RE project to me to qualify for an operation licence and grid access in South Africa.

2.7.3 Invest in refining spatial biodiversity planning

Spatial biodiversity planning is clearly important for supporting economic development in the region by helping development identify and avoid areas of highest sensitivity in the landscape. Investing in improving the quality of the input data (see above) will only improve the confidence with which this information can be used. Several areas where spatial planning can improve include:

Design an **ecological corridor network** for the region or "develop the detailed spatial framework for Vision 2040". This regional ecological corridor network is the basic building blocks of Vision 2040 and the biodiversity economy. This network connects all core biodiversity conservation landscapes in the Namakwa Region with one another and with those neighbouring regions such as the Knersvlakte (south), SKA (east) and Sperrgebied (north). It is imperative that the spatial framework for Vision 2040, mega-living landscapes and the landscape ecological corridor network be laid down before GH2 is implemented to avoid corridors being cut or diverted by poorly located development. This biodiversity spatial framework should be used as a baseline spatial layer informing where GH2 infrastructure can be in the landscape to aligned with the biodiversity economy aspirations of the region.

A key element currently missing from the regional ecological corridor network are the spatial requirements for migratory bats and birds, specifically migratory routes (fly ways), roosts and breeding areas. These are poorly known and are not well considered in current conservation plans. This is an urgent research priority.

The biodiversity spatial framework indicates core biodiversity protection landscapes in the region and the ecological corridor network connecting these areas. It therefore becomes an important tool informing the protected area expansion strategy and thus provides the spatial blueprint for biodiversity offset receiving areas (see Botha 2026).

Other recommended spatial planning activities include

Conduct a national scale RE SEA to determine no-go or set aside areas for RE development where RE projects cannot be proposed. A key informant will be using observed mortality rates and population viability models to determine limits on RE development to prevent loss of species populations.

Embed bat and bird sensitivity mapping information into planning tools (e.g. EMFs, SDFs, IDPs), identify no-go zones for critical habitats that can be incorporated into CBA maps, map evidence-based buffers for

critical habitats, and identify and map least cost linear-infrastructure corridors to avoid high-risk avian areas and maintain landscape connectivity.

2.7.4 Plan for the biodiversity economy

Significant environmental impact and conflict with the biodiversity economy sector can be efficiently avoided through informed spatial planning of GH2 rollout.

The Namakwa Region is part of the Succulent Karoo Biome, a global biodiversity hotspot. Therefore, there are extensive and widespread biodiversity sensitivities throughout the region that will influence where and how development should be planning in the region. The spatial analysis demonstrates that at least 70% of the landscape is considered medium to very high biodiversity sensitivity.

As a result of the regions global biodiversity hotspot status there is considerable effort going into growing the protected area network and developing the biodiversity economy. This affects as much as 70% of the region. Biodiversity conservation is an important land use and significant force for rural economic development. Therefore, new developments entering this landscape need to be sensitive to this reality. Biodiversity conservation is like mining in that it is inextricably linked to where resources are located in the landscape. These are fixed meaning that for the most part there is low spatial flexibility as to where these land uses can develop. In contrast, agriculture, human settlement and infrastructure and renewable energy are not directly linked to fixed natural resources and therefore there is a greater measure of spatial flexibility as to where these can develop in the landscape.

It is important that GH2 does not compete with the conservation sector for high biodiversity value land. Therefore, the key policy recommendation for the development of GH2 in the region is to be cognisant of the regions exceptional biodiversity, the spatial blueprint for the development of the biodiversity economy (i.e., the biodiversity spatial framework, protected areas expansion strategy, Vision 2040 and mega-living landscapes) and the spatial constrains on this blueprint imposed by the intricacies of the regions exceptional biodiversity. The sensitivity analysis has shown that at least a third of the region is considered in the lower sensitivity category leaving ample room to accommodate the stated land requirements of the GH2. It is imperative that GH2 development demonstrate spatial flexibility in where it develops to minimise biodiversity impact but more important to not to compromise the economic potential of the biodiversity economy in the region.

2.7.5 Visual impacts and protecting sense of place

It is important for the GH2 development to be aware of the physical landscape in which it is operating. Landscape "wilderness" aesthetic or sense of place is an important economic resource. The naturalness of the Namaqualand landscape and the distinct visual aesthetic is a key resource supporting the tourism industry and hence the biodiversity economy. It is important to acknowledge this and strive toward protecting this resource within the GH2 development ambitions. Where possible the GH2 should align and support that biodiversity economy ambitions, which are spatially less flexible, rather than conflicting with biodiversity economy options. To this end biodiversity sensitivity and visual aesthetic are linked and hence the recommendation for considering visual impacts.

Protected areas and the biodiversity economy in the region will continue to grow to cover at least 30% of the region by 2030. Tourism is a big part of this economic growth. Sense of place and landscape visual character are critical components of the nature experience. Renewable energy can be very destructive to visual resources. In addition to avoiding biodiversity sensitivities, it is very important to consider the visual impacts of development. Whilst visual and biodiversity impacts are not correlated, within the context of protected area development and the biodiversity economy where nature in natural landscapes is the primary economic resource, they do have an important relationship from an economic perspective.

2.7.6 Proactive mitigation and biodiversity offsets

The extent to which cumulative, indirect, or induced impacts from the entire GH2 fleet and SEZ can be attributed to any individual project remains uncertain. This complexity makes it challenging to assign offset liability and supports the recommendation that SEZ proponents should proactively address impacts on

behalf of future tenants. By investing in forward-looking offset schemes, the SEZ could facilitate smoother implementation, minimize land use conflicts, and effectively manage risks to important biodiversity sites and ecological corridors (Botha 2026). Adopting this proactive strategy toward offsets would provide greater transparency regarding offset outcomes and associated costs, thereby supporting more effective budgeting, planning, and regulatory compliance.

The offset strategy should support the biodiversity economy by using GH2 biodiversity offsets, where appropriate, to build the regions protected area network (Botha 2026).

Linked with a proactive offset strategy should be a proactive mitigation strategy. GH2 should consider establishing a mitigation fund linked to GH2 projects to fund:

1. Retro fitment of installed infrastructure such as powerlines, fences and roads to meet biodiversity and ecosystem design standards for wildlife permeability and mortality reduction, and freshwater quality.

2. Ecosystem restoration projects identified as part of a broader impacted mitigation strategy aimed at improving the general ecological condition of landscapes impacted by RE (see above).

2.7.7 Integrated GH2 mitigation and biodiversity offset strategy and implementation plan

Planning for the biodiversity economy, investing in the scientific knowledgebase, spatial biodiversity planning, protecting the sense of place, and implementation of proactive mitigation strategies and biodiversity offsets should all be developed and implemented through a singular integrated regional-scale GH2 mitigation and biodiversity offset strategy and implementation plan rather than on a project-by-project basis. This implementation plan should include:

- An implementation plan and spatial framework that supports the biodiversity conservation vision for the region. The plan should give expression to the regional protected area network (i.e. blue print for the living landscape) and be aligned with and develop upon the provincial and national protected area expansion strategy and Vision 2040.

- Provides a spatial plan that identifies potential recipients of biodiversity offsets and mitigation (i.e. ecosystem restoration areas) linked to GH2 development.

- Identifies and mandates the key role players (state, scientific community, civil society and NGO) necessary to develop and implement the plan.

- Provides a clear funding model to support the purchase and management of conservation land linked to the quantum of GH2 investment. Funding should also cover implementation of mitigation measures and funding the development of the biodiversity economy linked to this investment.

- Recognising that the protected area estate is the cornerstone of the biodiversity economy, identify practical pathways for economic beneficiation of the conservation estate. Included here is identifying the beneficiaries of the biodiversity economy components specifically linked to the GH2 investment.

- Sets clear time-bound area and funding targets to be achieved within 5-, 10-and 15-year implementation horizons that are aligned with the rate and extent of GH2 development.

- Provides for regular (3–5-year intervals) review of the implementation strategy.

- Provides for independent oversight and review of the implementation plan and outcomes.

2.7.8 Build a community of practice

Capacity and coordination: DFFE should establish a national biodiversity and renewable energy technical forum to foster scientific research and communication between stakeholders (scientists, regulator, conservation, operators, developers and landowners). In the South African experience, creating a community of practice that facilitates and promotes the interaction of role players and sharing/communicating of information is an excellent strategy for unlocking the skills and benefits of the regions limited and dispersed scientific and research resources. Examples such as the Biodiversity Planning Forum, Fynbos Forum, Arid Zone Ecology Forum, SKEP, Thicket Forum, etc. are all testament to how investing in communication can bring science, policy and implementation together to unlock tangible on the ground outcomes for biodiversity and the environment.

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2.9 Appendix 1 Summary of Datasets

Table 2-14: Summary of projects with biodiversity prioritisation datasets of relevance to the Namakwa Region.

No.	Data Name	Source	Reference	Notes
1	Namakwa District Biodiversity Sector Plan 2009	http://bgis.sanbi.org/Projects/Detail/52	Marsh *et al.*, 2009	
2	Richtersveld Municipality Biodiversity Assessment 2008	not available online	Berliner & Desmet 2008	Incorporated into NDM BSP
3	Northern Cape Critical Biodiversity Areas 2016	http://bgis.sanbi.org/Projects/Detail/203	Holness & Oosthuysen 2016	Superseded by 2024 version
	Northern Cape Critical Biodiversity Areas 2025	not available online	Oosthuysen & Geldenhuys 2025	
4	National Protected Area Expansion Strategy, NPAES 2010	http://bgis.sanbi.org/Projects/Detail/144	reference?	Superseded by NPAES 2017
5	National Protected Area Expansion Strategy, NPAES 2017	not available online	DEA 2017	
6	Northern Cape Protected Area Expansion Strategies, NC PAES	not available online	no reference	Included in NPAES 2017
7	DENC Protected Area Development Focus Areas	not available online	Desmet & Helme 2017	
8	Namakwa District Ecosystem Based Adaptation Priority Mapping (2015)	http://www.conservation.org/publications/Documents/CI-CASCADE-Namakwa-Vulnerability-Assessment. pdf	Bourne *et al.* 2015	
9	Richtersveld Important Biodiversity Areas, Pieter van Wyk, 2018	This project	This project	
10	SANBI Threated Species Program - Species point localities for threatened & rare species, 2017	not available online	Data obtained directly from SANBI in 2017	
11	Leslie Hill Succulent Karoo Trust Priorities	not available online	Desmet 2006	
12	Bushmanland Conservation Initiative	not available online		
13	WP2 Bird Assessment			
14	Key Biodiversity Areas (KBAs)			
15	Important Bird Areas (IBAs)			

2.10 Appendix 2 Biodiversity Sensitivity Analysis Technical Notes.

Biodiversity Plan Sensitivity

The biodiversity spatial planning inputs (Table 2-16) were combined into a 4-class high-low category map as follows:

1. For SANBI threatened species, re-classifying the mapped categories in the input datasets into CBA Map equivalent categories (Table 2-16).

2. Re-classify the CBA map codes into a binary code (Table 2-15).

3. Sum the binary codes for all inputs. The use here of a binary code allows for raster grids to be added using ArcGIS Map Calculator whilst retaining the underlying CBA/ESA status classification of individual input datasets.

4. Following a maximum of inputs principle, re-classify the summed binary code into a combined CBA map category. For example, after adding the binary CBA code for all input grids together, a final value of 1120 means that the site was categorised as a PA in one of the inputs datasets (1 x 1000), as a CBA1 in one dataset (1 x 100), as a CBA2 in two datasets and not identified as an ESA in any of the input datasets.

5. Re-classify the CBA map categories into 4-class high-low categories (Table 2-15).

Table 2-15: Re-classification look-up values used in the integration analysis.

Original Input Classification	Re-Classification Binary Code	4-Class Value	Class Name
Other natural area, no value	0	1	Low
ESA	1	2	Medium
CBA2	10	3	High
CBA1	100	4	Very High
PA	1000	4	Very High

Table 2-16: Summary of individual input datasets integrated in this analysis and their relevant re-classification look-up values.

No.	Name	File Name	Field Name	Re-Classification Values
1	Namakwa District Biodiversity Sector Plan 2009	NDM_biodiversity_corridor.shp NDM_expert_critical_terrestrial.shp NDM_expert_important_terrestrial.shp NDM_kloofs.shp NDM_slopes.shp NDM_vegetation_CBA.shp	Various labelled ESA_* or CBA_*	T1 or A1 = 100 T2 or A2 = 10 EAS_T = 1
2	Northern Cape Critical Biodiversity Areas 2024	Northern_Cape_CBA_Map.shp	CBA_CAT	Critical Biodiversity Area One = 100 Critical Biodiversity Area Two = 10 Ecological Support Area = 1 Other Natural Areas = 1 Protected Area = 1000
5	SANBI Threatened and Rare Species Point Localities, 2017[1]	Allthrspp_nc_feb2017 and NC_TOCC_feb2017	VALUE	CR, EN & Cr Rare Sp. = 100 VU & Rare = 10

Notes:
1: SANBI TSP data – selected only species with locality accuracy of 5000 or less.; Buffered points by 250m

Protected Area Expansion Sensitivity

The protected area expansion and development inputs datasets were combined into a 4-class high-low category map as follows:

1 All areas earmarked by each input in Table 2-8 were classified as 1, i.e. area earmarked by a protected area expansion or development plan.

2 The six input layers were then added together resulting in values ranging from 0 (not earmarked by any input) through to a maximum of 6 (area earmarked by all six inputs).

3 This combined layer was then reclassified into a 4-class high-low classification scale as follows (Figure 2-21):

Input Value (Number of overlapping plans)	4-Class Value	Class Name	Interpretation
0	1	Low	No plan has earmarked this area for PA expansion of development
1	2	Medium	
2	3	High	
>=3	4	Very high	3 or more plans have earmarked this area for PA expansion or development

2.11 Appendix 3 Succulent Karoo Expert Areas Dataset

Expert mapped important areas for biodiversity in the Succulent Karoo (Figure 2-18) is an important biodiversity database that captures knowledge on the distribution of biodiversity from relevant plant experts. In the absence of detailed species distribution datasets or models, the expert mapped areas have historically been a key informant of biodiversity plans and protected areas expansion strategies. This map was first developed by Desmet (2006) in response to the lack of species-level spatial information available for conservation planning and was updated in 2012, 2019 and again as part of this project with data for the Richtersveld from Pieter van Wyk as part of WP1 (Figure 2-18).

Expert mapped areas are, in the opinion of the individual expert interviewed, important areas for the representation and conservation of biodiversity in the Succulent Karoo based on the presence of endemic/rare/threatened plant species and/or unique/rare habitats or species assemblages. The purpose of the dataset is to distil the wealth of expert field-based knowledge on the patterns and distribution of biodiversity in the Succulent Karoo into a spatial dataset that can inform conservation planning, specifically the activities of the WWF-managed Leslie Hill Succulent Trust (LHSKT). In total 23 plant biodiversity experts have contributed to the Succulent Karoo Expert Areas Database since inception with a total of 174 unique areas being mapped covering 1 721 949ha or 17% of the Succulent Karoo biome.

Table 2-17: The list of plant biodiversity experts who have contributed to the Succulent Karoo expert mapped areas database.

Expert Name	Year				Total
	2007	2012	2019	2025	
Adam Harrower	10	4			14
Andrew Young		17			17
Chris Rodgerson	10	10			20
Dee Snijman, John Manning & Peter Goldblatt	11				11
Derek Tribble		18			18
Desmet & Helme		16	1		17
Ernst van Jaarsveld	8				8
Florent Grenier			1		1
Graham Williamson	21				21
Helga van der Merwe & Enrico Oosthuysen			1		1
Jan Vlok	15	3			18
John Lavranos	10				10
Matthew Opel		4			4
Norbert Kleinmichel	10				10
Peter Bruyns	18	2			20
Philip Desmet	70				70
Pieter van Wyk			1	47	48
Steven Hammer	22	13			35
Terry Smale	12				12
Tom Jacobs	21				21
Grand Total	**238**	**87**	**3**	**47**	**376**

CHAPTER 2a

Avifauna

CHAPTER 2a: Avifauna

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Executive Summary

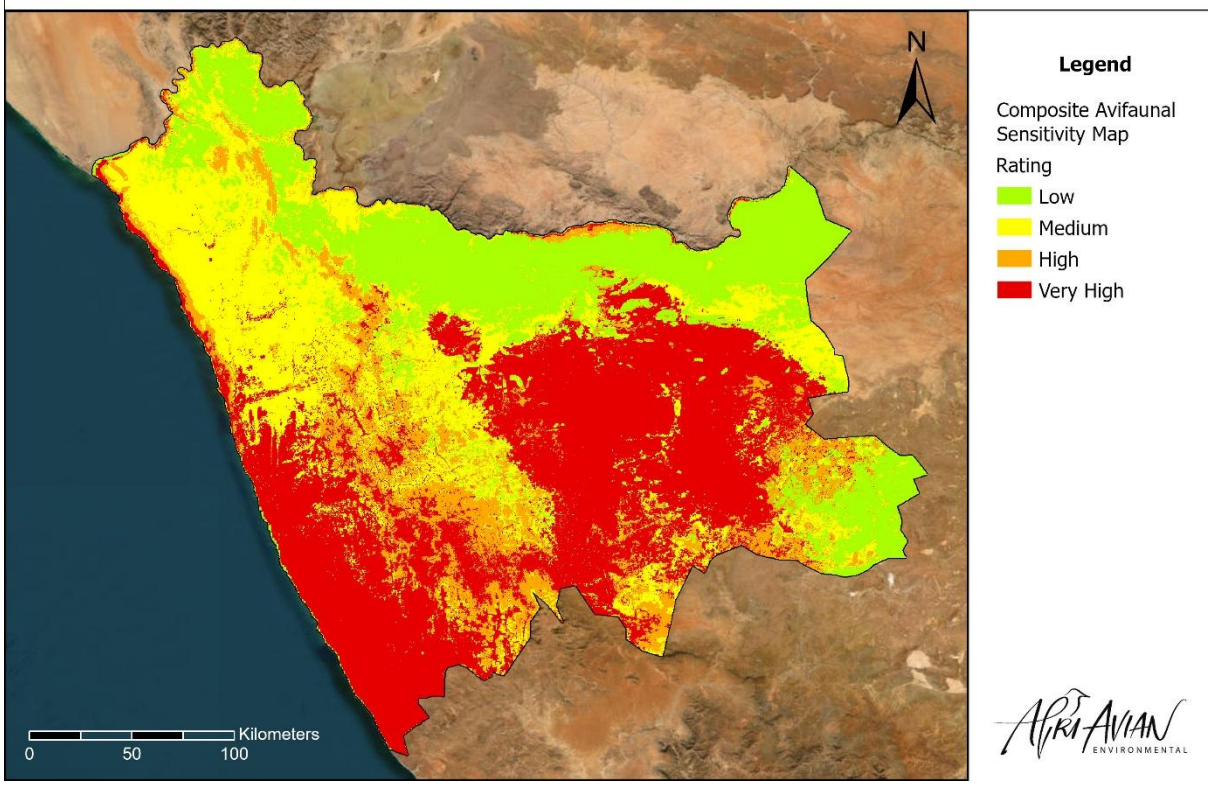
This Avifaunal Specialist Assessment forms part of the Strategic Environmental Assessment (SEA) for the proposed Boegoebaai Port, Special Economic Zone (SEZ), and associated Green Hydrogen (GH_2) developments in the Northern Cape Province of South Africa. Work Package 2 (WP2) evaluates potential impacts on avifauna across the Namakwa Region, covering the Richtersveld, Nama Khoi, Kamiesberg, and Khai-Ma local municipalities, under three development scenarios:

- **Scenario 0:** Dynamic Baseline (no GH_2 development, 2023–2050)
- **Scenario 1:** "Small GH_2" (5 GW electrolyser, 0.5 Mtpa GH_2 by 2030)
- **Scenario 2:** "Big GH_2" (40 GW electrolyser, 4 Mtpa GH_2 by 2050)

The study integrates multi-year bird atlas data, species distribution modelling, habitat mapping, and a weighted risk assessment for 44 priority avifaunal species—comprising threatened, endemic, and range-restricted bird species.

The Namakwa Region lies largely within the Succulent Karoo Biodiversity Hotspot, hosting 15 Key Biodiversity Areas (KBAs) and several protected areas. Habitats range from coastal duneveld and estuarine wetlands to arid shrublands and mountain scrub, supporting species of global and national conservation concern such as Black Harrier (EN), Ludwig's Bustard (EN), Martial Eagle (EN), and Red Lark (VU, endemic). The DFFE Screening Tool classifies much of the region as of Very High avian sensitivity, particularly for wind-related impacts. The figure below shows avifaunal sensitivity of the Namakwa Region as it relates to impacts posed by renewable energy-related, including linear infrastructure in support of the various GH_2 development scenarios.

Composite Avifaunal Sensitivity Map of the Namakwa Region



Interpretation of the Avifaunal Sensitivity Maps:

Five avifaunal sensitivity maps were produced to reflect the relative ecological sensitivity of the landscape to these potential impact pathways. Each map is derived from species distribution models weighted by species-specific vulnerability scores (threat status, range size, endemism, and susceptibility to each impact type). These maps represent potential risk or relative sensitivity to renewable energy–related infrastructure rather than fixed exclusion or "no-go" zones. They are intended as a strategic-level planning tool to guide early screening, highlight areas warranting increased caution and preconstruction monitoring, and inform project-level environmental impact assessments (EIAs). Final delineation of any formal avoidance or exclusion areas must occur during site-specific EIAs, informed by local surveys and observer effort.

Key impact pathways relating to priority avifauna include:

- **Displacement due to Disturbance** – Noise, lighting, and human activity during construction and operation.
- **Habitat Loss / Fragmentation / Transformation** – Port, SEZ, renewable energy and linear infrastructure footprints.
- **Collisions** – Wind turbines, powerlines, masts, and other tall structures.
- **Electrocutions** – Transmission and distribution infrastructure, particularly affecting large raptors and vultures.

Key findings concluded from this avifaunal risk assessment are:

- **Without mitigation**, both GH_2 development scenarios present **High to Very High** risks to priority avifaunal species, especially in areas of **Very High Sensitivity**.
- **Scenario 2 ("Big GH_2")** carries the greatest cumulative risk, with potentially severe to extreme consequences for Endangered and Critically Endangered bird species.
- **With implementation of best-practice mitigation**, risks can be reduced to **Moderate–High**, but residual impacts remain considerable in sensitive habitats.

Even the baseline scenario reflects ongoing pressures as a result of climate change, mining, agriculture, and existing renewable energy expansion.

In conclusion, the Namakwa Region's exceptional avifaunal diversity faces substantial risk from large scale GH_2 and associated infrastructure development given the scale of the proposed infrastructure required. Strategic avoidance of high and very high sensitivity areas, rigorous application of the mitigation hierarchy, and the implementation of robust monitoring frameworks are essential to balance renewable energy ambitions, associated with the GH_2 development proposal for the Boegoebaai Port and SEZ, with biodiversity conservation in the broader Namakwa Region. The SEA and this avifaunal risk assessment therefore provide a defensible, spatially explicit framework to guide sustainable regional planning for development and safeguarding irreplaceable bird populations.

Key recommended strategic management actions resulting from this avifaunal risk assessment include:

1. Spatial Planning & Sensitivity Controls

Embed avifaunal sensitivity mapping into planning tools (such as EMFs, SDFs, IDPs), designate no-go zones for critical habitats, apply science-based buffers, align infrastructure to avoid very high and high-risk areas, and cap cumulative development in sensitive landscapes.

2. Technology-Specific Standards

Adopt bird-safe design and operational mitigation measures for wind and solar infrastructure, powerlines, masts, and port/desalination facilities to ensure minimising collision, electrocution, and disturbance risks through appropriate siting, engineering, and seasonal restrictions.

3. Monitoring & Adaptive Management

Use standardised pre- and post-construction monitoring protocols with GenEst[1], set Thresholds of Potential Concern (TPCs), link results to Potential Biological Removal (PBR) rates and Population Viability Analysis (PVA), and trigger adaptive measures when thresholds are exceeded.

4. Governance & Data Management

Mandate avifaunal standards and independent oversight in approvals, require cumulative impact reviews, ensure open data sharing, and establish a regional technical forum for coordinated decision-making.

5. Incentives & Financing

Fast-track low-risk, high-standard projects and fund biodiversity actions such as retrofitting hazardous infrastructure and securing key buffer habitats through a dedicated conservation fund.

[1] A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (https://www.usgs.gov/software/genest-a-generalized-estimator-mortality).

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Abbreviations

BGIS	Biodiversity Geographic Information System
BLSA	BirdLife South Africa
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
CWAC	Coordinated Waterbird Counts
DFFE	Department of Forestry, Fisheries and the Environment
E	Endemic
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EMPr	Environmental Management Programme
EN	Endangered
EWT	Endangered Wildlife Trust
GenEst	Generalized Estimator of Mortality
GH_2	Green Hydrogen
GPS	Global Positioning System
GW	Gigawatt
IBA	Important Bird Area
IDP	Integrated Development Plan
IUCN	International Union for the Conservation of Nature
KBA	Key Biodiversity Area
kV	Kilovolt
LC	Least Concern
Mtpa	Million Tonnes Per Annum
MW	Megawatt
NA	Not Endemic
NCEDA	Northern Cape Economic Development Trade and Investment Promotion Agency
NE	Near Endemic
NGO	Non-Governmental Organization
NPAES	National Protected Area Expansion Strategy
NT	Near Threatened
OHL	Overhead Powerline
PAOI	Proposed Area of Impact
PBR	Potential Biological Removal
PSC	Project Steering Committee

PVA	Population Viability Analysis
PV	Photovoltaic
SABAP1	First Southern African Bird Atlas Project
SABAP2	Second Southern African Bird Atlas Project
SANBI	South African Biodiversity Institute
SANEDI	South African National Energy Development Institute
SANParks	South African National Parks
SCC	Species of Conservation Concern
SDF	Spatial Development Framework
SDM	Species Distribution Model
SEA	Strategic Environment Assessment
SEZ	Special Economic Zone
SLE	Endemic to South Africa, Lesotho and Eswatini
TNPA	Transnet National Ports Authority
TPC	Thresholds of Potential Concern
VU	Vulnerable
WEF	Wind Energy Facility
WP2	Work Package 2

1. INTRODUCTION

The Transnet National Ports Authority (TNPA) has embarked on determining the feasibility for the development, construction, and operation of a deep-water port with associated landside port facilities at Boegoebaai, Northern Cape. The proposed new port development is primarily to enable the Northern Cape's Provincial Economic Development strategy including the Green Hydrogen (GH_2) Strategy and expanding the mining and industrial base in the Northern Cape.

Green hydrogen is hydrogen gas (H_2) that is produced using renewable energy sources, typically solar or wind power, through a process called electrolysis. In this process, water (H_2O) is split into hydrogen (H_2) and oxygen (O) using an electric current, and when that electricity comes from renewable sources, the resulting hydrogen is considered "green."

Green hydrogen production, at the scale envisaged, is a diverse and multifaceted process with many direct and indirect impacts, both positive and negative. All programme components (including their interconnected transport corridors) would require vast areas of land surface, as well as other resource intensive inputs, all proposed in a sparsely populated but ecologically sensitive, arid region. Existing land uses in the study area include conservation, agriculture, fisheries, tourism, and mining.

A Strategic Environmental Assessment (SEA) has been initiated through a collaboration between the South African National Energy Development Institute (SANEDI), Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA), and the Transnet National Ports Authority (TNPA) (the Project Steering Committee (PSC)). The Council for Scientific and Industrial Research (CSIR) has been appointed to undertake this independent SEA. The overarching purpose of the SEA is to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai Port, Special Economic Zone, and wider Namakwa region in a sustainable manner.

AfriAvian Environmental has been appointed by the CSIR to conduct the SEA's avifaunal component for the proposed Boegoebaai Port and Special Economic Zone (WP1 report dated April 2025[2]) and the wider Namakwa Region (**WP2 i.e., this report**).

2. SCOPE OF THIS STRATEGIC ASSESSMENT -WORK PACKAGE 2 (WP2)

2.1 Study Area i.e., Namakwa Region

The spatial scope for the WP2 Avifaunal Assessment is delimited by four local municipalities: the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities (**Figure 1**).

[2] Froneman et al. 2025. Strategic Environmental Assessment for the proposed Boegoebaai Port and Special Economic Zone: Work Package 1 – Avifaunal Specialist Assessment. AfriAvian Environmental (Pty) Ltd.

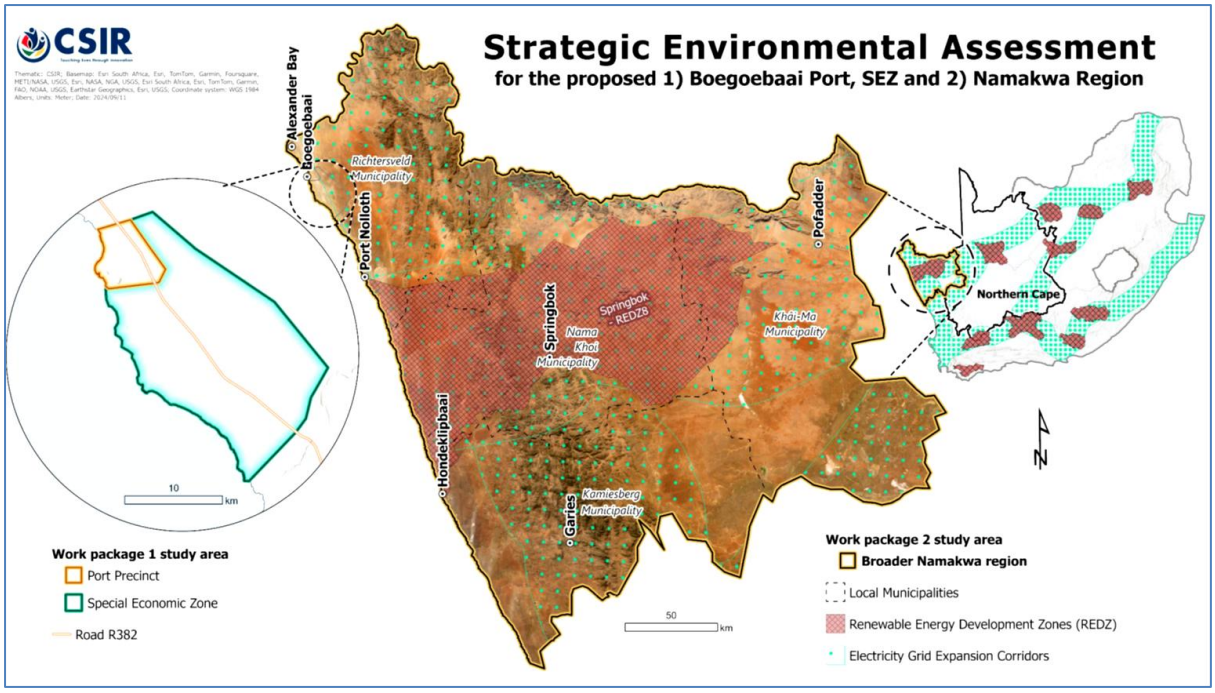

Figure 1: The spatial extent of the two SEA Work Packages with this report focusing on the Work Package 2 study area i.e., the Broader Namakwa Region (Source: CSIR, 2025).

2.2 GH_2 Development Scenarios for Assessment

Two GH_2 development scenarios will be assessed, each compared to an existing dynamic baseline, where no GH_2 development occurs but other anthropogenic and climate changes continue, and are described below:

2.2.1 SCENARIO 0 – DYNAMIC BASELINE (2023 – 2050)

The Boegoebaai Port and SEZ remains undeveloped and no GH_2 is produced in this area of the Northern Cape. The Namakwa Region's economy proceeds to be shaped by mining (i.e., diamonds, zinc, lead, copper and sand), agriculture (mainly livestock), fishing, and a growing renewable energy sector, alongside seasonal tourism linked to the Namaqualand wildflower displays. Also persisting are the current social (e.g. migration, unemployment), ecological and climatic (e.g. desertification, storm surges, coastal flooding, etc.) trends impacting on the Namakwa Region.

Contrary, conservation is being promoted as the preferred land use for the Namakwa Region, rather than mining or industrial activities that carry environmental costs. This approach is supported by landscape conservation initiatives (for example, SANParks' Mega Living Landscapes, conservation stewardships and park management), provincial strategic planning under NPAES, and Nature Reserve expansion plans.

2.2.2 SCENARIO 1 – "SMALL GH_2" (by 2030)

The Boegoebaai Port and SEZ are developed and a five (5) GW electrolyser producing 0.5 million tonnes GH_2 per annum (Mtpa) and its derivatives are supported by 10 GW of renewable energy (the scenario assumes 60% solar; 40% wind).

2.2.3 SCENARIO 2 – "BIG GH_2" (by 2050)

The Boegoebaai Port and SEZ are expanded and GH_2 development is upscaled to a 40 GW electrolyser producing a total of 4 Mtpa GH_2 and its derivatives supported by 80 GW of renewable energy (the scenario assumes 60% solar; 40% wind).

2.3 Infrastructure Types impacting Avifauna within the Namakwa Region

2.3.1 Renewable energy and electrical grid infrastructure

While some wind and solar PV generation will be located near the SEZ, the sensitivity of the local environment and potential coastal impacts (e.g., corrosion) mean that most power will come from dispersed renewable projects, often several hundreds of kilometres distant, each requiring its own site-specific environmental impact assessment (EIA) (Error! Reference source not found.). Electricity will be supplied to the GH_2 production plant via new transmission and distribution infrastructure (**Table 2**).

Table 1: Brief description of the main renewable energy-related infrastructure aspects (Source: CSIR, 2025)

Renewable energy	Aspect	Description
Wind	Turbines	Rotor with blades, nacelle, tower, generating capacity of 4-8 MW per turbine, hub height 150-180 m, blade length ~100 m
	Associated infrastructure	Foundations (~32 m^2), access roads, battery energy storage system (BESS), on-site electrical system, substations, transmission lines, construction camp, operations and maintenance facilities, meteorological masts, communication towers.
Solar PV	Solar panels	Monocrystalline/polycrystalline silicon cells, panel height ~6 m, fixed or dual-axis tracking, single or bifacial modules.
	Associated infrastructure	Inverters, mounting structures, BESS, foundations, access roads, electrical system, substations, transmission lines, electrical components, construction camp, operations and maintenance facilities.

Note that the typical parameters for wind and solar PV infrastructure provided in Table 1 above, such as the individual generating capacity of turbines, hub height, blade length and PV panel height, are based on current industry practice. These parameters are used as the assumption in this SEA and are likely to change due to technological advancements in the period to 2050.

Renewable energy (wind and solar) facilities and associated powerline infrastructure can impact avifauna through collision and electrocution risks, particularly for large, slow-flying or migratory species; habitat loss or alteration from facility footprints; and disturbance from noise, lighting, and human activity. Poorly sited wind or solar installations can displace sensitive species or increase mortality due to collisions in areas of suitable habitat and high-use bird corridors. Powerlines may also create barrier effects, disrupting flight paths and access to key foraging or breeding areas. Careful siting, bird-friendly pylon design, and proper marking of powerlines can reduce these risks.

2.3.2 Green hydrogen plants

Green hydrogen plants are the core production hubs that turn water and renewable electricity into a storable, transportable, and versatile clean fuel. This makes them central to both the green hydrogen value chain and the broader renewable energy transition (**Table 2**). Green hydrogen plants are the conversion engines that link renewable energy generation to a wide range of low-carbon applications, while also accelerating renewable energy deployment, enabling deep decarbonisation, and creating new economic opportunities.

Green hydrogen plants themselves do not usually pose the same direct collision or displacement risks to birds as wind turbines or tall transmission structures. However, they can still have considerable, often indirect avifaunal impacts because they are rarely stand-alone facilities. They are typically part of a much larger infrastructure footprint that includes renewable energy generation, electricity transmission, water supply and export logistics. The green hydrogen plant is often the anchor for a web of associated infrastructure. While the plant's core process is relatively benign to birds, its enabling components i.e., the

renewable energy generation, electricity transmission, water supply and export facilities can create substantial avifaunal risks if not carefully sited, designed and managed.

2.3.3 Desalination plants

Desalination plants are critical enabling links in many large-scale green hydrogen projects, especially in coastal or arid regions where freshwater is scarce, but renewable energy potential is high (**Table 2**). Desalination plants make it possible to turn abundant seawater into the ultra-pure feedstock electrolysers need, unlocking green hydrogen production in water-scarce but renewable-rich regions, while also offering opportunities for community water supply and integrated, low-carbon infrastructure.

Desalination plants can affect avifauna primarily through habitat disturbance during construction and operation, noise and lighting impacts that may disrupt breeding or foraging behaviour, and indirect effects from associated marine infrastructure. Coastal intakes and brine discharge can alter nearshore ecosystems, potentially reducing prey availability for birds favouring the littoral active zone, while increased human activity and vessel traffic may disturb roosting and nesting sites.

2.3.4 Roads, rail and pipelines

Transport infrastructure such as roads, railways and pipelines (**Table 2**) can impact avifauna through habitat loss and fragmentation, disturbance by noise, vibration and lighting, as well as increased collision risk with vehicles, trains or overhead powerlines. Linear corridors may also create barrier effects, altering flight paths and access to feeding or breeding areas, while construction and maintenance activities can disrupt nesting and foraging. In sensitive habitats, these impacts can be significant, especially for large, low-manoeuvrability or ground-nesting bird species.

The following transport infrastructure is planned in the broader Namakwa Region:

- New pipelines for the bulk transport of GH_2 to and from Namibia, Saldanha Bay (Scenario 1) and Prieska (Scenario 2).
- New rail between the Boegoebaai Port and Kenhardt connecting to the existing Saldanha-Sishen railway route.
- Upgrade and expansion of roads to and from Alexander Bay.
- Roads associated with the construction, operation and maintenance of new renewable energy facilities, railways and pipelines.

2.3.5 Masts and towers

Masts and turbines are the vertical backbone of green hydrogen infrastructure, from capturing the wind that powers electrolysers, to gathering the climate data that underpins investment decisions, to enabling communications and control systems that keep complex, distributed renewable-hydrogen networks running smoothly.

Masts and towers can impact avifauna mainly through collision risk, particularly for large, fast-flying or nocturnal species attracted to or disoriented by lights. Guy wires on tall masts increase this risk. They may also cause habitat displacement if placed in sensitive areas and serve as perching or nesting sites for some species, which can lead to increased predation pressure or exposure to operational hazards. Careful siting, design, and proper marking can reduce these risks.

Table 2: GH2 development scenario quantifications (Scenario 1 and Scenario 2) for the Namakwa regional assessment (Source: CSIR, 2025)

	Aspect	Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	15 ha per 1 GW
	GH2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mpta GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mpta)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	57	454	1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28	227	0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mpta)
	Desalination output volume	Ml/day	36	286	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 operational.
	Desalination footprint	ha	7	57	5 Ml/day output needs 1 ha
	Desalination discharge	Ml/day	48	387	Ratio of desalinated water to brine discharge water to be 42.5:57.5. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine).
	Pipeline intake volume	Ml/day	84	672	Output + discharge
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	*GW*	*6*	*48*	60 % solar : 40 % wind
	RE footprint - solar	*ha*	*12 000*	*96 000*	0,5MW/ha
	RE extent - solar		*12 000*	*96 000*	Footprint = extent
	RE facilities - solar	*no of facilities*	*6*	*48*	Clusters of 1 GW facilities
	RE capacity - wind	*GW*	*4*	*32*	60 % solar : 40 % wind
	RE footprint - wind	*ha*	*4 000*	*32 000*	1 MW/ha
	RE extent - wind	*ha*	*40 000*	*320 000*	0,1 MW/ha
	RE facilities - wind	*no of facilities*	*3*	*21*	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 600	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	1 200	20 m servitude
	Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.
	Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)
	Main infrastructure components footprint	**ha**	**21 082**	**142 240**	

Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; Ml/day = million litres per day; km = kilometre

3. KEY POTENTIAL IMPACTS ON AVIFAUNA

3.1 Displacement due to Disturbance

The construction phase of any proposed development associated with the Boegoebaai Port and SEZ (see Section 2.2 and 2.3 above) can disturb bird populations and their habitats, particularly if construction activities occur in or near areas that birds rely on for nesting, feeding, or roosting. Birds are highly sensitive to changes in their environment, and the disruption caused by the construction and operation of the proposed project can have several adverse effects.

The noise and activity associated with vehicles, machinery and construction operations can disturb birds, especially those sensitive to human presence or loud sounds. Species that require quietness and undisturbed environments for nesting or breeding may abandon their nests if they perceive the area as unsafe or stressful. This disturbance can disrupt breeding cycles, leading to reduced reproductive success and therefore population decline.

Additionally, the presence of machinery and vehicles can pose direct threats to birds through collisions or accidental disturbances. Birds, particularly ground-nesting species, or those flying low over the area, may be at risk of injury or mortality from these activities.

The construction and operation of the proposed development may involve several activities aimed at excavating, processing, and utilising materials for construction purposes. Some of the activities which could be associated with the proposed development, which could cause species displacement due to disturbance, include:

- **Site Selection and Preparation**: This involves identifying suitable locations for the proposed development based on proximity to construction sites needing materials and the quality of materials available. Site preparation may include clearing vegetation and levelling the area.

- **Excavation**: The primary construction activity could be excavation, where soil, gravel, sand, or other materials are extracted from the ground using heavy machinery such as excavators, bulldozers, or loaders. This activity will be a significant source of noise and movement disturbance.

- **Material Processing**: Excavated materials often need processing to meet specific size and quality requirements for construction. This can involve crushing, screening, or washing the materials to remove impurities to ensure consistency.

- **Material Stockpiling**: Processed materials are stockpiled onsite for storage and subsequent transportation to construction sites. Proper stockpiling techniques are important to prevent erosion, maintain material quality, and ensure safety.

- **Transportation**: Transporting materials for the proposed project to construction sites is a significant part of operations. This may involve using trucks, conveyor belts, or other equipment to move materials efficiently and safely.

3.2 Displacement due to Habitat Loss / Fragmentation / Transformation

Construction activities and infrastructure, such as pipelines, powerlines and roads, can fragment habitats and restrict species movement / dispersal. Renewable energy developments in addition to the port related and green hydrogen developments can have significant impacts on avifauna, primarily through habitat loss and degradation. The construction and expansion of ports often involve land reclamation, dredging, and the destruction of wetlands and intertidal zones, which are critical habitats for many bird species (Dugan, 1990; BirdLife International, 2021). These areas serve as feeding, nesting, and roosting sites, particularly for migratory shorebirds that rely on undisturbed coastal habitats during their journeys (Goss-Custard & Verboven, 1993). In addition, the construction of renewable energy (wind and solar) facilities, their

associated electricity grid infrastructure and their extensive road network require the clearance of large areas of vegetation, earthworks and often trenching for foundations and component installations.

The loss of vegetation and natural landscapes disrupts ecological balance, leading to reduced food availability and increased competition among avian species (Ma et al. 2014). Pollution from port operations, including possible oil spills and chemical runoff, can degrade water quality and affect the health of aquatic ecosystems, further impacting bird populations dependent on these areas (Boersma et al. 2001). Such habitat loss and fragmentation can result in declining bird populations, threatening the biodiversity of avian communities in and around the proposed Port Expansion Area, as well as within the Namakwa Region.

3.3 Injury or Mortality due to Collisions

Wind energy generation has experienced rapid worldwide development over recent decades as its environmental impacts are considered to be relatively lower than those caused by traditional energy sources, with reduced environmental pollution and water consumption (Saidur et al. 2011). However, bird fatalities due to collisions with wind turbines and associated infrastructure such as powerlines, substations, communications towers and/or meteorological masts have been consistently identified as a main ecological drawback to wind energy (Drewitt & Langston, 2006).

Collisions with wind turbines appear to kill fewer birds than collisions with other man-made infrastructures, such as powerlines, buildings or even traffic (Erickson et al. 2005). Nevertheless, estimates of bird deaths from collisions with wind turbines worldwide range from 0 to almost 40 deaths per turbine per year (Sovacool, 2009). The number of birds killed varies greatly between sites, with some sites posing a higher collision risk than others, and with some species being more vulnerable than others. These numbers may not reflect the true magnitude of the problem, as some studies do not account for detectability biases such as those caused by scavenging, searching efficiency and search radius (Bernardino et al. 2013; Erickson et al. 2005; Huso & Dalthorp, 2014). Additionally, even for low fatality rates, collisions with wind turbines may have a disproportionate effect on some species. For long-lived species with low productivity and slow maturation rates (e.g. raptors), even low mortality rates can have a significant impact at the population level (Carrete et al. 2009; Drewitt & Langston, 2006).

High bird fatality rates at several wind farms have raised concerns among the industry and scientific community in South Africa and abroad. According to the latest BirdLife South Africa (BLSA) report on bird fatalities at operational wind farms, a total of 2444 unique bird fatality incidents were recorded at wind farms, with losses attributed to turbine collisions, powerlines and other anthropogenic impacts. These incidents involved 202 bird species. Of these, 198 were recorded as turbine collisions (BLSA, 2025). The situation is even more critical for Species of Conservation Concern (SCC) which sometimes are most at risk.

High profile examples include the Altamont Pass Wind Resource Area (APWRA) in California because of high fatality of Golden eagles (*Aquila chrysaetos*), Tarifa in Southern Spain for Griffon vultures (*Gyps fulvus*), Smøla in Norway for White-tailed eagles (*Haliaeetus albicilla*), and the port of Zeebrugge in Belgium for gulls (*Larus* sp.) and terns (*Sterna* sp.) (Barrios & Rodríguez, 2004; Drewitt & Langston, 2006; Everaert & Stienen, 2008; Thelander et al. 2003). Due to their specific features and location, and characteristics of their bird communities, these wind farms have been responsible for a large number of fatalities that culminated in the deployment of additional measures to minimize or compensate for bird collisions. However, currently, no simple formula can be applied to all sites; in fact, mitigation measures must inevitably be defined according to the characteristics of each wind farm and the diversity of species occurring there (Marques et al. 2014). An understanding of the factors that explain bird collision risk and how they interact with one another is therefore crucial to proposing and implementing valid mitigation measures (BLSA, 2025).

3.4 Injury or Mortality due to Electrocution

Electrocution refers to the scenario where a bird is perched, or attempts to perch, on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components

and/or live and earthed components (Van Rooyen, 2004). The electrocution risk is largely determined by the voltage of the proposed overhead powerline (OHL) and the pole/tower (pylon) design. Should the proposed OHL be constructed using a 132 kV tower specification, the electrocution impact for the majority of priority species will be negligible. The Cape Vulture is one of the priority species, due to its size and gregarious nature, capable of bridging the clearance distances of an OHL constructed using this specification.

Ordinarily, the construction of a single circuit powerline using the approved bird-friendly pylon/tower design D-DT-7649 in accordance with the Distribution Technical Bulletin titled *Refurbishment of 66/88 kV line kite type frames with D-DT-7649 type top configuration - Reference Number 240-170000467* will eliminate the electrocution risk. The configuration of the insulators and the clearance distances between the live and earthed components on this structure can comfortably accommodate a perching vulture. However, if the OHL is built on lattice structures, it is imperative that there is a minimum clearance of 1.8 m between the jumper cables and/or insulators and the horizontal earthed component on the lattice structure (pers. comm. Lourens Leeuwner - Eskom-EWT Strategic Partnership Manager). Additional mitigation in the form of insulating sleeves on jumper cables present on strain poles and terminal poles must be implemented (if suitable insulation material is readily available); alternatively, all jumper cables must be suspended below the crossarms.

Electrocutions within proposed on-site substations at both the Port Precinct, the SEZ and the renewable energy facilities are possible, however, the likelihood of this impact on the more sensitive SCC is remote, as these species are unlikely to regularly utilise the infrastructure within the on-site substation for perching or roosting. Species that are more vulnerable to this impact are medium-sized raptors, corvids, owls, and certain species of waterbirds.

4. APPROACH AND METHODOLOGY

To assess the avifaunal sensitivity of the Namakwa Region, various datasets were used to compile sensitivity layers for each priority species including SCC. The layers were ranked according to endemicity and conservation status, and fine scale habitat suitability to develop a four-tier sensitivity map. See Section 6.4 for more detail.

A weighted sensitivity modelling approach was applied to generate these layers. For each priority species, spatial predictions from species distribution and habitat suitability models were combined with conservation-weighting factors that accounted for (i) threat status, (ii) range size, and (iii) degree of endemism. These parameters were used to express each species' relative vulnerability to key impact pathways, namely disturbance/displacement, habitat loss, collision, and electrocution. The weighted species layers were then normalised and aggregated to produce cumulative, continuous sensitivity surfaces per impact type. This approach provides a precautionary yet comparable spatial framework across species and impact types, allowing for differentiation of relative ecological risk at a regional scale.

The following information sources and methods were used to conduct this study:

- Bird distribution data from the Second Southern African Bird Atlas Project (SABAP2) was obtained (https://sabap2.birdmap.africa/), to ascertain which species occur in the pentads relevant to the Namakwa Region. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5' × 5'). Each pentad is approximately 8 × 9 km. To get a more representative impression of the birdlife in the area, a consolidated dataset was obtained for a total of 874 pentads some of which intersect the proposed Port Precinct and SEZ development sites, with the Namakwa Region also referred to as the "study area" (**Figure**). This SABAP2 dataset is therefore based on avifaunal species presence recorded within the study area since 2007 (i.e., 18 years).

- The SABAP2 data in this region is usually not as comprehensive as in the rest of South Africa due to decreased observer effort (fewer people living in the area and access difficulty), therefore the data was supplemented by species distribution models and habitat suitability models as well as general knowledge of the area.

- A target species list was generated by assessing SABAP2 data, BirdLasser citizen science data and intersecting species distribution models for the Namakwa Region that includes the originally assessed 5 km Proposed Area of Impact (PAOI) buffer around the Boegoebaai Port Precinct and SEZ (AfriAvian WP1 Avifaunal Assessment, April 2025). This assessment of all available data yielded a priority list of 44 threatened and/or endemic avian species that were included in the analysis. Species distribution models have been developed for more than >100 SCCs as part of a national assessment of avian sensitivity. Species distribution models were developed using a standardised methodology that is aligned with what was used to develop avian models for the DFFE National Screening Tool.

- For the habitat suitability models, a classification of the vegetation types of the Namakwa region was obtained from the First Atlas of Southern African Birds (SABAP1) and the 2018 National Vegetation Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford, 2006, as revised by SANBI, 2018).

- The national threatened status of all priority species was determined with the use of the most recent edition of the Red List Book of Birds of South Africa, Lesotho, and Swaziland (Lee et al. 2025), and the latest authoritative summary of southern African bird biology (Hockey et al. 2005).

- The global threatened status of all priority species was determined by consulting the latest (2024) IUCN Red List of Threatened Species (http://www.iucnredlist.org/).

- The database on the Key Biodiversity Areas (KBAs) of South Africa (Key Biodiversity Areas in South Africa - SANBI) was consulted for information on potentially relevant KBAs within the study area.

- An intensive internet search was conducted to source information on the impacts of the proposed development on avifauna.

- Satellite imagery (Google Earth © 2025) was used to view the study area on a landscape level and to help identify bird habitat on the ground.

- The South African National Biodiversity BGIS map viewer was used to determine the locality of the study area relative to National Protected Areas.

- The DFFE National Screening Tool (https://screening.environment.gov.za/screeningtool/) was used to determine the assigned sensitivity of the study area as it relates to the Animal Species and Avian (Wind) Environmental Themes.

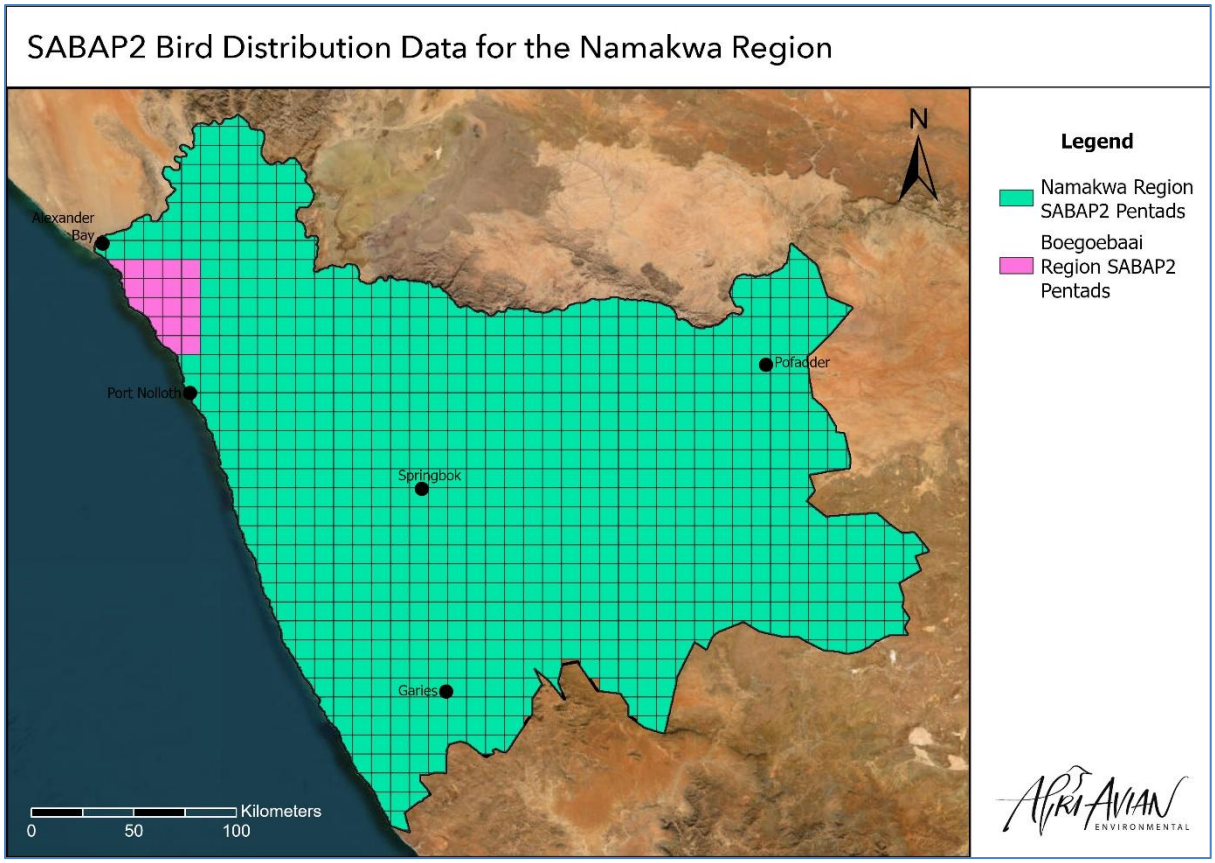

Figure 1: Bird distribution data for the WP2 study area i.e., Namakwa region (indicated in green) has been obtained from 874 SABAP2 pentads. The 20 pentads comprising the WP1 study area i.e., Boegoebaai Port and SEZ are indicated in pink.

5. ASSUMPTIONS AND LIMITATIONS

This study assumed that the sources of information used in this report are reliable. In this respect, the following must be noted:

- The focus of the study is primarily on the potential impacts of the planned development scenarios on priority avifaunal species which were defined as follows:
  - South African Red List species (Species of Conservation Concern)
  - South African endemics and near endemics
  - Waterbirds
  - Raptors; and
  - Species vulnerable to disturbance and/or habitat loss.
- The assessment of impacts is based on the baseline environment as it currently exists within the Namakwa Region and nearby surrounding environment.
- Conclusions in this study are based on experience of these and similar species in different parts of South Africa. Bird behaviour can never be entirely reduced to formulas that will be valid under all circumstances.

- The study area refers to the Namakwa Region that is 5 819 784.13 hectares in extent and covered by the 874 SABAP2 pentads, and that includes the proposed Boegoebaai Port and SEZ development area (**Figure**).

6. KEY ENVIRONMENTAL ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREA

6.1 Habitat Features

The Namakwa Region of the Northern Cape falls largely within the Succulent Karoo Biome, one of the world's biodiversity hotspots, and encompasses a rich mosaic of vegetation types that are classified based on climate, geology, soils, and plant communities (Mucina & Rutherford, 2006).

These vegetation types within the Succulent Karoo and the adjacent Desert, Fynbos and Nama Karoo biomes, range from arid winter-rainfall shrublands of the Lowland Succulent Karoo to the endemic-rich rocky slopes of the Upland Succulent Karoo/Kamiesberg Mountain Scrubland. Coastal habitats include Namaqualand Strandveld on calcareous sands, Coastal Duneveld with stabilised and mobile dunes, and Seashore Vegetation on rocky and sandy shores. Seasonal floral displays occur in the Namaqualand Blomveld, while inland sandy plains are represented by Inland Duneveld and Oograbies Plains Sandy Grassland. Unique features include Heuweltjiesveld on nutrient-rich termite mounds, Klipkoppe Scrubland with localised succulent endemics, and Riethuis–Wallekraal Quartz Vygieveld with specialised quartz-patch flora. Additional habitats comprise Namaqualand Sand Fynbos on sandstone soils, Arid Grassland in the eastern interior, ephemeral Namaqualand Rivers with riparian woodland, and saline wetlands such as Salt Pans and Arid Estuarine Salt Marshes, which are vital for waterbirds (Mucina & Rutherford, 2006; as revised by SANBI, 2018).

The Namakwa Region further includes several formally Protected Areas, declared in terms of the National Environmental Management: Protected Areas Act (Act No. 57 of 2003, as amended by Act 2 of 2022, such as the |Ai-|Ais/Richtersveld Transfrontier Park, the Namakwa National Park, Gamsberg Nature Reserve and the Goegap Nature Reserve (DFFE, 2022).

The Namakwa Region also comprises 15 Key Biodiversity Areas (KBAs). KBAs are 'sites that contribute significantly to the global persistence of biodiversity', which means they are the most important places in the world for species and their habitats – whether these be in terrestrial, freshwater, estuarine, or marine ecosystems. Sites qualify as global KBAs if they meet the specific standardised criteria and quantitative thresholds focused on one or more of five trigger aspects; threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability through quantitative analysis.

KBAs featured within the Namakwa Region (**Figure**) include the following:

a) Aggeneys - Pella - Pofadder
b) Bushmanland Inselbergs
c) Bushmanland Interior
d) Gariep Desert
e) Goegap
f) Kamiesberg
g) Kliprand
h) Namaqualand Sandveld North
i) Namaqua National Park
j) Namaqualand Hardeveld North
k) Namaqualand Hardeveld South

l) Namaqualand Sandveld South

m) Orange River Estuary - Southern Namib Desert

n) Richtersveld National Park

o) Southern Richtersveld

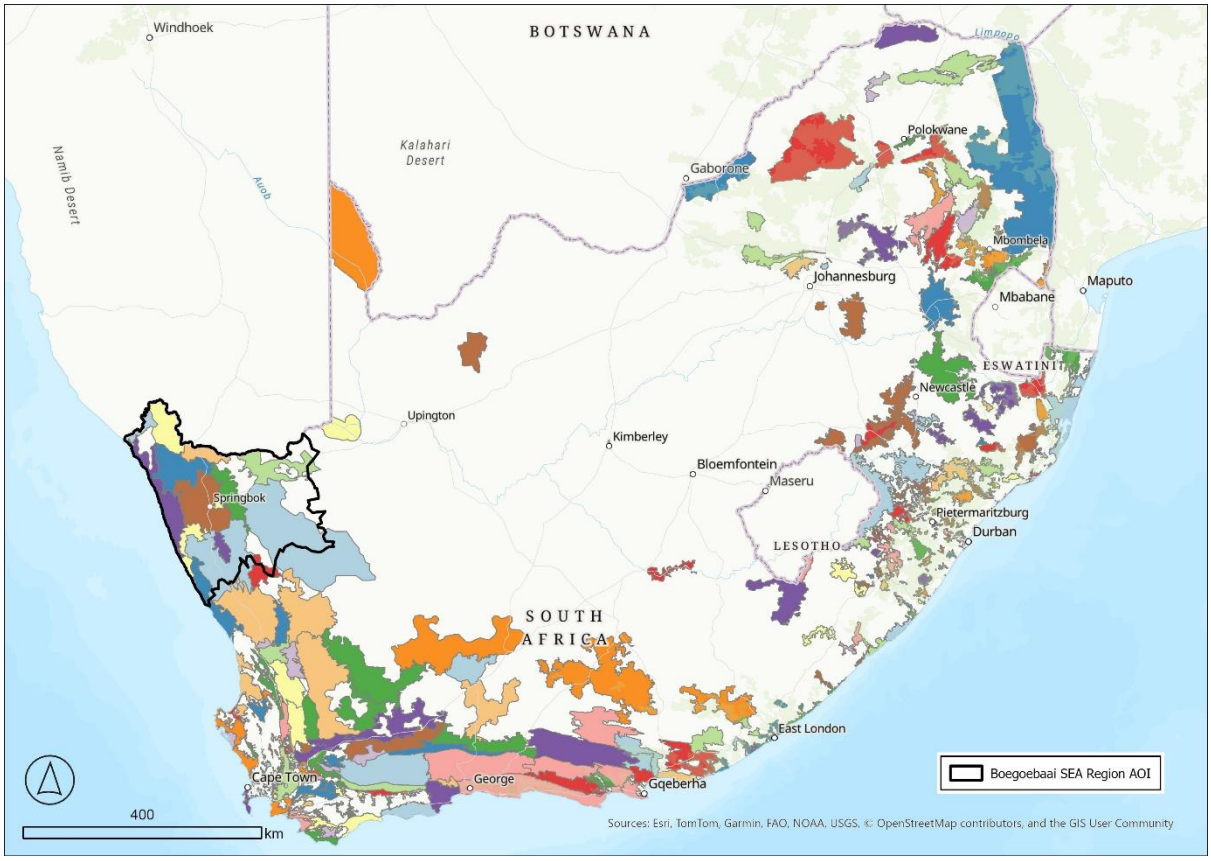

Figure 1: The Namakwa Region of South Africa (outlined in black) contains 15 Key Biodiversity Areas (Source: https://www.keybiodiversityareas.org/map).

6.2 Priority Bird Species of the Namakwa Region

To date, one hundred and thirty-eight (138) bird species have been recorded in the Namakwa Region through the Second Southern African Bird Atlas Project (SABAP2) over a period of 18 years. Of the 138 species, 44 are considered priority species. Priority species were defined as species that are particularly sensitive to displacement due to disturbance and/or habitat loss, as well as risk of collisions and electrocutions; endemic and near-endemic species; all SCC; waterbirds; raptors; and range restricted species. The 44 priority bird species recorded in the Namakwa Region that were selected for further assessment include SCC as well as those that are endemic or near-endemic to South Africa (**Table**).

It should be noted that observer effort in this area is generally low due to the sparseness of the human population and the remoteness (inaccessibility) of the area. Therefore, the SABAP2 species list is not necessarily fully comprehensive of the Namakwa Region.

Table 3: Priority avifaunal species including Species of Conservation Concern and/or endemic species that have been recorded in the Namakwa Region as it relates to the SEA. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, E = Endemic, NE = Near Endemic, SLE = Endemic to South Africa, Lesotho and Eswatini

Species Name	Scientific Name	Global Conservation Status	Regional Conservation Status	Endemism
African Fish Eagle	*Icthyophaga vocifer*	-	-	-
African Marsh Harrier	*Circus ranivorus*	-	VU	-
African Rock Pipit	*Anthus crenatus*	NT	-	SLE
Bank Cormorant[3]	*Phalacrocorax neglectus*	EN	EN	-
Bateleur	*Terathopius ecaudatus*	EN	EN	-
Black Harrier	*Circus maurus*	EN	EN	NE
Black Stork	*Ciconia nigra*	-	EN	-
Black-eared Sparrow-Lark	*Eremopterix australis*	-	-	NE
Black-headed Canary	*Serinus alario*	-	-	NE
Blue Crane	*Grus paradisea*	VU	VU	-
Burchell's Courser	*Cursorius rufus*	-	VU	-
Cape Cormorant[4]	*Phalacrocorax capensis*	EN	EN	-
Cape Clapper Lark	*Mirafra apiata*	-	-	NE
Cape Eagle-Owl	*Bubo capensis*	-	-	-
Cape Long-billed Lark	*Certhilauda curvirostris*	-	-	E
Cape Rock Thrush	*Monticola rupestris*	-	-	SLE
Cape Spurfowl	*Pternistis capensis*	-	-	NE
Cape Sugarbird	*Promerops cafer*	-	-	E
Cape Vulture	*Gyps coprotheres*	VU	VU	-
Caspian Tern	*Hydroprogne caspia*	-	VU	-
Chestnut-banded Plover	*Anarhynchus pallidus*	-	VU	-
Cinnamon-breasted Warbler	*Euryptila subcinnamomea*	-	-	NE
Curlew Sandpiper	*Calidris ferruginea*	VU	VU	-
Damara Tern	*Sterna balaenarum*	-	EN	-
Dune Lark (Coastal)	*Calendulauda erythrochlamys patae*	-	-	NE
Great White Pelican	*Pelecanus onocrotalus*	-	VU	-
Greater Flamingo	*Phoenicopterus roseus*	-	NT	-
Grey-winged Francolin	*Scleroptila afra*	-	-	SLE
Ground Woodpecker	*Geocolaptes olivaceus*	NT	NT	SLE
Jackal Buzzard	*Buteo rufofuscus*	-	-	NE

[3] Marine species were not included in this Terrestrial Avifaunal Study. Marine species assessments are included in the Marine Specialist Study for the Boegoebaai SEA.
[4] Marine species were not included in this Terrestrial Avifaunal Study. Marine species assessments are included in the Marine Specialist Study for the Boegoebaai SEA.

Species Name	Scientific Name	Global Conservation Status	Regional Conservation Status	Endemism
Karoo Eremomela	*Eremomela gregalis*	-	-	NE
Karoo Korhaan	*Heterotetrax vigorsii*	-	NT	-
Lanner Falcon	*Falco biarmicus*	-	NT	-
Ludwig's Bustard	*Neotis ludwigii*	EN	EN	-
Maccoa Duck	*Oxyura maccoa*	EN	VU	-
Martial Eagle	*Polemaetus bellicosus*	EN	EN	-
Orange-breasted Sunbird	*Anthobaphes violacea*	-	-	E
Peregrine Falcon	*Falco peregrinus*	-	-	-
Red Lark	*Calendulauda burra*	VU	VU	E
Sclater's Lark	*Spizocorys sclateri*	NT	NT	NE
Secretarybird	*Sagittarius serpentarius*	EN	VU	-
Sentinel Rock Thrush	*Monticola explorator*	NT	-	SLE
Southern Black Korhaan	*Afrotis afra*	VU	VU	E
Verreaux's Eagle	*Aquila verreauxii*	-	VU	-

6.3 DFFE Screening Tool

The Namakwa Region is classified partially as High, Medium and Low sensitivity for avifauna according to the Animal Species Theme of the DFFE Screening Tool (**Figure 2**). The Namakwa Region is classified partially as Very High, High, Medium and Low sensitivity for avifauna according to the Avian (Wind) Theme of the DFFE Screening Tool (**Figure 3**). The Namakwa Region also contains confirmed habitat for SCC as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, Government Notice 1150 of 30 October 2020). SCCs are listed on the IUCN Red List of Threatened Species (2025) or South Africa's National Red List (2025) as Critically Endangered, Endangered, Vulnerable or Near Threatened.

The occurrence of SCC in the Namakwa Region is confirmed by the SABAP2 data as indicated in **Table 3** (Section 6.2).

Based on the confirmed habitat, the SABAP2 data, and modelling outputs the overall classification of **Very High** and **High** sensitivity for avifauna in the Screening Tool is supported.

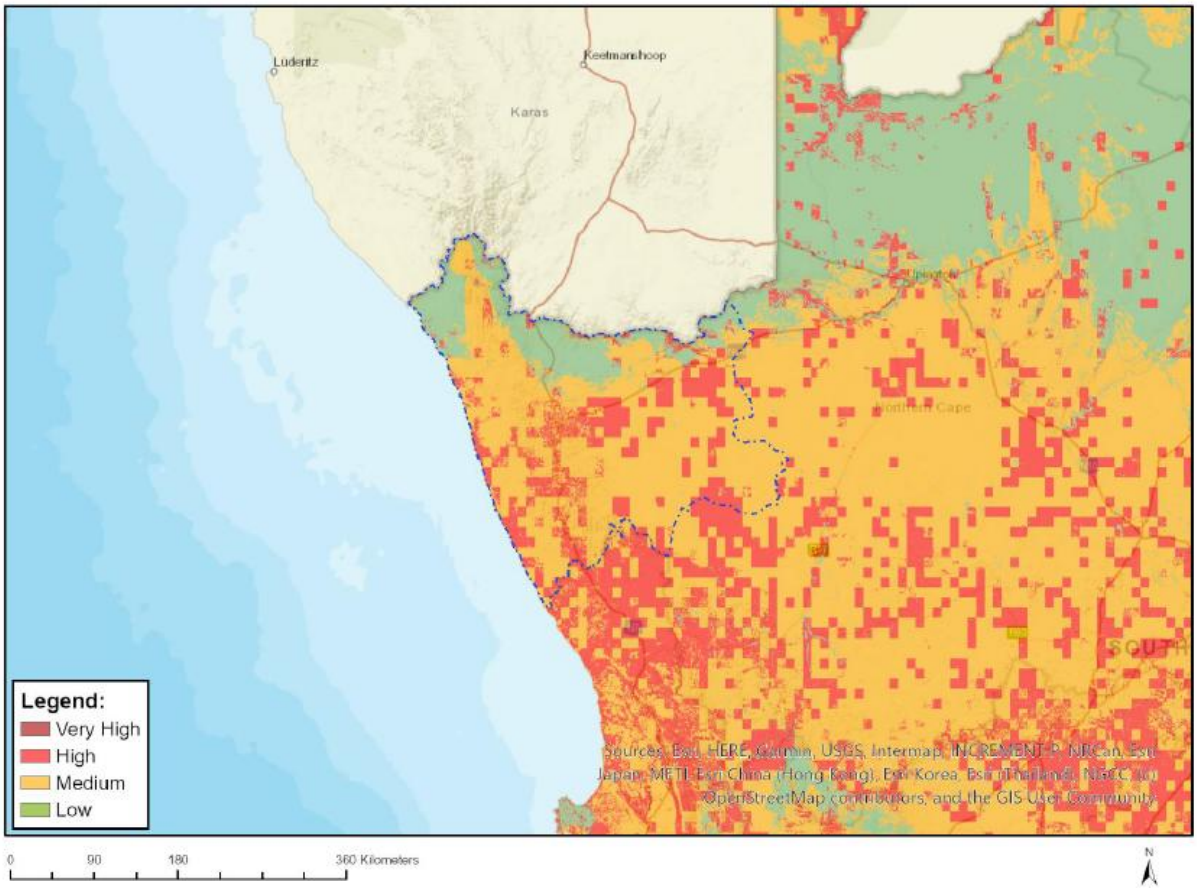

Figure 2: The sensitivity of the Namakwa Region as it relates to the Animal Species Theme (Source: DFFE Screening Tool, 2025).

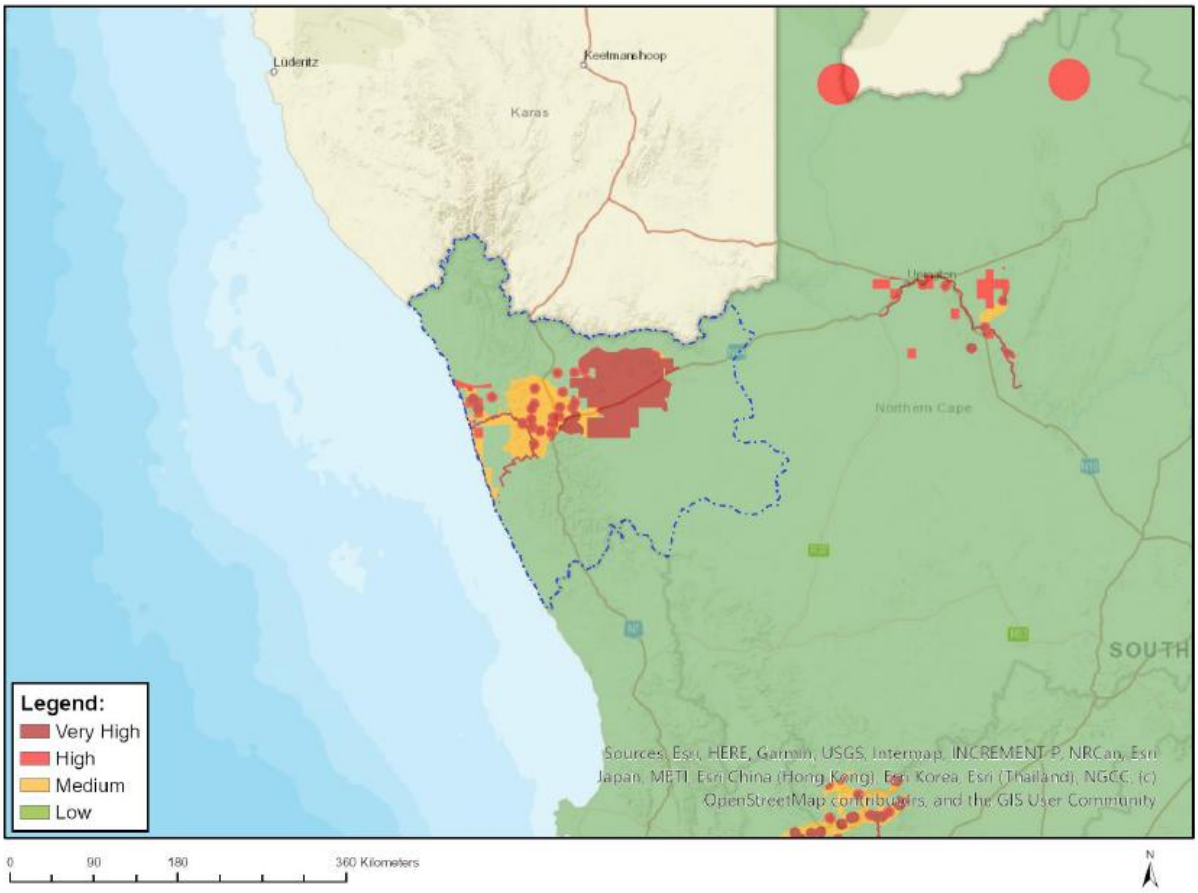

Figure 3: The sensitivity of the Namakwa Region as it relates to the Avian (Wind) Theme (Source: DFFE Screening Tool, 2025).

6.4 Sensitivity Analysis and Mapping

6.4.1 Study Area Definition

The sensitivity analysis for this risk assessment was conducted within the study area defined as the Namakwa Region, encompassing the Richtersveld, Nama Khoi, Kamiesberg, and Khâi-Ma Local Municipalities (including the Boegoebaai Port Precinct and SEZ) in the Northern Cape Province. The analysis area was defined using the established Area of Interest (AOI) polygon to ensure consistent spatial boundaries and exclude background areas that could bias statistical analyses.

6.4.2 Species Data and Distribution Modelling

- *Species Distribution Model Processing*

Species occurrence data and corresponding habitat suitability models were obtained from existing Species Distribution Model (SDM) datasets for the Namakwa Region. The SDM processing workflow involved several filtering stages to identify SCCs:

1. **Initial Dataset**: All available SDMs for the study area were compiled, representing the complete range of species with modelled habitat distributions.

2. **Habitat Threshold Filtering**: Species were filtered based on a minimum habitat area threshold of 5000 hectares within the study area (i.e. the species was distributed across ≥0.1% of the study

area). This threshold was applied to focus the analysis on species with sufficient habitat representation to warrant detailed impact assessment.

3. **Final Species Set**: Species meeting the habitat threshold criteria were retained for detailed impact scoring, while those below the threshold were excluded from quantitative risk assessment but documented for completeness. See **Annexure A** for details.

➢ *Species Attribute Integration*

Species-specific conservation attributes were integrated from authoritative databases for the 44 priority avian species that were selected for this risk assessment, including:

- South African Red Data Book (Lee et. al. 2025) conservation status classifications (CR, EN, VU and NT)
- Range size categories (Small, Medium, Large)
- Endemism classifications (Endemic, Sub-regional endemic, Near endemic)

6.4.3 Impact Scoring Framework

➢ *Impact Type Classification*

Four primary impact categories were assessed based on GH_2 and renewable energy related infrastructure effects on terrestrial avifauna:

1. **Displacement - Disturbance**: Behavioural avoidance and habitat abandonment due to human activities and infrastructure presence.
2. **Displacement - Habitat Loss/ Fragmentation/ Transformation**: Direct habitat loss through infrastructure footprint and associated developments.
3. **Collisions**: Direct mortality from collisions with infrastructure such as wind turbines, powerlines and masts/towers.
4. **Electrocutions**: Mortality from electrocution on transmission and distribution infrastructure.

➢ *Base Impact Scoring per Impact Category*

Species-specific susceptibility scores (0-5 scale) were assigned for each impact type based on:

- Literature review of species-specific vulnerability assessments;
- Expert knowledge of species ecology and behaviour; and
- Documented impacts from comparable developments typical of the GH_2 and renewable energy sectors.

6.4.4 Conservation Weighting System

A multiplicative weighting system was applied to base impact scores to prioritise species of higher conservation concern. See **Annexure A** for details:

➢ *Red Data Status Multipliers*

- Critically Endangered (CR): 16×
- Endangered (EN): 8×

- Vulnerable (VU): 4×
- Near Threatened (NT): 2×
- Least Concern (LC): 1×

➢ *Range Size Multipliers*

- Small range: 10×
- Medium range: 5×
- Large range: 1×

➢ *Endemism Multipliers*

- Endemic (E): 5×
- Sub-regional/local endemic (SLE): 5×
- Near-endemic (NE): 3×
- Not endemic (NA): 1×

6.4.5 Composite Weighting

The final conservation multiplier was calculated as:

Conservation Multiplier = Red Data Multiplier × Range Multiplier × Endemism Multiplier

Final Weighted Score per Impact = Base Impact Score × Conservation Multiplier (**Figure 7-10**)

6.5 Spatial Risk Mapping

6.5.1 Raster Processing

Individual species SDMs were processed to create weighted impact surfaces:

1. *NoData Handling*: NoData values in source rasters were converted to zero to enable mathematical operations while preserving spatial extent.
2. *Weight Application*: Each species' SDM was multiplied by its corresponding weighted impact score for each impact type.
3. *Cumulative Impact Calculation*: Species-specific weighted rasters were summed within each impact category to create cumulative impact surfaces.

6.5.2 Risk Classification

Cumulative impact rasters were classified into four risk categories using custom quantile breaks:

- **Low** Risk: 0-30th percentile (%)
- **Medium** Risk: >30th-60th percentile (%)
- **High** Risk: >60th-80th percentile (%)

- **Very High** Risk: >80th-100th percentile (%)

Quantile breaks were calculated from pixels with values >0 within the AOI (i.e., Namakwa Region) to ensure classification reflected actual impact gradients rather than background areas.

6.6 Quality Assurance

6.6.1 Data Validation

- SDM file integrity was verified through spatial extent and value range checks.
- Species name matching between SDM datasets and scoring databases was validated using automated and manual fuzzy matching procedures.
- Statistical outliers in scoring and weighting calculations were identified and verified.

6.6.2 Process Validation

- Incremental processing approaches were implemented to enable resumable workflows and individual species verification.
- Classification results were cross validated against alternative statistical methods (natural breaks, equal intervals) to ensure robustness.
- Final risk maps were visually inspected for spatial coherence and ecological plausibility.

6.7 Synthesis of Avian Sensitivity Mapping for Renewable Energy Technologies

The weighted species-impact modelling for 44 priority avifaunal species produced four primary sensitivity layers corresponding to key renewable energy impact pathways: disturbance/displacement, habitat transformation, collision, and electrocution (**Figures 7–10**). Together, these depict the relative ecological sensitivity of the Namakwa Region to large-scale renewable energy development (**Figure 11**).

While these maps share a common baseline of species-level ecological vulnerability, their dominant drivers differ between wind and solar PV infrastructure. Accordingly, two broad synthesis layers can be interpreted:

6.7.1 Sensitivity to Wind Energy Development

Wind energy infrastructure poses elevated risks of collision (with turbine blades, towers, and associated powerlines) and electrocution (on transmission infrastructure), as well as localised disturbance during construction and operation. The combined collision plus electrocution sensitivity surface therefore provides the most representative indicator of wind-related avian sensitivity.

At the regional scale, areas of Very High sensitivity correspond largely to:

- the Kamiesberg uplands and escarpment zones,
- the Springbok–Garies corridor, and
- parts of the coastal plain south of Port Nolloth, where raptor and large terrestrial species densities are elevated and flight activity intersects likely turbine-suitable topography.
- These zones align closely with previously mapped Key Biodiversity Areas (KBAs) and regions already classified as Very High sensitivity under the DFFE National Screening Tool.

6.7.2 Sensitivity to Solar PV Development

Solar PV installations have comparatively lower direct collision or electrocution risk but can result in habitat loss, fragmentation, and displacement of ground-nesting and/or habitat specialist bird species over large footprints. The combined habitat-loss and disturbance sensitivity surface therefore best represents solar-related avian sensitivity.

High and Very High sensitivity areas for solar PV broadly coincide with:

- the central Namaqualand shrublands and mountain foothills east of Springbok,
- the Garies–Kamiesberg–Springbok belt, and
- the southern and inland coastal plains where species richness and breeding habitat overlap with flat, developable terrain.
- Here, the potential for displacement of endemic and/or threatened larks, bustards, and ground-nesting species is greatest.

6.7.3 Interpretation and Application

These technology-specific syntheses highlight complementary but distinct spatial patterns of risk. They are intended to guide strategic-level screening and spatial planning, rather than prescribe exclusion zones. Local sensitivity can vary substantially depending on site characteristics such as habitat type, micro-topography, and proximity to breeding or foraging areas. Therefore, final technology-specific risk assessment and weighting should be refined through site-level EIA processes, informed by detailed avifaunal surveys.

At the SEA scale, these combined sensitivity layers offer an integrated, precautionary basis for identifying areas where:

- wind and solar development should be prioritised toward lower sensitivity zones, and
- pre-construction monitoring and mitigation planning should be emphasised in high-sensitivity zones.

This methodology provides a systematic, transparent, and scientifically defensible approach to quantifying cumulative species impact risks from renewable energy development and related infrastructure expansion across the Namakwa Region.

Following from the spatial risk mapping, the avian sensitivity of the Namakwa Region, generated from the weighted analysis incorporating the 44 priority avian species selected for further assessment per impact, is illustrated below in **Figure 7 – 10**. **Figure 11** depicts the composite avifaunal sensitivity of the Namakwa Region considering all four impact layers at maximum rule.

Figure 6 illustrates the avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating mainly nest/roost location data and GPS tracking data of 10 key priority SCC i.e., Black Harrier, Blue Crane, Cape Vulture, Ludwig's Bustard, Martial Eagle, Red Lark, Sclater's Lark, Secretarybird, Verreaux's Eagle and White-backed Vulture.

The species-impact scoring sheet detailing the information that generated the weighted analysis and subsequent sensitivity ratings for this avifaunal risk assessment, as outlined and discussed above, is included in **Annexure A**.

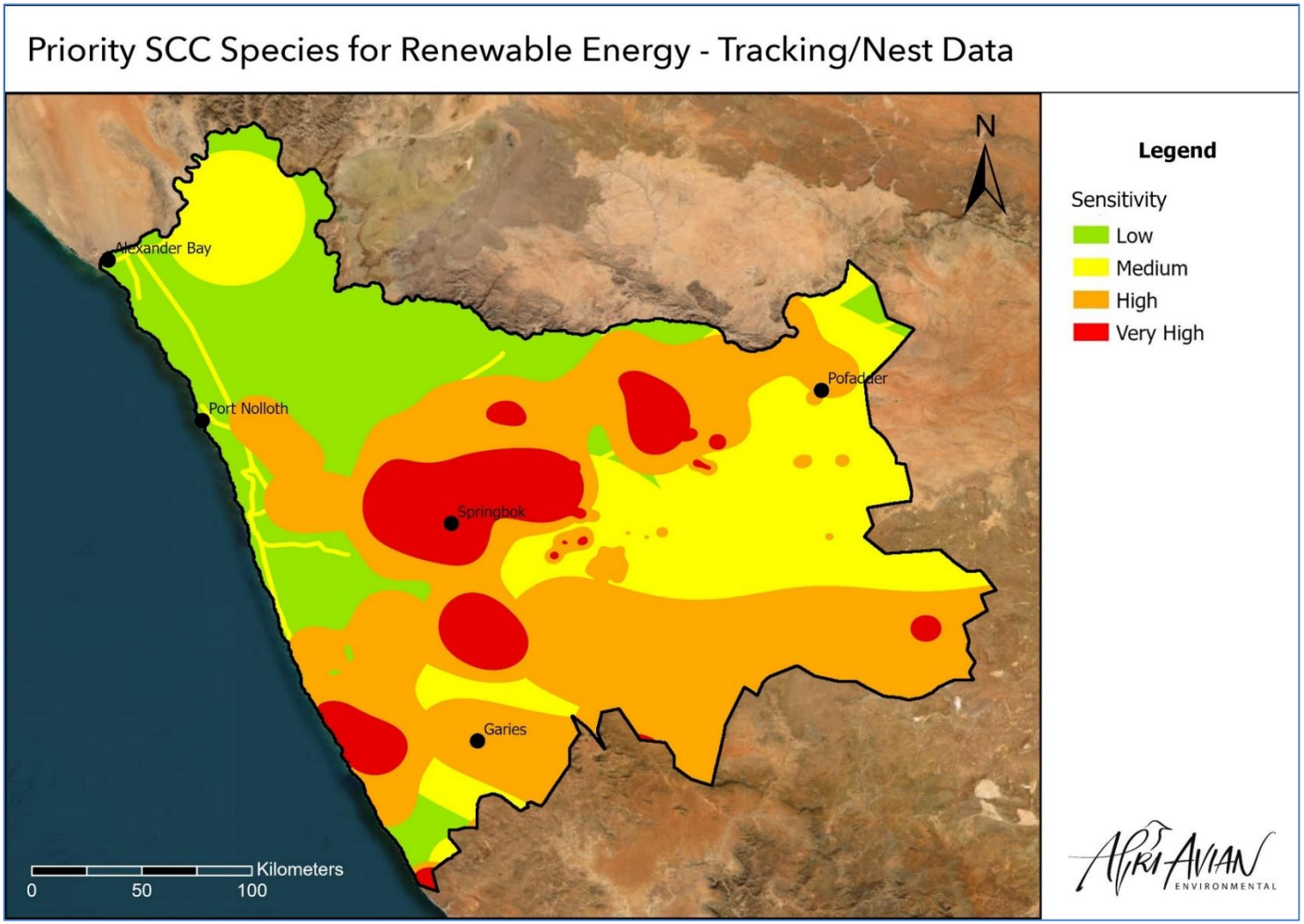

Figure 4: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating mainly nest/roost location data and GPS tracking data of 10 key priority SCC.

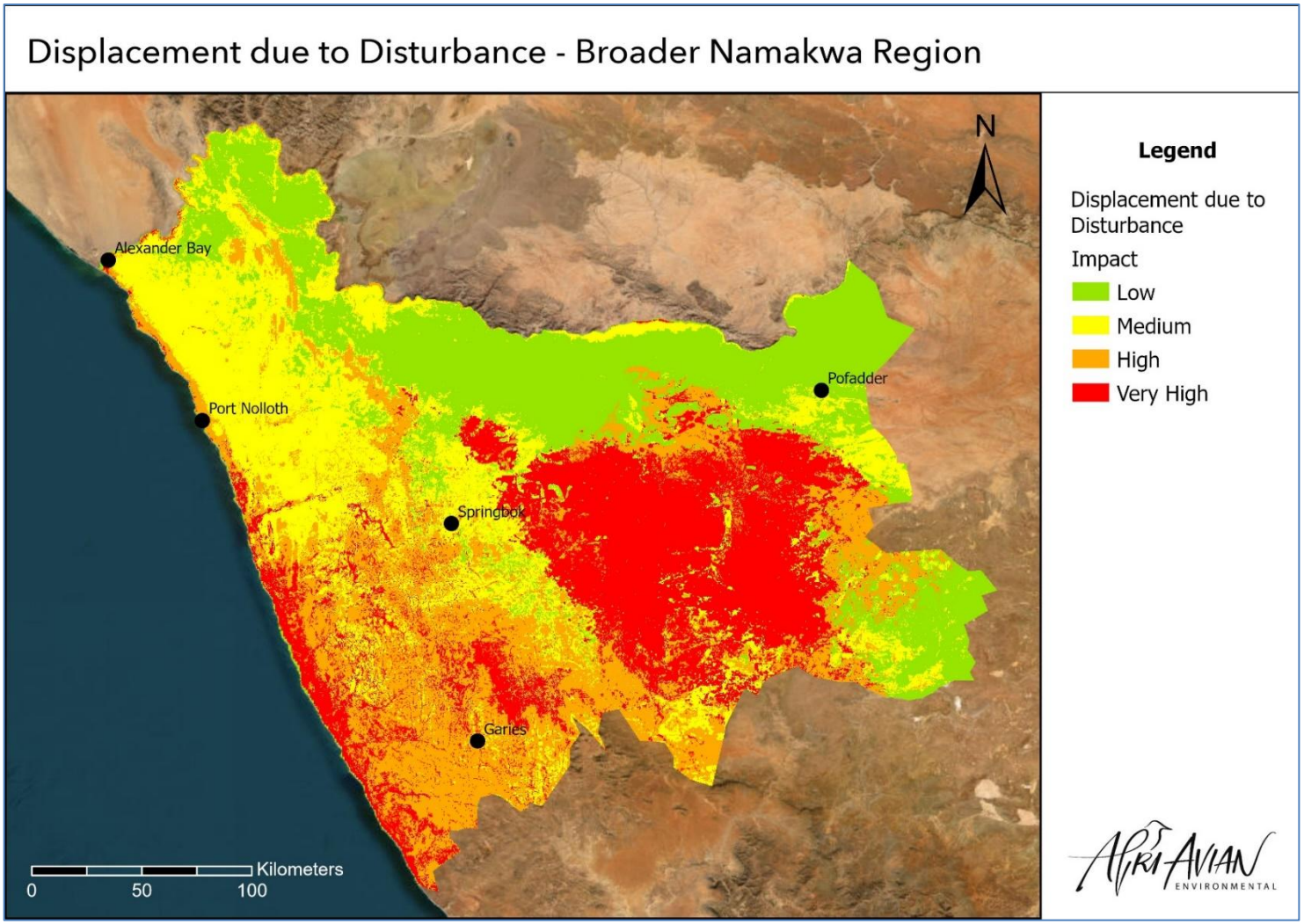

Figure 5: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of displacement due to disturbance.

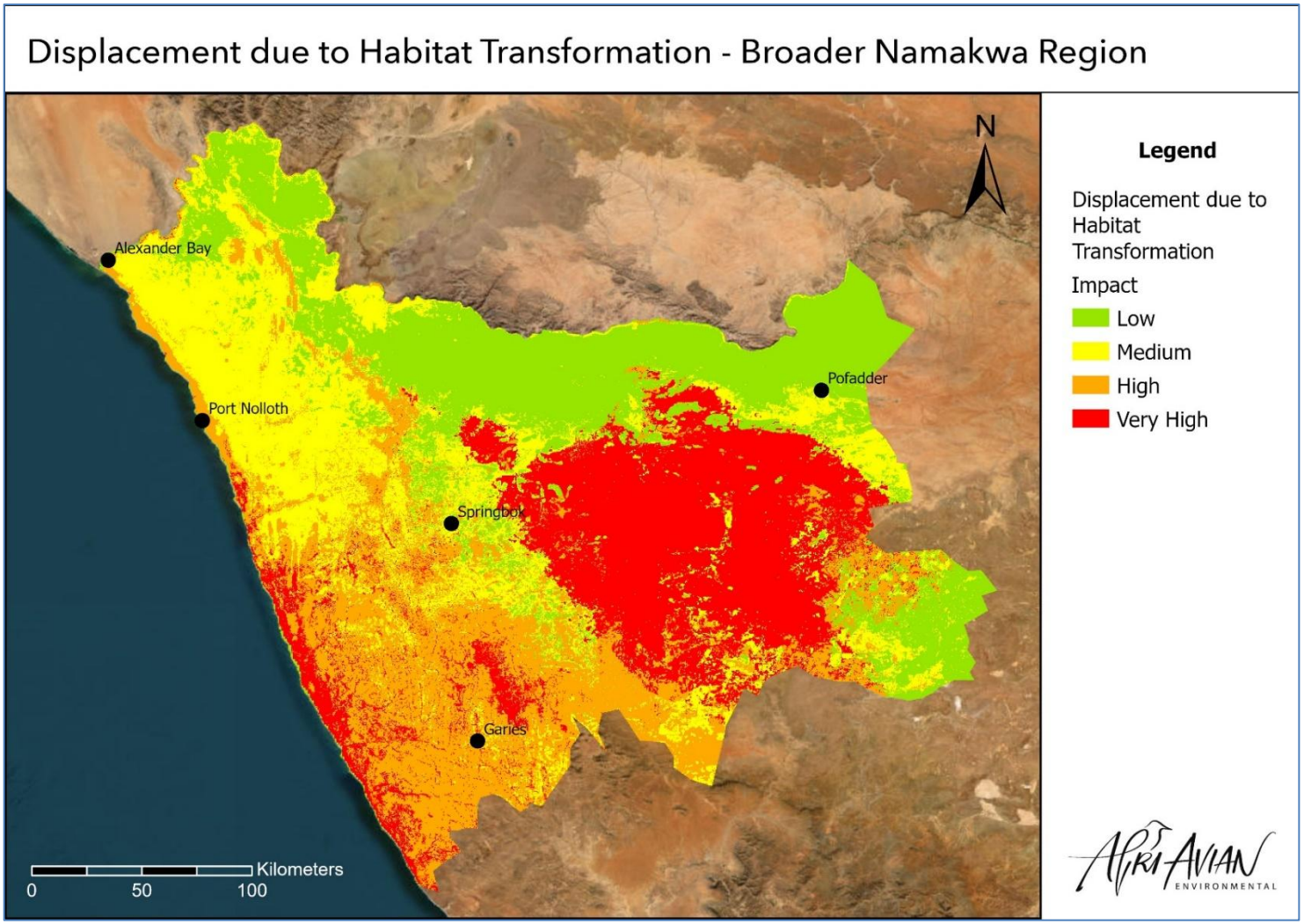

Figure 6: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of displacement due to habitat loss / fragmentation / transformation.

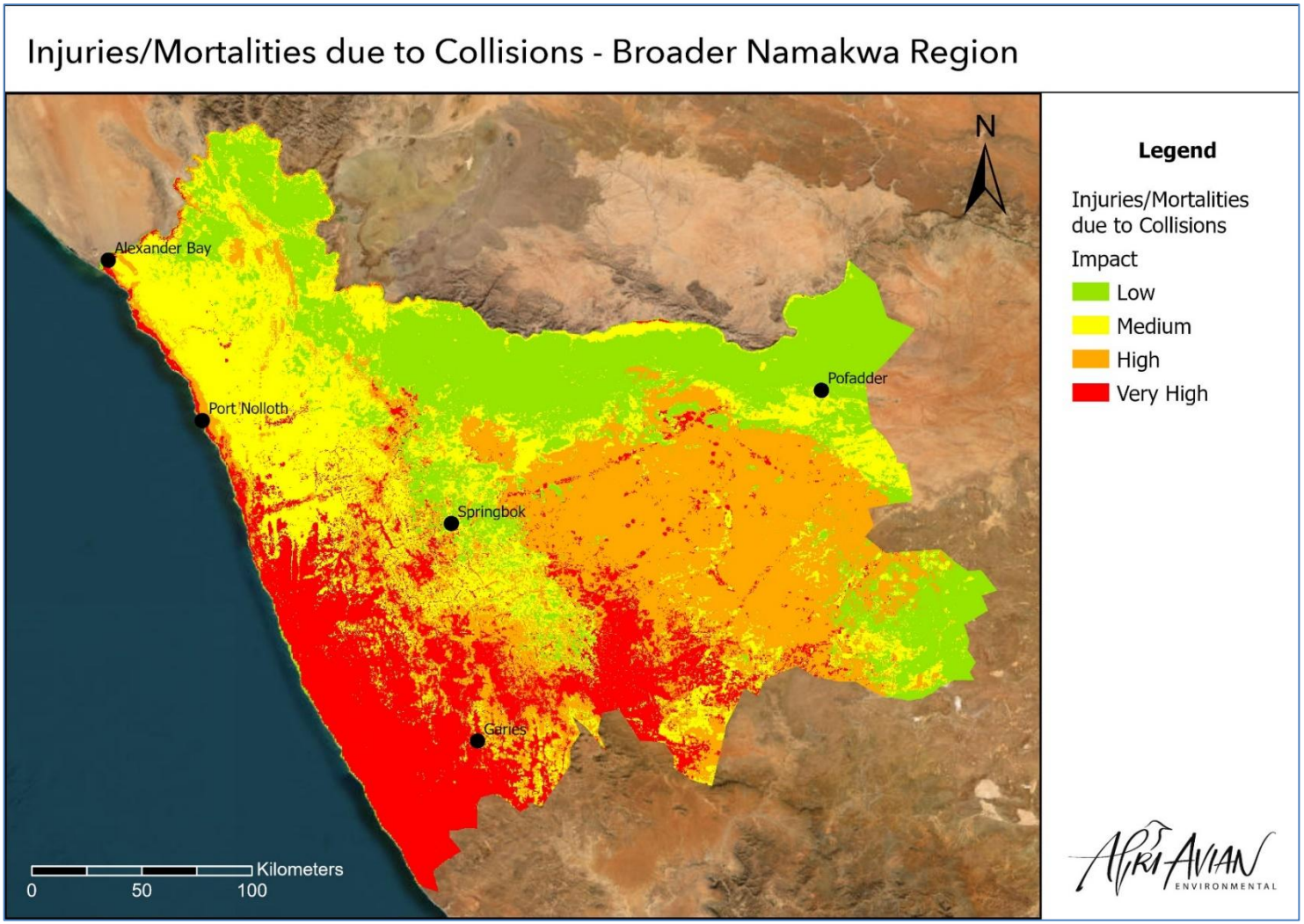

Figure 7: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of injuries or direct mortalities due to collisions.

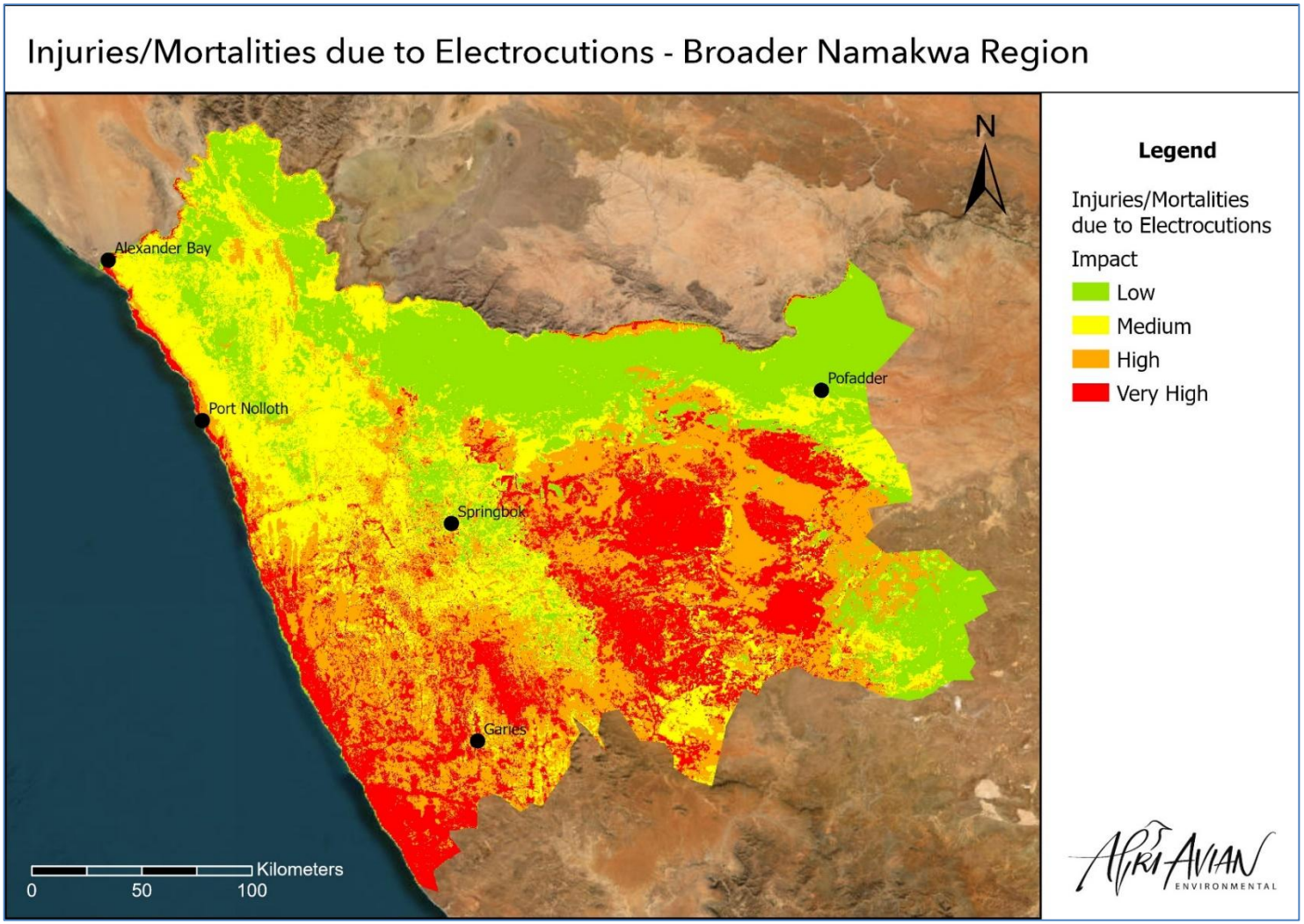

Figure 8: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of injuries or direct mortalities due to electrocutions.

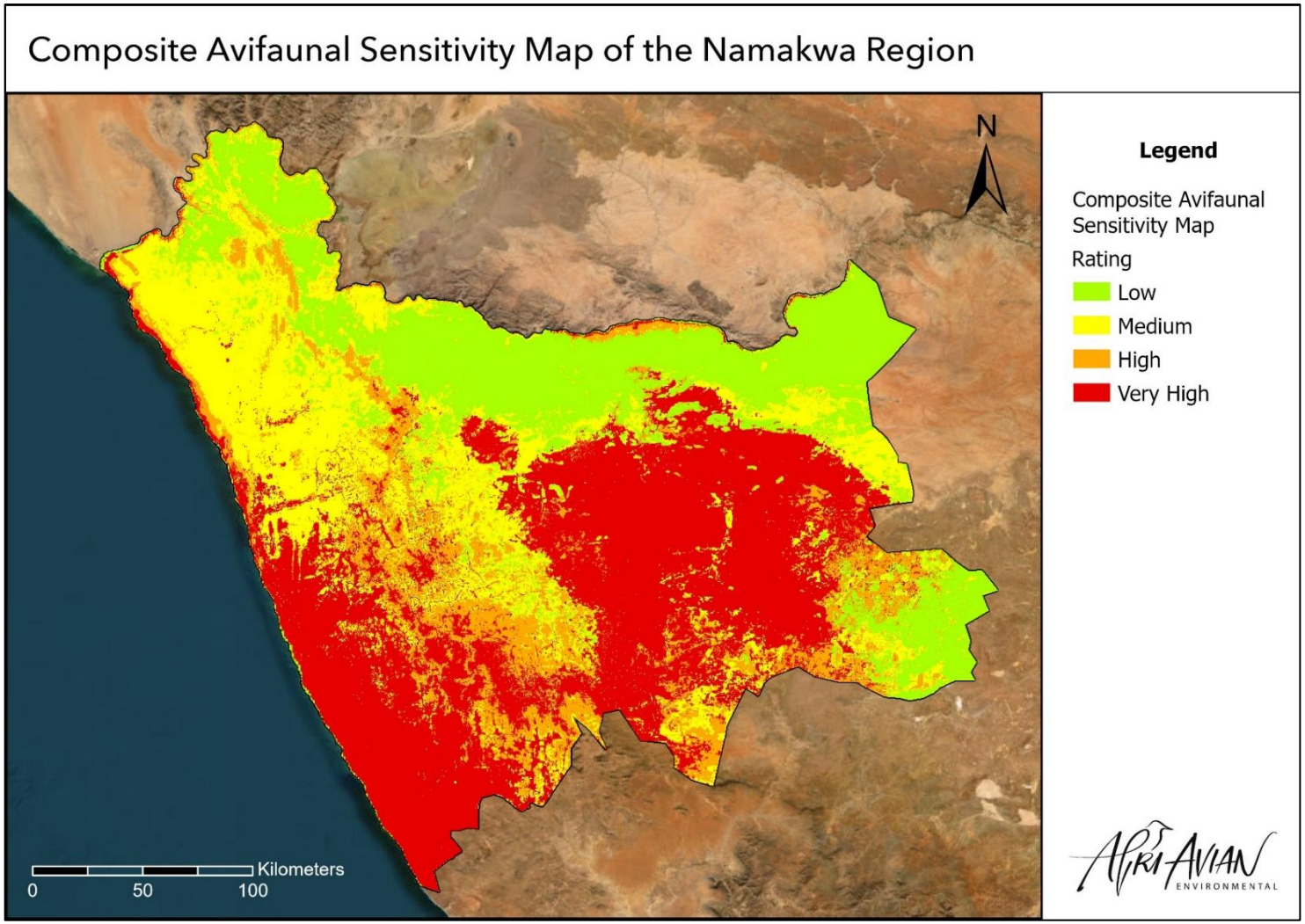

Figure 9: The composite avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment considering all four primary sensitivity layers applying the maximum rule.

7. RISK ASSESSMENT

7.1 How Risk is Determined

In this SEA, risk is determined by evaluating the likelihood of an impact occurring and the potential effect or consequence of that impact on priority avifaunal species occurring in the Namakwa Region (**Figure**).

For this avifaunal specialist assessment, undertaken as part of WP2 of the SEA, the potential impacts to avifauna (i.e., habitat loss, disturbance, collision and electrocution risk) are considered to be negative (-) in nature. At present, no direct or indirect opportunities for avifauna have been identified or are predicted under the current proposed project design and mitigation framework. That said, built-in safeguards such as biodiversity offsets, conservation servitudes, set-asides, micro-siting and collision deterrents are known to reduce adverse effects but remain classified as negative unless they deliver measurable net gains (e.g., new breeding sites, quantified increases in functional avifaunal habitat, and evidence that gains outweigh residual losses). As such, potential indirect opportunities for avifauna can be stipulated at a project-by-project level to potentially achieve an overall no net loss.

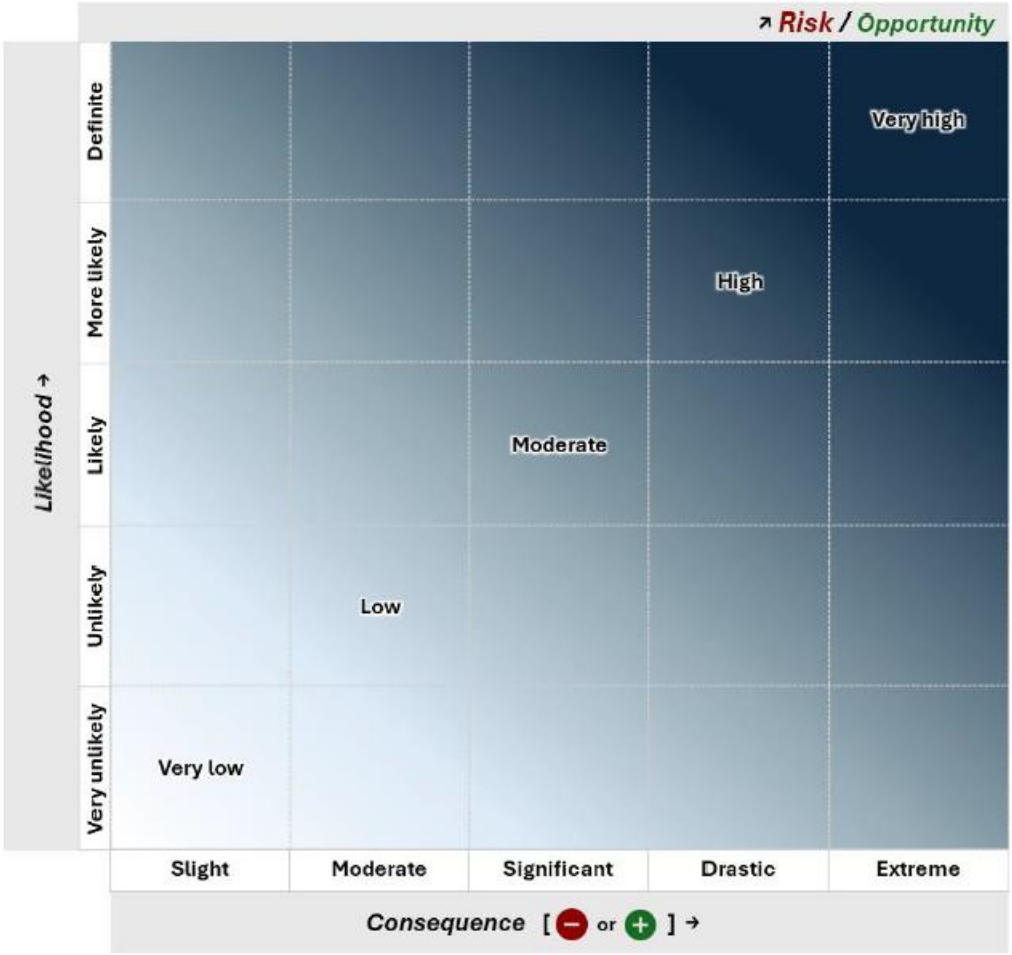

Figure 1: Risk and opportunity is qualitatively measured by multiplying the likelihood of an impact (negative or positive) by the severity of the consequence or benefit (Source: CSIR, 2025).

7.2 How Consequence is Determined

Consequence, also referred to as severity, refers to the potential outcome or effect if a risk or impact occurs. It is a key component in determining the overall level of risk and is assessed by evaluating the degree of harm or damage that could result.

In South African avifaunal specialist assessments, particularly those aligned with guidelines stipulated by BirdLife South Africa and Endangered Wildlife Trust, and in accordance with the Avifaunal Specialist Protocol (GNR 320 of 2020) in terms of the 2014 NEMA EIA Regulations (as amended) consequence thresholds are generally distinguished along a gradient of magnitude, extent, duration and reversibility of an impact occurring, and resultant conservation importance.

These consequence thresholds (**Table**) are often applied in impact significance matrices where consequence is combined with likelihood to determine overall significance ratings. For avifauna, the population viability context which include species' Red List status, range size, generation length and sensitivity to the impact mechanism, is central to assigning the correct threshold.

Table 4: Consequence thresholds defined for determining potential risk of impact to avifauna within the Namakwa Region

Threshold	Consequence levels defined for impact on Avifauna
Slight	Negligible to very low magnitude; localised; short-term; fully reversible; no measurable effect on population viability; affects only common/non-threatened/non-target species.
Moderate	Low to medium magnitude; local or limited regional extent; short- to medium-term; reversible with mitigation; may cause minor, non-sustained reductions in local abundance but no long-term viability risk.
Substantial	Medium magnitude; regional extent or affecting key habitats; medium- to long-term; partially reversible; measurable reduction in local population size or productivity; medium risk to one or more avifaunal species of conservation concern (Endemic and Near-Endemic species) but unlikely to threaten overall population persistence.
Severe	High magnitude; regional to national extent; long-term or permanent; largely irreversible; substantial reduction in population size or productivity; high risk to one or more avifaunal species of conservation concern (Vulnerable and Near-Threatened species) potentially affecting viability of local or metapopulations.
Extreme	Very high magnitude; national or global extent; permanent and irreversible; threatens survival of Endangered and Critically Endangered avifaunal species or leads to local extinction; affects critical habitats for Endangered and Critically Endangered avifaunal species.

7.3 How Risk Categories are Defined

Risk to avifauna in the Namakwa Region is assessed for each identified impact (see Section 3), considering the different types of avifaunal habitat characteristic of the study area (as described in Section 6.1), and incorporating the 44 priority avian species selected for this risk assessment (see Section 6.2), qualitatively against a predefined set of sensitivity criteria as described in Section 6.4 above. **Table** outlines the predefined risk categories utilised in this avifaunal risk assessment.

Table 5: Predefined risk categories applicable to the Avifaunal Risk Assessment for this SEA (Source: CSIR, 2025)

Risk (-) level	Category description
VERY LOW	Almost indiscernible negative impact
LOW	Slight negative impact, limited extent, and short duration, well within tolerance levels
MODERATE	Substantial impact, but less than major; within tolerance levels and below limits of acceptable change
HIGH	Major consequences, approaching tolerance and limits of acceptable change
VERY HIGH	Extremely negative impact, persistent/long lasting impact, beyond tolerance and limits of acceptable change

7.4 Risk Assessment with and without Mitigation

Table 6 shows the risk associated with the potential negative (-) impacts to priority avifaunal species determined for each development scenario: S0: Baseline Scenario, S1: Small scale GH_2 development, and S2: Big scale GH_2 development, for each sensitivity criteria, both with and without mitigation management.

It is important to note that the precautionary approach was exercised when following this risk assessment methodology and determining the risk associated with the potential negative (-) impacts to priority avifaunal species within the Namakwa Region.

Table 6: Risk Assessment determined for negative impacts to Avifauna within the Namakwa Region for each proposed GH_2 development scenario

Negative (-) impact	Development Scenario	Spatial receiving environment / receptor	Without management/mitigation			With management/mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Displacement due to disturbance such as noise, lighting and human activity	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH_2		Substantial	Definitive	Very High	Moderate	More likely	High
	S2: BIG GH_2		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	High Sensitivity	Moderate	Likely	Moderate	Slight	Likely	Moderate
	S1: SMALL GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH_2		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	Medium Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: SMALL GH_2		Moderate	More likely	High	Slight	Likely	Moderate
	S2: BIG GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
	S0: BASELINE	Low Sensitivity	Moderate	Likely	Moderate	Slight	Very unlikely	Very Low
	S1: SMALL GH_2		Moderate	More likely	High	Slight	Likely	Moderate
	S2: BIG GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
Displacement due to Habitat loss/ fragmentation/ transformation	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH_2		Extreme	Definitive	Very High	Severe	More likely	High
	S2: BIG GH_2		Extreme	Definitive	Very High	Severe	Definitive	Very High
	S0: BASELINE	High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH_2		Severe	More likely	High	Substantial	More likely	High
	S2: BIG GH_2		Extreme	Definitive	Very High	Severe	Definitive	Very High
	S0: BASELINE	Medium Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH_2		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	Low Sensitivity	Moderate	Unlikely	Low	Slight	Unlikely	Low
	S1: SMALL GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH_2		Substantial	Definitive	Very High	Substantial	More likely	High
Injury or mortality due to	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate

Negative (-) impact	Development Scenario	Spatial receiving environment / receptor	Without management/mitigation			With management/mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
collisions with wind turbines, solar panels, powerlines and masts/towers	S1: SMALL GH_2		Extreme	Definitive	Very High	Severe	More likely	High
	S2: BIG GH_2		Extreme	Definitive	Very High	Extreme	More likely	Very High
	S0: BASELINE	High Sensitivity	Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S1: SMALL GH_2		Severe	More likely	High	Substantial	Likely	Moderate
	S2: BIG GH_2		Extreme	Definitive	Very High	Severe	Likely	High
	S0: BASELINE	Medium Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: SMALL GH_2		Severe	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH_2		Severe	More likely	High	Substantial	Likely	Moderate
	S0: BASELINE	Low Sensitivity	Moderate	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: SMALL GH_2		Substantial	Likely	Moderate	Moderate	Very unlikely	Low
	S2: BIG GH_2		Substantial	More likely	High	Moderate	Likely	Moderate
Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: BASELINE	Very High Sensitivity	Severe	More likely	High	Substantial	Likely	Moderate
	S1: SMALL GH_2		Extreme	Definitive	Very High	Severe	More likely	High
	S2: BIG GH_2		Extreme	Definitive	Very High	Extreme	More likely	Very High
	S0: BASELINE	High Sensitivity	Severe	More likely	High	Substantial	Unlikely	Moderate
	S1: SMALL GH_2		Extreme	Definitive	Very High	Severe	Likely	High
	S2: BIG GH_2		Extreme	Definitive	Very High	Extreme	More likely	Very High
	S0: BASELINE	Medium Sensitivity	Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S1: SMALL GH_2		Severe	More likely	High	Substantial	Unlikely	Moderate
	S2: BIG GH_2		Severe	More likely	High	Severe	Likely	High
	S0: BASELINE	Low Sensitivity	Moderate	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: SMALL GH_2		Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S2: BIG GH_2		Severe	Likely	High	Substantial	Likely	Moderate

7.5 Recommended Management Responses for Risk Categories

The sensitivity mapping and risk categories used only provides a broad, strategic overview of the relative suitability and potential for development within and across the Namakwa Region. Even in areas of low sensitivity it is important that some form of project-level environmental impact assessment be undertaken to confirm and refine the outputs as presented in this SEA.

Where relevant, it is critical that implementation of one and/or more of the following recommended best practice measures be considered for the effective mitigation and management of negative impacts to avifauna when GH_2-related development activities are proposed:

- Habitat management and restoration (by restoring indigenous vegetation, re-establishing natural hydrology, and reconnecting fragmented patches outside the development footprint, while actively removing or mitigating on-site attractants such as open water or livestock/wildlife carcasses, bird species are drawn away from areas where potential collision, entanglement or disturbance risks are greatest).
- Anti-perching devices on tall infrastructure (bird-friendly pylon designs, insulated electrical components, meteorological masts and communication towers).
- Bird flight diverters (powerlines).
- Livestock/game carcass removal management.
- Turbine design (including height of blade tip from the ground).
- Turbine layout (e.g. not perpendicular to flight paths).
- Turbine blade cut-in speed.
- Shutdown on Demand (observer-led and automated including cameras and radar).
- Proactive curtailment (diurnal and nocturnal).
- Blade patterning.
- Monitoring, mitigation and proactive conservation beyond the facility footprint.

8. RECOMMENDED STRATEGIC MANAGEMENT ACTIONS TO MINIMISE AVIFAUNAL IMPACTS IN REGIONAL PLANNING

A regional approach should embed avifaunal risk management into Environmental Management Frameworks (EMFs), Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs), and downstream project-level Environmental Impact Assessments (EIAs) and Environmental Management Programmes (EMPrs) by setting clear spatial priorities, technology standards, and adaptive management rules. EMFs and SDFs can define strategic sustainability objectives, indicators, and targets that guide land-use and infrastructure planning across municipal IDPs and sector plans, improving consistency and decision quality at the EIA stage.

8.1 Sensitivity Mapping and Spatial Controls

- *Tiered sensitivity layers:* Map ecological features such as KBAs [previously Important Bird Areas (IBAs)], Red List species' status and their ranges, known flyways, nests, roosts/colonies,

wetlands/pans, shorelines and key foraging corridors, and then classify each as no-go, conditional / compatible or exclusion zones.

- *Buffers and setbacks:* Establish evidence-based buffers for wetlands, rivers, roosts/colonies, raptor and ground-dwelling species nests, coastal dunes, and pans (freshwater and saline). These buffers and setbacks require robust specialist motivation to deviate from.

- *Linear-infrastructure alignment:* Predefine preferred corridors for electricity grid, pipelines, roads, and rail to avoid high-risk avian areas and maintain landscape connectivity.

- *Cumulative "caps"*: Set development density/throughput thresholds for wind energy, solar energy, powerlines, GH_2 and port development within avian-sensitive landscapes to prevent cumulatively exceeding acceptable limits.

8.2 Mitigation Hierarchy and Policy Standards

- *Avoidance first*: Prioritise site screening to exclude high-risk features (e.g., vulture flight paths, crane breeding territories, tern islands, cormorant colonies).

- *Design optimisation*: Require technology-specific design standards (see Section 8.3 below) embedded as SDF/EMF overlays and standard EIA conditions.

- *Minimisation measures*: Implement recommended mitigation measures as included in the Environmental Management Programme (EMPr) for each proposed development application (see Section 7.5 above).

- *Offsets as last resort*: If residual impacts remain significant, apply like-for-like offsets with measurable, time-bound outcomes and independent verification (DFFE, 2023).

8.3 Technology-Specific Design Requirements

8.3.1 Wind Energy:

- *Siting controls:* Assign no-go buffers to critical habitat, key flight path corridors, nests and roosts/colonies, and apply micro-siting to avoid ridge saddles and thermalling zones.

- *Operational curtailment:* Mandatory automated/observer-based Shutdown-on-Demand protocols for high-risk wind priority species; implement seasonal curtailment where warranted.

- *Turbine specs:* Minimise hub-height/ rotor-diameter (shorter blade length) constraints to reduce risk of collision where species profiles support it.

8.3.2 Solar PV Energy:

- *Anti-attraction design:* Panel orientation/anti-reflective treatments; avoid "lake effect" near waterbird habitats.

- *Habitat retention:* Set aside vegetated corridors; manage fencing to permit small-fauna permeability, where safe.

8.3.3 Powerlines and Substations:

- *Collision mitigation:* High-performance (phosphorescent and staggered) bird flight diverters on high-risk spans; alignments parallel to topography and flyways to reduce crossings.

- *Electrocution mitigation:* Raptor-safe pole designs, adequate phase-conductor spacing, insulated jumpers, and perch guards where needed.

- *Substation aversion:* Netting and design to prevent perching/nesting in hazardous zones.

8.3.4 Masts and Towers:

- *Design/marking:* Minimise guyed masts; mark guy wires; use low-intensity, downward-shielded lighting.

- *Placement:* Avoid migratory corridors, wetlands, and ridgelines frequently used by soaring birds.

8.3.5 Roads, Rail and Pipelines:

- *Routing:* Avoid core/ critical habitats; maintain wetland hydrology with adequate culverts; minimise night works near breeding areas.

- *Operations:* Speed controls, carcass removal to deter scavenger activity, lighting management.

8.3.6 Desalination and Ports (where relevant):

- *Intakes/outfalls:* Low velocity screened intakes; offshore diffusers to protect prey bases; time construction to avoid breeding seasons.

- *Lighting and vessel traffic:* Shielded lighting; navigation protocols to reduce disturbance and strike risk.

8.4 Monitoring, Thresholds and Adaptive Management

- *Standardised monitoring:* Pre- and post-construction monitoring must follow consistent, defensible protocols, including systematic carcass searches with appropriate correction factors, carcass persistence and searcher efficiency trials, and standardised vantage point or activity budget surveys where relevant. All monitoring outputs should be integrated into municipal or regional data repositories to support cumulative impact tracking.

- *Thresholds of potential concern (TPCs):* Species- and site-specific trigger levels should be defined for collision rates, displacement indices, breeding success, and fatality thresholds. Exceedance of TPCs must automatically trigger corrective or adaptive management actions during construction and operations.

- *Adaptive responses:* A graduated suite of responses should be available when TPCs are exceeded, including enhanced line marking or bird flight diverters, additional curtailment windows, route adjustments for linear infrastructure, targeted habitat management, and intensified monitoring protocols.

- *Population context:* Monitoring results should be interpreted in relation to Potential Biological Removal (PBR) thresholds and, where data allow, Population Viability Analysis (PVA) for priority species. Development pacing and operational mitigation should be adjusted if cumulative risk approaches viability thresholds.

- *Environmental and logistical constraints to post-construction monitoring:* Post-construction fatality monitoring in the Namakwa Region may be constrained by several environmental and access-related factors that must be explicitly acknowledged in monitoring plans. Monitoring protocols should therefore be adapted to local conditions, with transparent documentation of limitations and the application of conservative correction factors where uncertainty is high –

- **Low carcass persistence** due to scavenger communities (jackals, corvids, raptors) may reduce detectability and require higher search frequencies or more intensive correction trials.
- **Challenging terrain and accessibility**, including rocky substrates, steep slopes, and remote turbine or transmission tower/line locations, may limit the feasibility of standardised transect searches and necessitate modified search designs.
- **Vegetation structure** (e.g., low shrubs, patchy cover) may influence detectability and require site-specific calibration of searcher efficiency.
- **Extreme weather conditions** (heat, wind, dust) may affect both carcass persistence and observer performance, requiring seasonal adjustments to monitoring intensity.
- **Safety and access restrictions** on private or mining-related land parcels may limit search coverage and require negotiated access agreements.
- **Remoteness and logistical constraints**: The Namakwa Region is vast, sparsely populated, and characterised by long travel distances between infrastructure sites. Deploying search teams is therefore time-consuming and costly, often requiring multi-day field trips, specialised vehicles, and careful scheduling to ensure adequate coverage. These logistical realities may limit search frequency and necessitate adaptive sampling designs, conservative correction factors, and transparent documentation of effort.

- *Species and area specific monitoring priorities:* Beyond standard monitoring requirements, certain species and landscape features in the Namakwa Region warrant enhanced or targeted monitoring due to their conservation status, mobility, or sensitivity to infrastructure. These enhanced monitoring requirements ensure that species with limited baseline data, high collision susceptibility, or regionally important populations are adequately assessed and that adaptive management is informed by the best available evidence –
  - **Large raptors (e.g., Vultures, Martial Eagle, Verreaux's Eagle):**
    - targeted collision-risk monitoring at turbines and transmission lines;
    - monitoring of known or potential roosts, nests, and foraging hotspots;
    - engagement with organisations such as VulPro and EWT to integrate rehabilitation and incidental observation data.
  - **Large terrestrial birds (e.g., Ludwig's Bustard, Kori Bustard, Blue Crane, Secretarybird):**
    - seasonal movement monitoring to detect shifts in habitat use;
    - targeted collision monitoring along transmission corridors and in topographic "funnel" areas.
  - **Wetland-associated species (e.g., flamingos, waterbirds):**
    - monitoring at ephemeral pans, estuaries, and inland wetlands where CWAC data indicate periodic high use;
    - assessment of disturbance or displacement linked to construction activity or increased traffic.
  - **High-risk landscape features:**
    - topographic ridgelines, escarpment edges, and valley funnels that concentrate flight paths;
    - areas adjacent to known breeding territories or communal roosts;
    - wetland or pan complexes that attract seasonal aggregations.

8.5 Governance, Permitting, and Data Management

- *Standard conditions:* Include avifaunal design standards and fatality monitoring, construction method statements, seasonal constraints, and independent Environmental Control Officer (ECO) oversight in approvals.
- *Cumulative reviews:* Require project-level EIAs to assess cumulative effects against EMF/SDF caps and regional monitoring data, not only project-alone impacts.
- *Open data:* Mandate submission of monitoring datasets (incl. GenEst[5] inputs/outputs) to a provincial repository to inform ongoing planning.
- *Capacity and coordination:* Establish a regional avifaunal technical forum (municipality, conservation NGOs, grid operators, developers) to review data and recommend adaptive policy updates.

8.6 Incentives and Financing

- *Performance-based approvals:* Fast-track low-risk sites and designs meeting gold-standard avifaunal criteria.
- *Mitigation funding:* Create a regional levy or biodiversity fund for retrofitting legacy powerlines, securing buffer habitats, and managing predator control where appropriate.

9. CONCLUSIONS AND RECOMMENDATIONS

The Namakwa Region, located mostly within the Succulent Karoo Biodiversity Hotspot, is of exceptional avifaunal importance and contains 15 Key Biodiversity Areas crucial for many threatened, endemic and range restricted avifaunal species. Spatial sensitivity mapping confirms extensive Very High and High avian sensitivity zones across the study area, particularly for wind farm related impacts.

The risk assessment shows that without mitigation, both Small GH_2 and Big GH_2 development scenarios present High to Very High risks to priority avifaunal species, especially in very high sensitivity areas. The Big GH_2 scenario carries the greatest cumulative risk, with potential severe to extreme consequences for Endangered and Critically Endangered species. Even with best practice mitigation, residual impacts remain substantial in habitats, especially high and very high sensitivity for the priority avifaunal species assessed.

Key impact pathways relating to priority avifauna include:

- Displacement from disturbance and habitat loss/fragmentation.
- Collisions with wind turbines, powerlines, and other tall structures.
- Electrocutions on transmission and distribution infrastructure.

The Namakwa Region's exceptional avifaunal diversity faces substantial risk from large scale GH_2 and associated infrastructure development given the scale of the proposed infrastructure required. Strategic avoidance of high and very high sensitivity areas, rigorous application of the mitigation hierarchy, and the implementation of robust monitoring frameworks are essential to balance renewable energy ambitions, associated with the GH_2 development proposal for the Boegoebaai Port and SEZ, with biodiversity

[5] A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (https://www.usgs.gov/software/genest-a-generalized-estimator-mortality).

conservation in the broader Namakwa Region. The SEA and this avifaunal risk assessment therefore provide a defensible, spatially explicit framework to guide sustainable regional planning for development and safeguard irreplaceable bird populations.

Key recommended strategic management actions resulting from this avifaunal risk assessment include:

1. Spatial Planning & Sensitivity Controls

Embed avifaunal sensitivity mapping into planning tools (such as EMFs, SDFs, IDPs), designate no-go zones for critical habitats, apply science-based buffers, align infrastructure to avoid very high and high-risk areas, and cap cumulative development in sensitive landscapes.

2. Technology-Specific Standards

Adopt bird-safe design and operational mitigation measures for wind, solar, powerlines, masts, and port/desalination facilities to minimise collisions, electrocution, and disturbance risks through siting, engineering, and seasonal restrictions.

3. Monitoring & Adaptive Management

Use standardised pre- and post-construction monitoring protocols with GenEst[6], set Thresholds of Potential Concern (TPCs), link results to Potential Biological Removal (PBR) rates and Population Viability Analysis (PVA), and trigger adaptive measures when thresholds are exceeded.

4. Governance & Data Management

Mandate avifaunal standards and independent oversight in approvals, require cumulative impact reviews, ensure open data sharing, and establish a regional technical forum for coordinated decision-making.

5. Incentives & Financing

Fast-track low-risk, high-standard projects and fund biodiversity actions, such as retrofitting hazardous infrastructure and securing key habitats, through a dedicated conservation fund.

[6] A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (https://www.usgs.gov/software/genest-a-generalized-estimator-mortality).

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11. ANNEXURE A

ANNEXURE A: Table detailing the species-impact scoring framework that defines the sensitivity categories underpinning the multiplicative weighting system used to enable the spatial risk mapping for this avifaunal specialist assessment—see Section 6.4 to Section 6.6 for a detailed description.

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_ weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_ weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Jackal Buzzard		NE	4549885	Large	1	1	3	3	1	3	2	6	4	12	3	9
Ludwig's Bustard	EN		4431321	Large	8	1	1	8	2	16	3	24	4	32	1	8
Karoo Eremomela		NE	3480362	Medium	1	5	3	15	1	15	2	30	1	15	1	15
Black-headed Canary		NE	3477791	Medium	1	5	3	15	1	15	2	30	2	30	1	15
Black Harrier	EN	NE	2541556	Medium	8	5	3	120	2	240	3	360	4	480	1	120
Karoo Korhaan	NT		2223362	Large	2	1	1	2	1	2	2	4	4	8	1	2
Black-eared Sparrow-Lark		NE	1969719	Medium	1	5	3	15	1	15	3	45	1	15	1	15
Burchell's Courser	VU		1899542	Medium	4	5	1	20	1	20	3	60	2	40	1	20
Secretarybird	EN		1730344	Medium	8	5	1	40	2	80	3	120	3	120	2	80
Cape Clapper Lark		NE	1257024	Medium	1	5	3	15	1	15	3	45	1	15	1	15
Red Lark	VU	E	1255419	Small	4	10	5	200	2	400	4	800	3	600	1	200
Lanner Falcon	NT		1202044	Large	2	1	1	2	1	2	2	4	4	8	2	4
Cape Eagle-Owl			1063543	Medium	1	5	1	5	2	10	3	15	3	15	2	10
Sclater's Lark	NT	NE	994121	Medium	2	5	3	30	2	60	3	90	1	30	1	30
Southern Black Korhaan	VU	E	876964	Medium	4	5	5	100	1	100	2	200	4	400	1	100

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_ weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_ weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Verreaux's Eagle	VU		681532	Large	4	1	1	4	1	4	2	8	4	16	4	16
Cinnamon-breasted Warbler		NE	648753	Medium	1	5	3	15	2	30	3	45	1	15	1	15
Cape Spurfowl		NE	647396	Medium	1	5	3	15	1	15	2	30	2	30	1	15
Ground Woodpecker	NT	SLS	614111	Medium	2	5	5	50	2	100	3	150	1	50	1	50
Martial Eagle	EN		522475	Large	8	1	1	8	1	8	2	16	4	32	4	32
Cape Long-billed Lark		E	500163	Medium	1	5	5	25	1	25	3	75	1	25	1	25
African Fish Eagle			339981	Large	1	1	1	1	1	1	2	2	3	3	2	2
Black Harrier	EN	NE	267195	Medium	8	5	3	120	2	240	3	360	4	480	1	120
Cape Rock Thrush		SLS	202608	Large	1	1	5	5	1	5	3	15	1	5	1	5
Grey-winged Francolin		SLS	183958	Medium	1	5	5	25	1	25	3	75	2	50	1	25
Maccoa Duck	EN		148242	Medium	8	5	1	40	1	40	2	80	2	80	1	40
African Rock Pipit	NT	SLS	143003	Medium	2	5	5	50	1	50	2	100	2	100	1	50
Blue Crane	VU		131653	Medium	4	5	1	20	2	40	3	60	4	80	1	20
Greater Flamingo	NT		129414	Large	2	1	1	2	2	4	3	6	4	8	1	2
Curlew Sandpiper	VU		105250	Medium	4	5	1	20	1	20	2	40	1	20	1	20
Caspian Tern	VU		73302	Large	4	1	1	4	1	4	2	8	2	8	1	4
Peregrine Falcon			66138	Large	1	1	1	1	1	1	2	2	4	4	2	2
Black Stork	EN		60809	Medium	8	5	1	40	2	80	2	80	4	160	2	80
Sentinel Rock Thrush	NT	SLS	39864	Medium	2	5	5	50	1	50	3	150	1	50	1	50

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_ weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_ weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Damara Tern	EN		32984	Small	8	10	1	80	1	80	2	160	2	160	1	80
African Marsh Harrier	VU		30611	Medium	4	5	1	20	2	40	3	60	3	60	1	20
Great White Pelican	VU		30565	Medium	4	5	1	20	1	20	2	40	3	60	3	60
Black Stork	EN		26412	Medium	8	5	1	40	2	80	2	80	4	160	2	80
Bateleur	EN		23835	Small	8	10	1	80	2	160	2	160	3	240	3	240
Barlow's Lark			20149	Small	1	10	1	10	1	10	3	30	1	10	1	10
Chestnut-banded Plover	VU		15181	Medium	4	5	1	20	1	20	3	60	1	20	1	20
Cape Vulture	VU		10238	Large	4	1	1	4	1	4	2	8	4	16	4	16
Cape Sugarbird		E	8336	Medium	1	5	5	25	1	25	3	75	1	25	1	25
Orange-breasted Sunbird		E	5151	Medium	1	5	5	25	1	25	3	75	1	25	1	25

CHAPTER 2b

Bats

CHAPTER 2b:
Bats

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Appointment of Specialist

Study:	Chapter 2b: Bats. Strategic environmental assessment for the proposed Boegoebaai port, special economic zone (SEZ) and the Namakwa region. Work Package 2 – Namakwa region
Specialist:	Werner Marais
Professional Registration Number:	400169/10 – SACNSAP (South African Council for Natural Scientific Professions) – Zoological Science
Specialist Company:	Animalia Consultants (Pty) Ltd.
Report completed by:	Werner Marais & Rebecca Welch
Appointed by:	Council for Scientific and Industrial Research (CSIR)

Independence

Animalia Consultants (Pty) Ltd has no connection with the developer or any other party who stands to gain financially should the proposed development be approved by the relevant decision-making authorities. Animalia Consultants (Pty) Ltd is not a subsidiary, legally or financially, of the developer. Animalia Consultants (Pty) Ltd's remuneration for services by the developer in relation to this proposal is not linked to the approval by the decision-making authorities responsible for permitting this proposal.

Animalia Consultants (Pty) Ltd herewith discloses that it also renders services and distributes certain products that may assist in minimising and monitoring environmental impacts during the operational phase of renewable energy developments. This report is based on sound scientific principles and industry best practices and is in no way subject to or premised on Animalia Consultants (Pty) Ltd's aforementioned services and products. Animalia Consultants (Pty) Ltd thus confirms that it is independent as is defined in the Environmental Impact Assessment Regulations of 2014 and that its report herein is objective.

Applicable Legislation

Legislation dealing with biodiversity applies to bats and includes the following:

- NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; Especially sections 2, 56 & 97). The Act calls for the management and conservation of all biological diversity within South Africa. Bats constitute an important component of South African biodiversity and therefore all species receive attention, in addition to those listed as Threatened or Protected.

Applicable Guidelines

Guidelines dealing with biodiversity applies to bats and includes the following:

- THE SOUTH AFRICAN BEST PRACTICE GUIDELINES for pre-construction studies recommends sensitivity map buffer rules and mitigation by avoidance. MacEwan, K., Sowler, S., Aronson, J., and Lötter, C. 2020. *South African Best Practice Guidelines for Pre-construction Monitoring of Bats at Wind Energy Facilities - ed 5*. South African Bat Assessment Association.

- THE BAT MORTALITY THRESHOLD GUIDELINES impose sustainable bat mortality thresholds for operating wind farms, indicating when wind farms need to apply active mitigation measures. MacEwan, K., Aronson, J., Richardson, E., Taylor, P., Coverdale, B., Jacobs, D., Leeuwner, L., Marais, W., Richards, L. 2020. *South African Bat Fatality Threshold Guidelines – ed 3*. South African Bat Assessment Association.

Executive Summary

Animalia Consultants (Pty) Ltd ('Animalia') was appointed by the Council for Scientific and Industrial Research ('CSIR') to conduct a Bat Specialist Assessment for the Strategic Environmental Assessment (SEA) of the proposed Boegoebaai Port, Special Economic Zone (SEZ) that would support the green hydrogen economy and required renewable energy development in the Namakwaland region, South Africa. The development of green hydrogen and its derivatives (e.g., green ammonia, green methanol) aims to decarbonise the South African energy sector, create jobs and skills, and support a Just Energy Transition. This assessment focuses on the Richtersveld, Nama Khoi, Kamiesberg, and Khaî Ma Local Municipalities, covering approximately 5.8 million hectares, and highlights key bat-related sustainability considerations for the proposed regional renewable energy developments.

Site Sensitivity Analysis

The bat sensitivity assessment categorised areas based on their relative importance for roosting, foraging, and conservation value, providing a framework to guide development planning and risk avoidance (**Figure (i)**). Areas of **very high or high sensitivity** represent habitats with exceptional to strong roosting or foraging potential, high bat activity, or the presence of species of conservation concern. These areas pose significant risks to bat populations and are generally unsuitable for development. **Medium sensitivity** areas have moderate or uncertain bat activity and may host Near Threatened or Rare species. Development may be possible here but requires detailed, site-specific assessment and mitigation during the EIA phase. **Low sensitivity** areas offer limited roosting or foraging potential and low bat activity, making them comparatively more suitable for development, though local sensitivities must still be verified through further investigation.

Areas of Very High Sensitivity include open water sources, perennial rivers, wetlands, coastlines, protected areas, and bat roosts. These features are crucial for bat activity as they offer water, moisture, and abundant insect or fruit food sources, with roosts being particularly important due to the potential for large-scale impacts on bat populations. High Sensitivity zones are associated with limestone geology, which may contain undiscovered caves that serve as ideal roosting habitats. Medium Sensitivity areas include non-perennial watercourses, where seasonal moisture may attract insect prey, supporting bat foraging. Low Sensitivity applies to all remaining areas without these specific features. In addition to these categories, Roost Investigation Zones and Roost Caution Zones are identified around known bat roosts, with their size and importance determined by species, colony size, and roost type, highlighting areas that may be used extensively by bats and therefore require careful consideration.

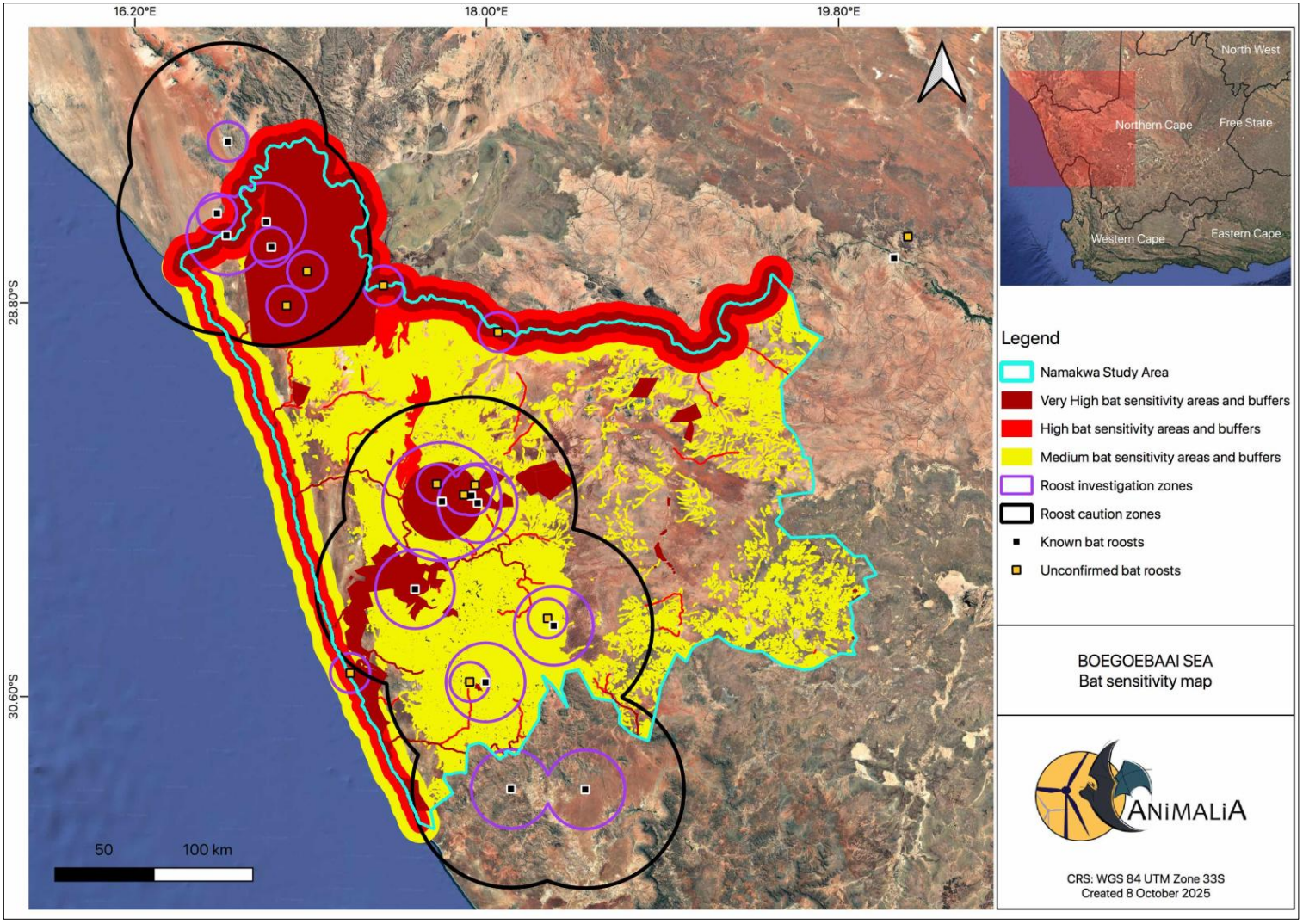

Figure (i). Bat sensitivity map of the Namakwa study region, showing Very High, High, Medium and Low sensitivity zones and their buffers. As well as Roost Investigation and Roost Caution zones

Impact Assessment

Three potential negative impacts on bats have been identified in relation to the proposed expansion of renewable energy infrastructure within the Namakwa Region, namely the **destruction or disturbance of bat roosts** during construction, the **loss and fragmentation of foraging habitat** during construction and operation, and **bat mortalities** due to direct blade impact or barotrauma during foraging and migration. Each identified impact has been assigned a consequence, likelihood, and overall risk rating for each development scenario (Sc0, Sc1, and Sc2). For each impact under all development scenarios, risk to bats increases with both project scale and habitat sensitivity. Very High and High sensitivity areas present the greatest risk, with impacts remaining High to Very High even after mitigation. Medium sensitivity areas show moderate risks that can be reduced through effective management, while Low sensitivity areas consistently represent minimal risk. While the level of risk varies between scenarios, all potential impacts show a reduction in risk when appropriate mitigation and management measures are implemented. The risks associated with each impact, across all scenarios and sensitivity tiers, both before and after mitigation, are summarized below:

Table (i). Risks to bats associated with each impact across all scenarios and sensitivity tiers, both before and after mitigation

Scenario	Sensitivity Tier	Impact	Risk Without Mitigation	Risk With Mitigation
S0: Baseline	Very High	Roost disturbance	Moderate	N/A
		Habitat loss	Moderate	N/A
		Bat mortalities	High	N/A
	High	Roost disturbance	Moderate	N/A
		Habitat loss	Moderate	N/A
		Bat mortalities	Moderate	N/A
	Medium	Roost disturbance	Low	N/A
		Habitat loss	Low	N/A
		Bat mortalities	Low	N/A
	Low	Roost disturbance	Very Low	N/A
		Habitat loss	Very Low	N/A
		Bat mortalities	Low	N/A
S1: Small GH2	Very High	Roost disturbance	High	High
		Habitat loss	High	High
		Bat mortalities	Very High	High
	High	Roost disturbance	High	Moderate
		Habitat loss	High	Moderate
		Bat mortalities	High	Moderate
	Medium	Roost disturbance	Moderate	Low
		Habitat loss	Moderate	Low
		Bat mortalities	Moderate	Low
	Low	Roost disturbance	Low	Very Low
		Habitat loss	Low	Very Low
		Bat mortalities	Moderate	Low

Scenario	Sensitivity Tier	Impact	Risk Without Mitigation	Risk With Mitigation
S2: Big GH2	Very High	Roost disturbance	Very High	Very High
		Habitat loss	Very High	Very High
		Bat mortalities	Very High	Very High
	High	Roost disturbance	High	High
		Habitat loss	High	High
		Bat mortalities	Very High	High
	Medium	Roost disturbance	High	Moderate
		Habitat loss	High	Moderate
		Bat mortalities	Moderate	Moderate
	Low	Roost disturbance	Low	Low
		Habitat loss	Low	Low
		Bat mortalities	Moderate	Low

Strategic Management Recommendations

To manage and mitigate the potential impacts of renewable energy and green hydrogen (GH_2) development, the following strategic actions are recommended:

National Policy:

- Operational bat mortality monitoring reports from wind energy facilities should be shared with DFFE and SABAAP to support ongoing development of effective mitigation measures.
- Conduct a national-scale SEA spatial risk analysis to identify areas unsuitable for GH_2, PV, or wind energy development, preventing proposals in Very High-risk areas.

Regional Planning:

- Avoid renewable energy or GH_2 development in areas of Very High bat sensitivity, using the sensitivity analysis and impact-risk assessment to guide proposals.
- Initiate research to map migratory routes of cave-dwelling bats within and near the Namakwa Region.

Future EIA Studies:

- Preconstruction bat studies for wind energy facilities should cover a minimum of 12 months, including at least 75% of the rainy season, to account for seasonal and climatic variability.
- Bat EIA studies should account for potential fruit bat activity, considering proximity to natural or agricultural food sources, and monitor non-echolocating species.
- Studies must consider the Near Threatened *Cistugo seabrae* (Angolan Hairy Bat), addressing knowledge gaps in its behaviour, habitat use, and turbine collision risk.
- It is critical for Roost Investigation zones around bat roosts to receive further field investigations during the EIA phase of a renewable energy project to verify species presence, colony size, and roost significance.

- If a proposed renewable energy project is located within a Roost Caution zone, the identified roost must be explicitly considered during the EIA process. The study design and data analysis should make appropriate provision for roost location, species, and potential impacts to determine if species present in the applicable roost may be impacted by the proposed project.

Enhancing Positive and Reducing Negative Impacts:

- Preserve non-transformed habitats to maintain the floral and faunal biodiversity that supports bat populations.

- Ensure that Very High sensitivity areas are avoided for any renewable energy or GH_2 development proposals, integrating regional-level risk assessments for planning and site selection.

- Initiate research programs and projects to contribute data and knowledge required for the long-term positive benefit of bat conservation in the Namakwa region.

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Abbreviations

Abbreviation	Explanation
ACR	African Chiroptera Report
CSIR	Council for Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and Environment
EIA	Environmental Impact Assessment
PLP	Polarized light pollution
PV	Photovoltaic
REDZ	Renewable Energy Development Zone
SABAA	South African Bat Assessment Association
SABAAP	South African Bat Assessment Association Panel
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
WEF	Wind Energy Facility

1. INTRODUCTION

Animalia Consultants (Pty) Ltd (hereafter 'Animalia') has been appointed by Council for Scientific and Industrial Research (hereafter 'CSIR), to undertake a Bat Specialist Assessment for the Strategic Environmental Assessment (SEA) of the Proposed Green Hydrogen economy and associated renewable energy (wind energy and solar voltaic) within the Namakwa Region, South Africa.

This report will highlight the key bat-related sustainability considerations associated with the development of a Northern Cape Green Hydrogen economy. The assessment will focus on parts of the Namakwa District, including the Richtersveld, Nama Khoi, Kamiesberg, and Khaî Ma Local Municipalities, collectively covering approximately 5.8 million hectares.

1.1 Terms of reference

The objectives and terms of reference for the strategic environmental assessment are the following from a bat impact perspective:

- Describe the existing baseline characteristics of the regional area, including existing impacts in the region;
- Classify spatial regions according to their sensitivity to bats, identifying which regions are more or less suitable for future development;
- Identify strategic-level constraints, opportunities, impacts, and strategic management actions to protect bats;
- Provide a bat sensitivity map indicating areas of avoidance and mitigation zones for the proposed region.
- Recommend mitigation measures to avoid and/or minimise impacts and/or optimise benefits associated with the expansive regional renewable energy (wind and solar PV) generation and transmission infrastructure; and
- Provide an integrated decision-making framework to guide project developers, practitioners, and policymakers to minimise the impacts on bats.

1.2 The bats of South Africa

Bats form part of the order Chiroptera and are the second largest group of mammals after rodents. They are the only mammals to have developed true powered flight and have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are compact and light, thereby reducing the total body weight. This unique wing profile allows for the manipulation of wing camber and shape, exploiting functions such as agility and manoeuvrability. This adaption surpasses the static design of bird wings in function and enables bats to utilise a wide variety of food sources, including, but not limited to, a large diversity of insects (Neuweiler 2000). Species-based facial features may differ considerably as a result of differing lifestyles, particularly in relation to various feeding and echolocation navigation strategies.

Most South African bats are insectivorous and can consume large quantities of insects each night (Taylor 2000; Tuttle & Hensley 2001). Some species also feed on amphibians, fruit, nectar and other invertebrates (Rautenbach 1982; Taylor 2000). Collectively, bats deliver critical ecosystem services, notably insect pest regulation, pollination and seed dispersal, that underpin ecosystem stability as well as agricultural productivity and human well-being (Tuneu-Corral *et al.* 2023). Fruit bat-mediated pollination is increasingly threatened by climate change (Ratto *et al.* 2018; Zamora-Gutierrez *et al.* 2021), while seed dispersal by fruit bats is important for forest regeneration and has substantial economic value (van Toor *et al.* 2019). Large, abundant populations of insectivorous and fruit bats are particularly important for

maintaining these services (Winfree *et al*. 2015), and migratory species can further suppress local insect pest outbreaks that resident predators cannot control (McCracken *et al.* 2012). Bats are, however, highly sensitive to human pressures — including habitat loss, pesticides, agricultural intensification, invasive predators (e.g. free-ranging cats), hunting, collisions with vehicles and wind turbines, and climate change (Frick *et al.* 2020).

Bats are regarded as keystone species within cave ecosystems (Tanalgo *et al.* 2022). Their presence supports a wide range of highly specialised and often endemic cave-dwelling organisms, many of which depend on bat guano as their primary nutrient source (Ferreira 2019; Furey and Racey 2016). Globally, it is estimated that at least half of all bat species make use of caves for roosting, either seasonally or throughout their life cycle (Furey and Racey 2016). As such, bats play a central role in maintaining the ecological functioning of cave systems and can serve as valuable ecological indicators and conservation surrogates, providing insight into ecosystem health and priorities for safeguarding (Ferreira 2019; Cunha *et al.* 2020).

Urban development and agricultural practices have contributed to the deterioration of bat populations on a global scale. Public participation and funding of bat conservation are often hindered by negative public perceptions and unawareness of the ecological importance of bats. Some species choose to roost in domestic residences, causing disturbance and thereby decreasing any esteem that bats may have established. Other species may occur in large communities in buildings, posing as a potential health hazard to residents in addition to their nuisance value. Unfortunately, the negative association with bats obscures their importance as an essential component of ecological systems and their value as natural pest control agents, which actually serves as an advantage to humans.

Many species of bats roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities concurrently (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity of up to 30 years (O'Shea *et al*. 2003) and the relatively low predation of bats when compared to other small mammals. However, bat populations are not able to adequately recover after mass mortalities and major roost disturbances.

1.3 Bats and wind turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case-study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesized that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, most bat mortalities have been found to be caused by barotrauma (Baerwald *et al*. 2008). This is a condition where low air pressure found around the moving blades of wind turbines causes the lungs of a bat to collapse, resulting in fatal internal haemorrhaging (Kunz *et al*. 2007). Baerwald *et al*. (2008) found that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma.

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. However, the dependency of a bat on each of these factors is subject to the species, its behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above-mentioned factors. Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water; in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and

consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure as roosting spaces or that swarms of insects may get trapped in low pressure air pockets around turbines, also encouraging the presence of bats. The presence of lights on wind turbines has also been identified as a possible cause for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect activity and subsequent increased foraging activity of bats (Johnson *et al*. 2003). Clearings around wind turbines, in previously forested areas, may also improve conditions for insects, thereby attracting bats to the area. The swishing sound of turbine blades has also been proposed as a possible source for disorientation in bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may additionally affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesized, from personal observations, that the echolocation capabilities of bats are designed to locate smaller insect prey or avoid stationary objects, and may not be primarily focused on the detection of unnatural objects moving sideways across the flight path.

A cautionary tale regarding the cumulative impacts that wind energy is able to exert on bat populations is provided through the case study of the hoary bat (*Lasiurus cinereus*). This bat is a common, migratory species across much of the Americas and is currently listed as Least Concern (Gonzalez *et al*. 2016). However, it is also the most frequently encountered victim of fatality around turbine stands in North America. Using population modelling, it has been calculated that hoary bats could decline by as much as 90% over the next 50 years, assuming static population growth rates, and allowing for the current expansion of the wind energy industry in the United States and Canada (Frick *et al*. 2017). There has been an urgent call to curb hoary bat deaths on account of wind farms before the risk of extinction escalates.

South African operational monitoring studies currently point to South African bats being just as vulnerable to mortality from turbines as international studies have previously indicated. The main species of concern are *Laephotis capensis* (Cape serotine bat), *Tadarida aegyptiaca* (Egyptian free-tailed bat) and *Miniopterus natalensis* (Natal long-fingered bat), in this region and in general. It is important from both a conservation and an ecological standpoint to maintain the abundance of even our common species, especially given the scale of wind energy prospecting occurring in South Africa at present.

Whatever the reason for bat fatalities in relation to wind turbines, it is clearly a significant ecological problem which requires attention. Most bat species only reproduce once per year, bearing one young per female, thus their numbers are slow to recover from mass mortalities. It is very difficult to assess the true number of bat deaths in relation to wind turbines, due to carcasses being removed from sites through predation, the rate of which differs from site to site as a result of habitat type, species of predator and their numbers (Howe *et al*. 2002, Johnson *et al*. 2003). Various mitigation measures are being researched and experimented with globally. The implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed, has been proven to be the most effective mitigation measure currently. This relies on the principle that the prey of bats will not be found in areas of strong winds and more energy is required for the bats to fly under these conditions. The impact on bats foraging in the area will be higher when uncurtailed turbine blades are left to turn slowly in low wind speeds; it is a misperception that faster turning blades present a higher mortality risk.

1.4 Bats and solar energy

Currently there is no evidence of photovoltaic (PV) facilities posing a direct threat of fatality impact on bats during operation. However, roosting and foraging habitats may be significantly impacted during the construction phase. This is primarily due the fact that PV facilities require large areas of land to be cleared, and in some cases, earthworks are required for levelling purposes. This can result in habitat that is suitable for micro roosts, such as rocky outcrops, clumps of trees and certain vegetation being destroyed, which can also be fatal to bats residing in such roosts. Natural vegetation can support higher insect food quantities and diversity than cleared land, therefore foraging habitat can also be displaced by PV facilities.

The presence of security lights on and around PV facilities can create significant light pollution that will impact bat feeding habits and species compositions negatively, by discouraging photophobic (light averse) species and encouraging species that readily forage around lights attracting insects.

Evidence exists of bats using polarised light at dusk to calibrate their internal magnetic compasses (Grief *et al.* 2014), and some PV solar panels are strong reflectors of horizontally polarised light (Polarised Light Pollution or PLP) which can possibly interfere with this method of navigation, additionally horizontal polarised light can mimic light reflected from water bodies (Szaz *et al.* 2016). Although, the degree of impact on bats needs to be determined for bats foraging near and around their roost, since the study referenced experimented on the homing capabilities of bats released away from their roost.

2. PROJECT DESCRIPTION

2.1 Renewable energy and transmission lines

Some power generation infrastructure (wind and solar PV) will be located in reasonably close proximity to the SEZ, however, due to the sensitivity of the local receiving environment and potential impacts of the coastal environment on the generation facility (e.g. corrosion), in most cases, power will be generated from dispersed renewable energy projects (each requiring their own EIA processes), in some cases, several hundred kilometers away. Electricity will then be delivered to the GH_2 production plant using a combination of new and existing transmission and distribution infrastructure (**Table 2-1**). In such cases the development and permitting of the generation components will be undertaken by 3rd parties, and the developer may not have control of the whole project. The project owner will purchase power from 3rd parties (or purchase the projects outright and own and operate them) and negotiate with the utility to wheel the power using the existing or new build grids. The project components are likely to be permitted separately, with the hydrogen developer permitting the electrolyser, ammonia plant, desalination plant and, in some cases, the export port facilities, and the generation (wind and solar PV) and transmission being permitted by several other 3rd party entities such as Independent Power Producers (IPPs) and Eskom.

Table 2-1: Brief description of the main renewable energy aspects.

Renewable energy	Aspect	Description
Wind	Turbines	Rotor with blades, nacelle, tower; sizes 4-8 MW, hub height 150-180 m, blade length ~100 m.
	Other	Foundations (~32 m^2), access roads, Battery Energy Storage System (BESS), on-site electrical system, substation, transmission lines, construction camp, operations & maintenance facilities, meteorological towers.
Solar	Solar panels	Monocrystalline/polycrystalline silicon cells; height ~6 m. Fixed or dual-axis tracking. Single or bifacial modules.
	Other	Inverters, mounting structures, BESS, foundations, access roads, electrical system, substations, transmission lines, electrical components, construction camp, operations & maintenance facilities.

2.2 The three GH2 scenarios proposed

Two GH_2 development scenarios will be assessed, each compared to an existing dynamic baseline (**Figure 2-1**), where no GH_2 development occurs but other anthropogenic and climate changes continue, described as follows:

• **SCENARIO 0 – DYNAMIC BASELINE (2023 – 2050):** Boegoebaai Port and SEZ remains undeveloped. No GH_2 is produced in the Northern Cape. The region proceeds on current ecological, climatic (e.g.

desertification, storm surges) and developmental trends, including all other non-GH_2 activities (e.g. independent renewable energy development). The Springbok Renewable Energy Development Zone (REDZ) is located within the Namakwa study region (**Figure 2-2**). REDZs are areas designated by the government to fast-track renewable energy development. Consequently, renewable energy projects are likely to proceed within the Springbok REDZ even under Scenario 0 (Sc0).

• **SCENARIO 1 – "SMALL GH_2" (by 2030):** 5 GW electrolyser producing 0.5 mtpa GH_2 and derivatives supported by 10 GW of renewable energy (assume 60% solar / 40% wind)

• **SCENARIO 2 – "BIG GH_2" (by 2050):** Upscaled GH_2 development to a 40 GW electrolyser producing a total of 4 mtpa GH_2 and derivatives supported by 80 GW of renewable energy (assume 60% solar / 40% wind)

Each of the GH_2 development scenarios will be associated with different development footprints and scales of infrastructure (**Table 2-2**).

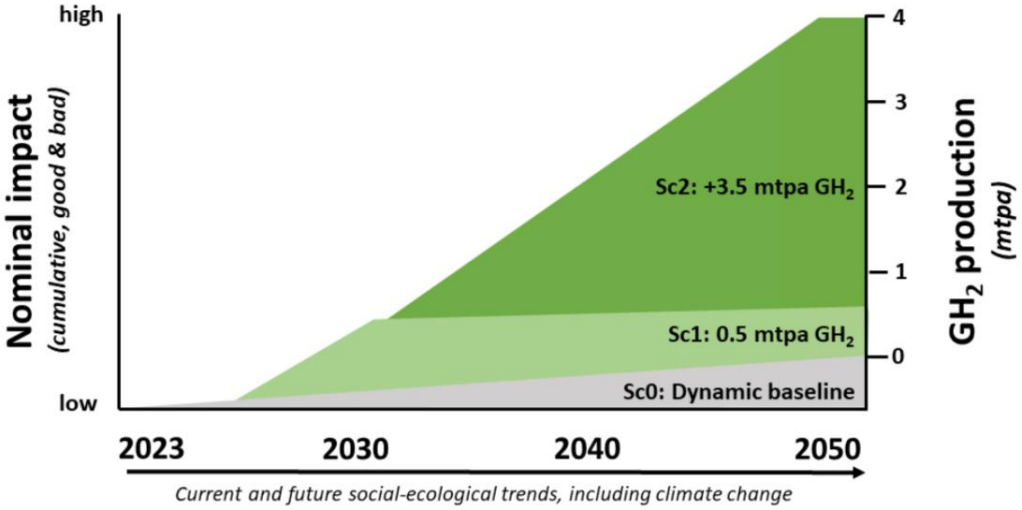

Figure 2-1: Indicative diagram of the scenarios approach for assessing cumulative impacts

Table 2-2: GH_2 development scenario quantifications (Sc1 and Sc2) for the regional assessment.

	Aspect	Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	15 ha per 1 GW
	GH2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mpta GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mpta)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	57	454	1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28	227	0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mpta)
	Desalination output volume	Ml/day	36	286	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 operational.
	Desalination footprint	ha	7	57	5 Ml/day output needs 1 ha
	Desalination discharge	Ml/day	48	387	Ratio of desalinated water to brine discharge water to be 42.5:57.5. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine).
	Pipeline intake volume	Ml/day	84	672	Output + discharge
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	*GW*	*6*	*48*	60 % solar : 40 % wind
	RE footprint - solar	*ha*	*12 000*	*96 000*	0,5MW/ha
	RE extent - solar		*12 000*	*96 000*	Footprint = extent
	RE facilities - solar	*no of facilities*	*6*	*48*	Clusters of 1 GW facilities
	RE capacity - wind	*GW*	*4*	*32*	60 % solar : 40 % wind
	RE footprint - wind	*ha*	*4 000*	*32 000*	1 MW/ha
	RE extent - wind	*ha*	*40 000*	*320 000*	0,1 MW/ha
	RE facilities - wind	*no of facilities*	*3*	*21*	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 600	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	1 200	20 m servitude
	Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.
	Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)
	Main infrastructure components footprint	**ha**	**21 082**	**142 240**	
Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; Ml/day = million litres per day; km = kilometre					

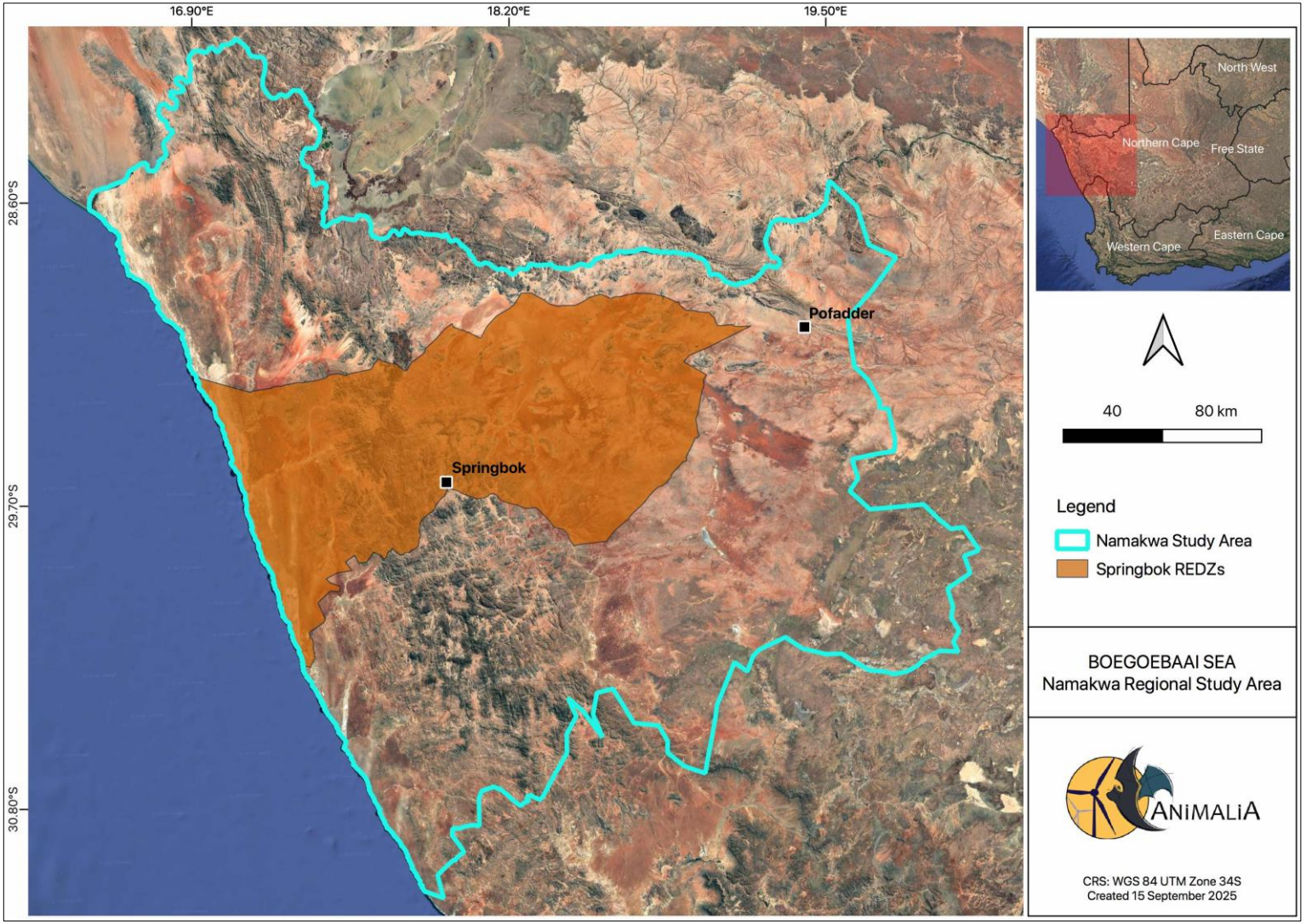

Figure 2-2: The proposed Namakwa region project study area

3. ASSESSMENT METHODOLOGY

3.1 Specialist credentials

Details of the Specialist, Declaration of Interest and Curriculum Vitaes of the team are provided in **Appendix 1 – 3.**

3.2 Desktop assessment and sensitivity mapping

A comprehensive desktop assessment was undertaken to evaluate bat sensitivity within the study region. This process considered multiple environmental and ecological factors, including the distribution of ecoregions, known bat roost locations, land-cover types, irrigated agricultural areas, protected areas, urban development, and the occurrence of species of conservation importance. Additional layers such as coastlines, rivers, wetlands, dams, and regional geology were incorporated to generate a spatially explicit bat sensitivity map.

The sensitivity mapping process involved assessing habitat features and landscape characteristics likely to support bat roosting, foraging, and movement. Key considerations included the presence of man-made structures, surface rock formations (potential roosting habitat), topography (which can influence surface rock occurrence), landcover and vegetation types (roosting and foraging habitat), climate (affecting insect abundance and fruit availability), and surface water resources (providing drinking water and attracting insects). These factors were evaluated through a review of geographic and ecological literature as well as analysis of satellite imagery.

3.3 Assumptions and limitations

As with any environmental study, there are certain assumptions and limitations that exist around the current knowledge we possess regarding bats and their behaviour, movements and distribution. Some important points are discussed briefly below:

- This assessment provides a strategic, high-level desktop evaluation to support the SEA. The protocols developed and recommendations provided may require targeted field verification in specific areas.
- Distribution maps of South African bat species still require further refinement, therefore, the list of bat species presented for this region should be regarded as indicative rather than exhaustive. Where a species is known to occur near the region, its presence has been assumed for this assessment.
- The migratory paths of South African bats are largely unknown, thus limiting the ability to determine if renewable energy development in this region will have a large-scale effect on migratory species.
- Available bat roost data is limited to records voluntarily contributed by bat specialists and information published in the literature. In some cases, the coordinates provided in published sources are dated and may no longer reflect current conditions.
- There is a lack of region-specific research on the impacts of solar PV developments on bats in South Africa, limiting the ability to make fully evidence-based predictions.
- The sensitivity map is based partially on satellite imagery and information from several databases. However, given the large extent of the region, there is always the possibility that what has been mapped may differ slightly to what is on the ground.

4. BASELINE DESCRIPTION OF THE RECEIVING ENVIRONMENT

The following chapter presents the baseline description of the receiving environment within the Namakwa study region, reflecting current conditions in the absence of renewable energy facilities associated with this project (Scenario 0).

4.1 Biomes, ecoregions and land use

South Africa is characterized by a rich diversity of ecological regions, which can be described at different scales using biomes and ecoregions. Biomes are broad ecological units defined by general climate, vegetation types, and associated fauna, with South Africa comprising nine major biomes, including Fynbos, Grassland, and Savanna. Ecoregions, such as those defined by Dinerstein *et al.* (2017), are finer-scale areas within or across biomes that share distinctive ecological characteristics, including specific species composition, vegetation structure, and ecological processes. While biomes provide a general overview of ecological patterns, ecoregions offer more spatially explicit information useful for conservation planning and environmental assessments.

The study region contains five of South Africa's nine biomes, predominantly Nama Karoo and Succulent Karoo, as well as Desert, and scattered extents of the Fynbos and Azonal biomes. In 2014, Seamark conducted a study whereby estimates of species richness were calculated based on the assemblages of bats within each biome (Figure 4-1). Bat species richness varies markedly across South African biomes (Seamark 2014). The Azonal biome supports the highest diversity within this region, with 45 species recorded, representing 73% of the country's total bat fauna. In contrast, the desert biome hosts the lowest diversity, with only five species (8% of the national total). Intermediate levels of diversity are found in other biomes: 17 species (27%) in Fynbos, 12 species (19%) in Nama-Karoo, and 13 species (21%) in the Succulent Karoo. This gradient reflects differences in habitat complexity, resource availability, and ecological conditions across the biomes.

Ecoregions often share the majority of their species and ecological processes, experience similar environmental conditions, and interact in ways that are essential for their long-term persistence. Consequently, conservation strategies are most effective when designed at the ecoregional scale (Anderson 2003; Ricketts and Imhoff 2003). The study region encompasses four ecoregions: the Namaqualand-Richtersveld Steppe, Gariep Karoo, Succulent Karoo and Xeric Shrublands, and Renosterveld Shrubland (Figure 4-2).

4.1.1 Namaqualand-Richtersveld Steppe

The Namaqualand-Richtersveld Steppe extends along the western coast of Namibia into South Africa, encompassing fog-affected coastal plains and the adjacent escarpment. The region is underlain by ancient granites and gneisses of the Namaqualand Metamorphic Province, with rugged mountains, rocky outcrops, and gently undulating plains creating a highly heterogeneous landscape. Rainfall is mostly in winter, ranging from 20 mm in the arid northwest to over 400 mm in the escarpment, supplemented by fog and dew. The flora is dominated by succulents, geophytes, and dwarf shrubs, with extremely high levels of plant endemism. Much of the ecoregion remains natural or semi-natural, though overgrazing, agriculture, and mining have caused localized habitat degradation.

4.1.2 Gariep Karoo

The Gariep Karoo ecoregion is an extensive, arid landscape of low, succulent dwarf shrubs and tall stem succulents, interspersed with perennial grasses and riparian thickets along the Orange River. Vast areas in this ecoregion within in the study area are comprised of arid, flat, barren areas. However, in the north and north-west of the study area the terrain is rugged, with mountains creating local variations in rainfall and temperature, and the geology is dominated by arid-adapted soils overlying sedimentary and metamorphic rocks. Vegetation structure is highly heterogeneous, with shrubs, grasses, and isolated trees providing shelter and foraging sites for wildlife. Heavy grazing, invasive plants, and mining have altered plant composition in parts of the ecoregion, but remaining natural and semi-natural areas continue to support diverse ecological processes.

4.1.3 Succulent Karoo and Xeric Shrublands

The Succulent Karoo ecoregion is an arid, semi-desert landscape with reliable winter and spring rainfall (150–300 mm) and extreme summer temperatures often exceeding 40°C. Vegetation is dominated by highly diverse dwarf succulents and geophytes, with poor tree richness. Trees derived from distant savannas can be found in close proximity to perennial river corridors. The region's soils and topography support these specialized plants, resulting in high levels of endemism, particularly in centers such as the Van Rhynsdorp and Little Karoo. Despite overgrazing and agricultural pressures in some areas, much of the ecoregion remains intact, providing structurally complex habitats.

4.1.4 Renosterveld Shrubland

The Renosterveld Shrubland, part of the Cape Floristic Region, is a species-rich, Mediterranean-climate ecoregion in southwestern South Africa, with annual rainfall of 250–650 mm and mild summer temperatures rarely exceeding 30°C. Vegetation is dominated by low shrubs, especially ericoids such as renosterbos (*Elytropappus rhinocerotis*), with a rich ground layer of grasses and geophytes, including many highly endemic species. Soils are fertile, fine-textured, and derived from shale and sandstone, which historically supported dense vegetation but have been heavily transformed by agriculture in lowland areas.

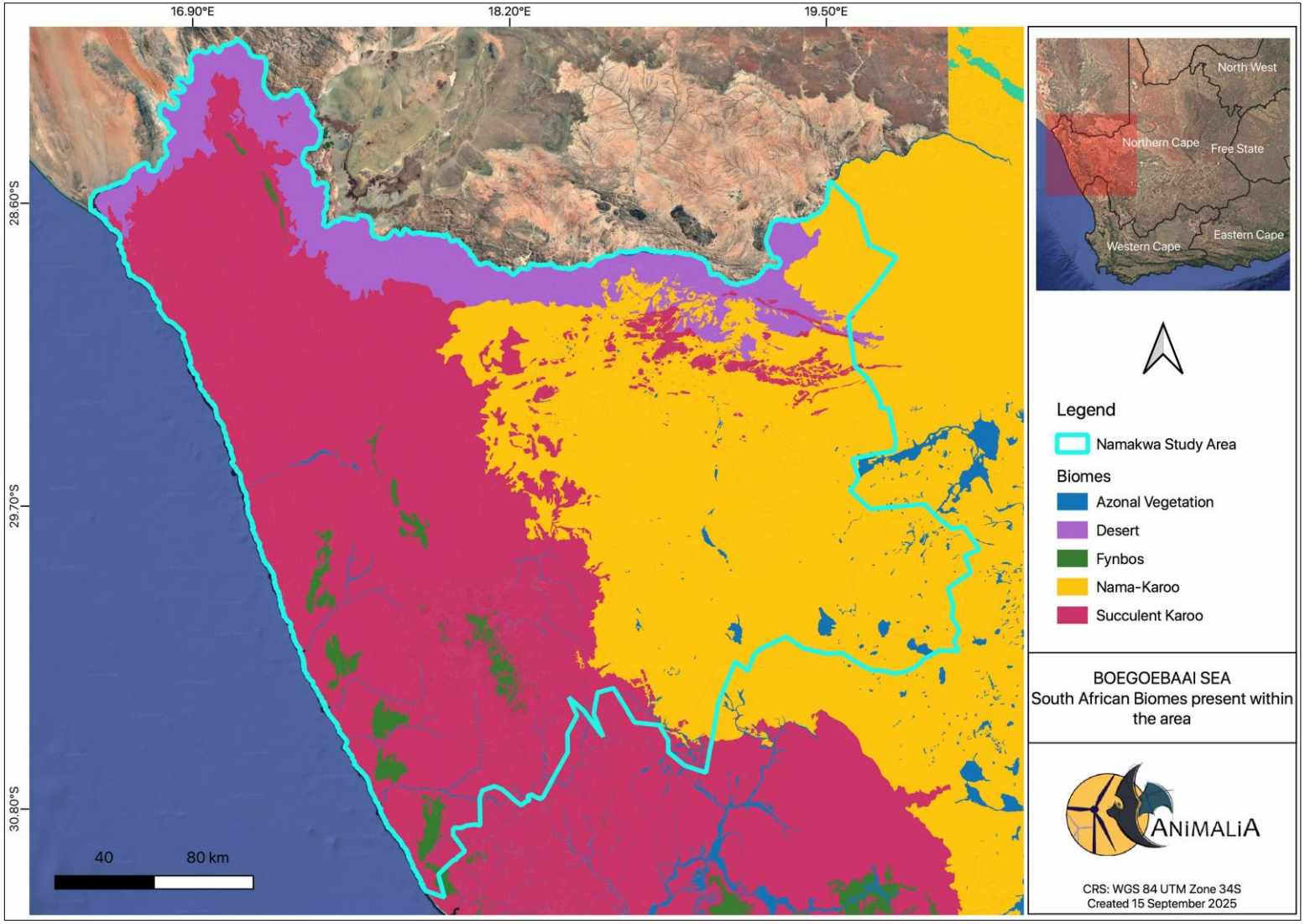

Figure 4-1: Biomes on and surrounding the proposed study area (Mucina and Rutherford 2018).

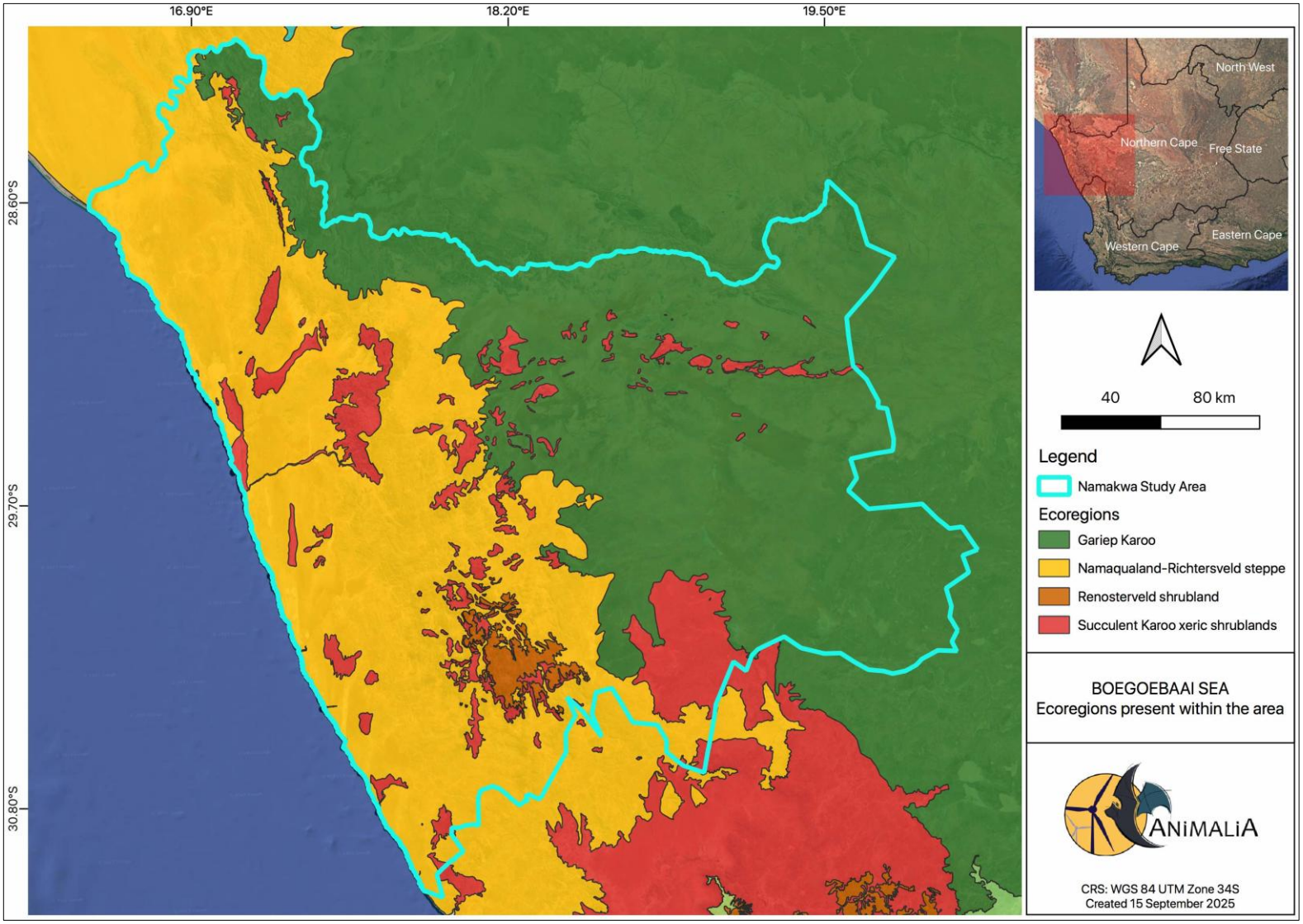

Figure 4-2: Ecoregions on and surrounding the proposed study area (Dinerstein *et al.* 2017).

Table 4-1: Potential of the ecoregions to serve as suitable roosting and foraging spaces for bats, specifically to the terrain and habitat in the study region.

Vegetation Unit	Foraging Potential	Comments	Roosting Potential	Comments
Namaqualand-Richtersveld Steppe	**Medium - High** (spaces between hills and koppies, built up areas and waterbodies) **Low - Medium** (other areas)	The hills and koppies can offer shelter from wind for bats and insect prey. Often farmsteads and buildings have water available, and insects are attracted to such areas because of domestic activities.	**Medium - High** (rocky areas, limestone geology, mining areas and built-up areas) **Low - Medium** (other areas)	Roosting space is available in the form rocky outcrops and crevices, mines, fissures in rocks and hollows. Man-made structures in built up areas such as houses and buildings can offer an abundance of roosting habitat for certain species in the area.
Gariep Karoo	**Medium** (grassland areas, around waterbodies and buildings) **Low** (other areas)	Grassland habitats are associated with a wide insect diversity and can offer an abundance of insect prey. Foraging potential is higher in areas with water as insect diversity is generally higher in these areas. Often farmsteads and buildings have water available, and insects are attracted to such areas because of domestic activities.	**High** (Buildings) **Low** (other areas)	Man-made structures in built up areas such as houses and buildings can offer an abundance of roosting habitat for certain species in the area.
Succulent Karoo and Xeric Shrublands	**Medium - High** (spaces between hills and koppies, built up areas and waterbodies) **Medium** (other areas)	The hills and koppies can offer shelter from wind for bats and insect prey. Often farmsteads and buildings have water available, and insects are attracted to such areas because of domestic activities.	**Medium - High** (rocky areas and built-up areas) **Low - Medium** (other areas)	Roosting space is available in the form rocky outcrops and crevices as well as mines. Man-made structures in built up areas such as houses and buildings can offer an abundance of roosting habitat for certain species in the area.
Renosterveld Shrubland	**Medium - High** (spaces between hills and koppies) **Medium** (other areas)	The hills and koppies can offer shelter from wind for bats and insect prey. Often farmsteads and buildings have water available, and insects are attracted to such areas because of domestic activities.	**Medium - High** (rocky areas and built-up areas) **Medium** (other areas)	Roosting space is available in the form rocky outcrops and crevices. Man-made structures in built up areas such as houses and buildings can offer an abundance of roosting habitat for certain species in the area.

4.2 Land-use

The National Landcover Dataset provides a country-wide classification of land cover types for South Africa, categorised into nine classes: forest, shrubland, grassland, waterbodies, wetlands, barren land, cultivated land, built-up areas, and mines & quarries. Within the study area, shrubland dominates, interspersed with extensive areas of barren land. Mines and quarries are primarily located along the western edge of the study region, while grasslands are concentrated in the north-east and forested areas in the south-west (**Figure 4-3**). Small pockets of cultivated land occur in the south-west, and major waterbodies are largely restricted to the south-east of the study area.

The distribution of landcover types within the study area has direct implications for bat habitat and foraging opportunities. Shrubland and forested areas provide potential roosting and foraging habitats, while grasslands offer foraging grounds for open-air and clutter-edge foraging species. Barren land and mined areas are generally of low habitat value but may contain caves or crevices that serve as roost sites. Waterbodies, wetlands, and cultivated areas may act as important foraging sites due to higher insect availability. Bats in farmlands play a vital role as natural predators of crop pests (Taylor *et al.* 2011; Noer *et al.* 2012). More recently, they have also been shown to prey on commensal livestock insects (insects that live around livestock) and parasitic livestock insects (insects that feed on livestock; Downs and Sanderson 2010; Ancillotto *et al.* 2017). Livestock-dominated areas can support bat populations by maintaining semi-open habitats preferred by certain species (Duvergé and Jones 2003; Lòpez-González *et al*. 2015), increasing the availability of prey such as dung-associated insects (Duvergé and Jones 2003), and providing artificial water sources for drinking (Korine *et al.* 2015; Russo *et al.* 2016). The spatial arrangement and extent of these landcover types should therefore be considered when assessing potential impacts of renewable energy developments on bat populations.

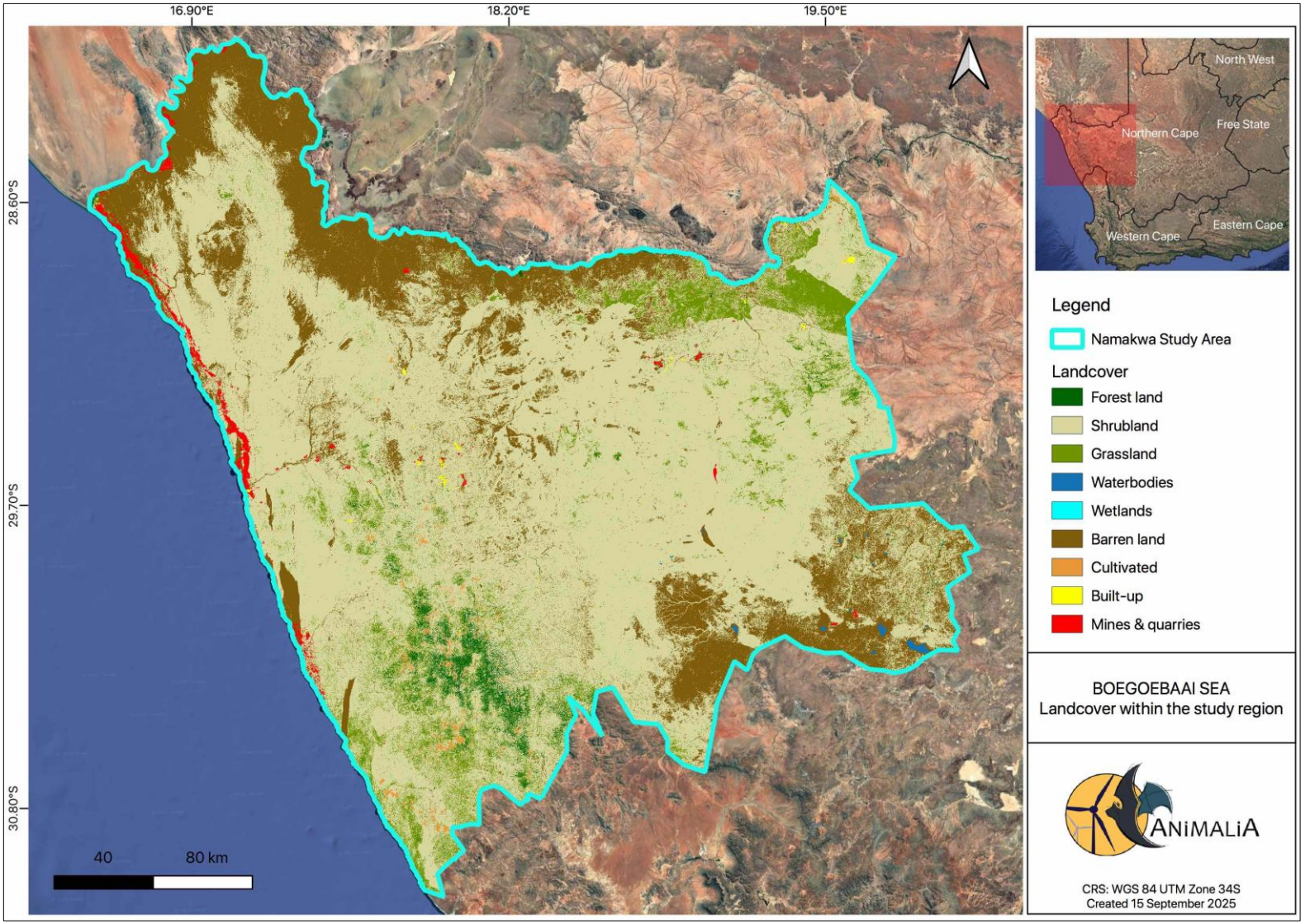

Figure 4-3: Land cover across the Namakwa study region.

4.3 Conserved and protected areas, known sensitivities and cave/roosts within the regional project area

The study region contains 19 protected areas but no formally conserved areas (SAPAD and SACAD, DFFE 2025 Q1; **Figure 4-4**). Richtersveld National Park, also designated as a Heritage Site, has two known roosts. Goegap Nature Reserve supports two known roosts and records of four bat species, while Namaqua National Park contains a single roost. Beyond these examples, most bat records and roosts fall outside protected areas, indicating that these protected sites are generally not major hotspots for bat activity or roosting. However, the presence of intact natural vegetation within protected areas may enhance bat diversity and activity levels.

The Strategic Environmental Assessment (SEA; Department of Environment Forestry and Fisheries 2019) assigns a minimum buffer of 500 m to all known bat roosts for wind and solar PV energy. Maximum buffers vary depending on the size of roost and the type of bats. Maximum buffers are assigned in accordance with the buffers designated in the South African Best Practice Guidelines for Pre-construction Monitoring of Bats at Wind Energy Facilities (MacEwan *et al*. 2020). Therefore, any possible cave/roost locations may be assigned a No-Go buffer for renewable energy of up to 20 km if they are found to be supporting large enough bat colonies.

To manage potential impacts of proposed renewable energy developments on bats, three types of zones have been applied around known and potential roosts: No-Go (Very High sensitivity) zones, Roost Investigation zones, and Caution zones. These buffers are based on colony size and foraging guild, as summarised in **Table 4-2**.

No-Go (Very High sensitivity) zones: Turbines cannot be sited within these distances of roosts. For roosts with more than 2,000 individuals, No-Go zones are 20 km. For roosts with fewer than 2,000 individuals, and for roosts of unknown size, a standard precautionary distance of 500 m is applied or buffer distances described in **Table 4-2** are adhered to.

Roost Investigation zones: Within these zones, it is critical to conduct further field investigations during the EIA phase of a renewable energy project to verify species presence, colony size, and roost significance.

Caution zones: During the EIA process, any identified roosts must be explicitly considered. The study design and data analysis should make appropriate provision for roost location, species, and potential impacts to determine if species present in the applicable roost may be impacted by the proposed project.

These buffers and investigation zones provide a precautionary approach to minimise potential impacts on bats while ensuring that proposed renewable energy developments are informed by accurate field data.

Table 4-2: Bat roost buffer distances and investigation zones by colony size and foraging guild.

Colony size	Foraging guild	No-Go (Very High sensitivity) zone	Roost investigation zone	Caution Zone
> 2000 individuals	Open-air	20 km	30 km	50 km
	Clutter-edge	20 km	30 km	50 km
	Clutter	20 km	30 km	50 km

	Unknown	20 km	30 km	50 km
500 - 1999 individuals	Open-air	10 km	20 km	50 km
	Clutter-edge	10 km	20 km	50 km
	Clutter	2.5 km	10 km	50 km
	Unknown	2.5 km	20 km	50 km
< 500 individuals	Open-air	500 m	5 km	10km
	Clutter-edge	500 m	5 km	10km
	Clutter	500 m	1 km	N/A
	Unknown	500 m	5 km	10km
Unknown	Open-air	500 m	20 km	50 km
	Clutter-edge	500 m	20 km	50 km
	Clutter	500 m	10 km	50 km
	Unknown	500 m	20 km	50 km

Known bat roosts in the study area were assessed. A larger radius of 50 km was considered in this study to account for migration paths from roosts to foraging areas. Thirteen known bat roosts have been identified, based on collected specimens and observations (Bats KZN and SABAA databases; ACR 2020, **Figure 4-5** and

Table 4-3).

Within the study region, areas of limestone geology are present (**Figure 4-5**). These formations are highly susceptible to the development of extensive cave systems. As caves provide ideal roosting habitat for bats, it is possible that undiscovered roosts may occur within these areas.

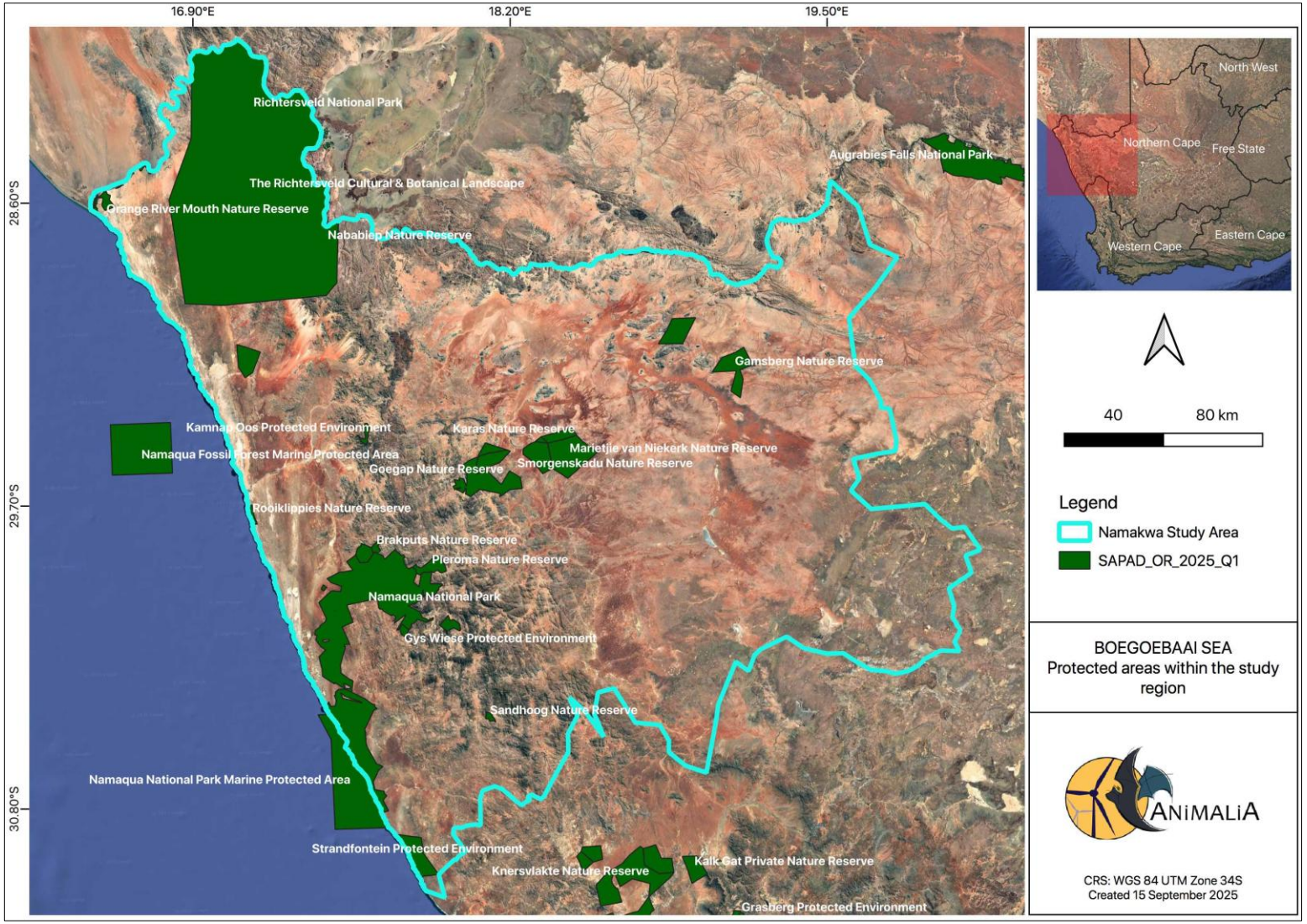

Figure 4-4: Protected areas within the Namakwa study region (DFFE, Q1 2025).

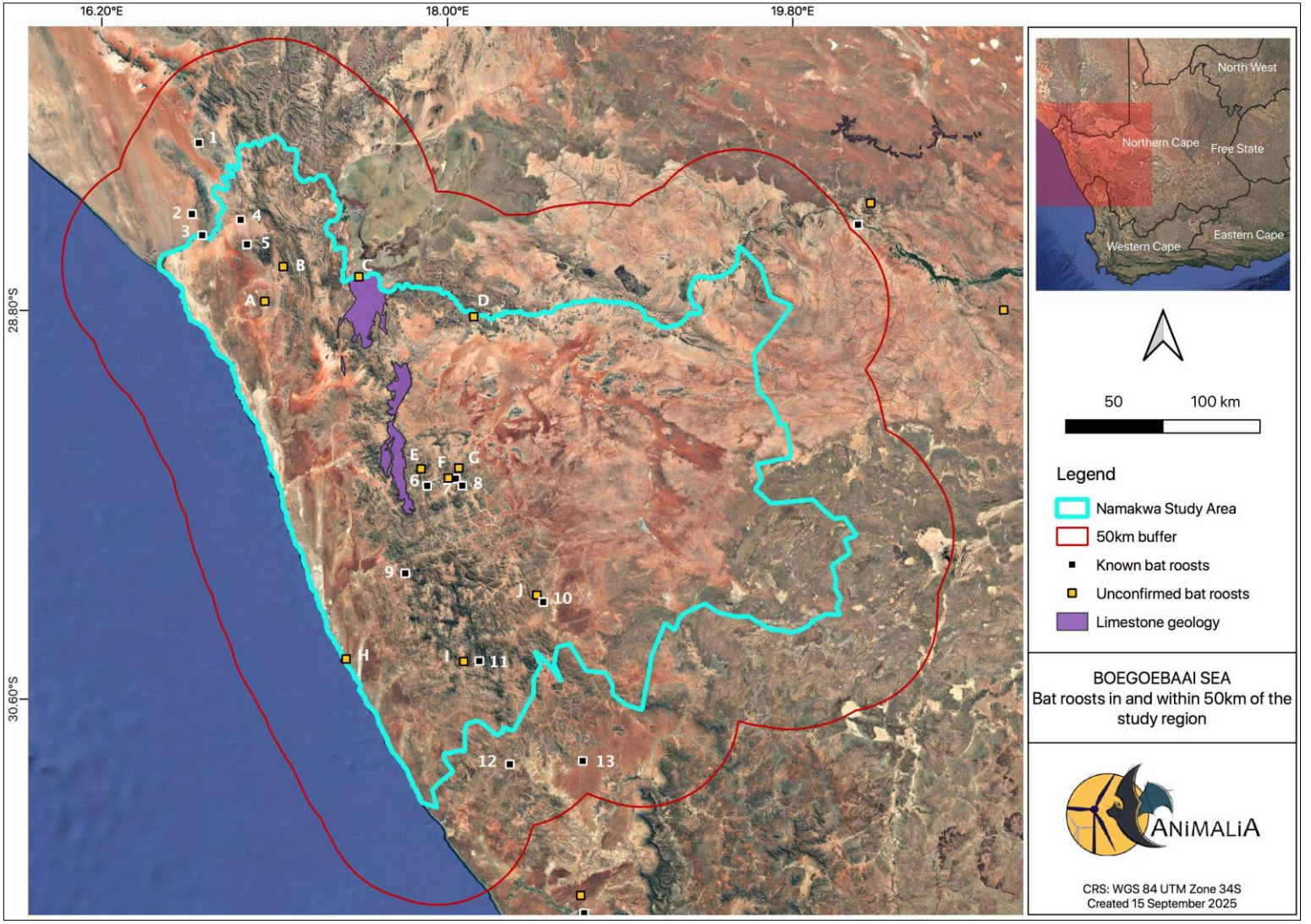

Figure 4-5: Bat roosts and areas of limestone in the study region and within 50 km of the proposed study region (Bats KZN and SABAA).

Table 4-3: Bat roosts in and within a 50km of the proposed Namakwa study region.

Map ID	Roost Name	Additional information	No-Go (Very High sensitivity), Roost Investigation zones, Caution zones
1	Brandkaros	*Hipposideros caffer* and *Nycteris thebaica*; colony size unknown	500 m No-Go zone 10 km roost investigation zone 50 km caution zone
2	Wondergat	*Nycteris thebaica* and *Rhinolophus capensis*; colony size unknown	500 m No-Go zone 10 km roost investigation zone 50 km caution zone
3	Brandkaros II	None	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
4	Wondergat Cave	Large size roost (500-1999), species unknown	2.5km No-Go zone 20 km roost investigation zone 50 km caution zone
5	Doringpoort river	*Nycteris thebaica*; colony size unknown	500 m No-Go zone 10 km roost investigation zone 50 km caution zone
6	Welbedacht Mine	*Nycteris thebaica, Miniopterus natalensis;* > 2000 individuals	20 km No-Go zone 30 km roost investigation zone 50 km caution zone
7	Hester	*Nycteris thebaica*; colony size unknown	500 m No-Go zone 10 km roost investigation zone 50 km caution zone
8	Goegab	*Miniopterus natalensis, Tadarida aegyptiaca*; colony size unknown	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
9	Aronegas	None	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
10	Orrelgat	None	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
11	Roodebergskloof	None	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
12	Kersbos	None	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
13	Steenkampskraal Mine	*Miniopterus natalensis, Rhinolophus capensis and Rhinolophus clivosus*; colony size unknown	500 m No-Go zone 20 km roost investigation zone 50 km caution zone
A	Unconfirmed bat roost a	None	500 m No-Go zone 10 km roost investigation zone
B	Unconfirmed bat roost b	None	500 m No-Go zone 10 km roost investigation zone
C	Unconfirmed bat roost c	None	500 m No-Go zone 10 km roost investigation zone
D	Unconfirmed bat roost d	None	500 m No-Go zone 10 km roost investigation zone

Map ID	Roost Name	Additional information	No-Go (Very High sensitivity), Roost Investigation zones, Caution zones
E	Unconfirmed bat roost e	None	500 m No-Go zone 10 km roost investigation zone
F	Unconfirmed bat roost f	None	500 m No-Go zone 10 km roost investigation zone
G	Unconfirmed bat roost g	None	500 m No-Go zone 10 km roost investigation zone
H	Unconfirmed bat roost h	None	500 m No-Go zone 10 km roost investigation zone
I	Unconfirmed bat roost i	None	500 m No-Go zone 10 km roost investigation zone
J	Unconfirmed bat roost j	None	500 m No-Go zone 10 km roost investigation zone

4.4 Currently confirmed, previously recorded as well as literature-based species probability of occurrence

"Occurrence in area" was determined based on species distribution information (**Table 4-4**). Species records from the ACR database (2020) were also consulted to confirm species presence within a 100 km radius of the site, providing further context for regional occurrence and likelihood of encounter. In addition, the presence of suitable roosting and foraging habitats was assessed relative to known habitat preferences described in the literature.

The column of "Likelihood of risk of fatality" describes the likelihood of risk of fatality from direct collision or barotrauma with wind turbine blades for each bat species. The risk was assigned by MacEwan *et al.* (2020) based on species distributions, altitudes at which they fly and distances they traverse; and assumes a 100% probability of occurrence.

4.5 Description of trends influencing the baseline receiving environment up to 2050 (Scenario 0 - Boegoebaai Port and SEZ remains undeveloped)

Availability of artificial bat roosting spaces may increase substantially:

Natural bat roosting spaces in the forms of crevices, hollows and caves are limited in the region, the increase of man-made structures and buildings will create artificial roosting space for several bat species. Even though the district's population is expected to decline by 11% by 2050, with Kamiesberg facing a 42% decrease, the Richtersveld and Karoo Hoogland may see moderate population growth (CSIR, 2023) and new mining developments, particularly in Aggeneys and the Namakwa Special Economic Zone (SEZ) will result in an increase of artificial bat roosting space.

Availability of natural bat foraging habitat may decrease moderately:

Desertification, overgrazing and resulting wind erosion can result in natural bat foraging habitat to be declining. Projected changes in temperature, rainfall levels and patterns could shift vegetation and corresponding animal distributions. These factors can decrease insect activity and alter natural habitats, therefore decreasing the availability of natural bat foraging habitat.

Light pollution will increase substantially:

An increase in man-made structures will result in an increase of light pollution. Certain bat species can benefit from this since the lights attract insects and these species forage readily around lights. But photophobic bat species will be deterred by lighting, therefore altering the species composition of a population in an area.

Agricultural practices (croplands) may increase moderately:

Croplands can provide artificial foraging habitat for bats due to irrigation and sometimes increased insect activity, although insect diversity is lower in croplands. Since agriculture in the Namakwa District is shifting toward high-value crops such as table grapes and dates along the Orange River (CSIR, 2023), this may be a localised driver of change.

Agricultural practices (livestock) may decrease moderately, or remain unchanged as a netto effect of several factors:

Livestock farming attracts bats, since animal dung and activity attracts concentrations of insect prey. Water scarcity, harsh conditions and overgrazing may cause a decrease of livestock farming in the area. However, the increasing renewable energy industry in the region will provide more financial stability to farmers, allowing more sustained farming practices.

Agricultural pest control (chemical) may decrease substantially:

The drive to organic farming, increased revenue from pesticide restricted exports and global awareness will lower the use of chemical pesticides in the region. Pesticides are harmful to bats due to bioaccumulation of toxins from insect prey, which can be transferred to pups during suckling.

Renewable wind energy development will increase substantially:

Wind energy is expected to increase significantly in the region. This can have negative effects on bat populations if managed incorrectly. Ongoing research, mitigations and mortality prevention strategies are critical.

Accessible surface water may decrease substantially:

Bats need to drink from water sources with available open surface water. Climate change projections for the Namakwa District indicate drier, hotter conditions, heightening water demand. This trend is expected to significantly increase pressure on water resources, with rising temperatures and reduced rainfall exacerbating water scarcity (Bourne et al., 2015). And groundwater recharge is expected to decrease over most parts of the district (CSIR, 2023). Therefore, available open water sources are expected to decline.

Protected areas may increase moderately:

Protected areas preserve natural bat foraging habitat, insect prey diversity and therefore also diversity of bats in the region. The distinctive biodiversity of the Succulent Karoo biome has gained global attention, prompting substantial investments from the government, non-governmental organisations, and the private sector to expand conservation areas across the biome (Hoffman *et al*. 2015).

Table 4-4: Table of species that have been previously recorded within the study region and within 100 km of the study region. Roosting or foraging behaviour is also briefly described (Monadjem *et al.* 2020).

Species name Common name	Occurrence in region	Conservation status (Red List Regional Listing 2016)*	Possible roosting habitat on or near the region	Possible foraging habitat utilised on or near the region	Likelihood of risk of fatality (MacEwan *et al.* 2020; Animalia evaluation)
Tadarida aegyptiaca Egyptian free-tailed bat	Occurrence record in the region	LC	Roosts in rock crevices, hollows in trees, and behind the bark of dead trees. The species has also taken to roosting in roofs of buildings.	It forages over a wide range of habitats; its preferences of foraging habitat seem independent of vegetation. It seems to forage in all types of natural and urbanised habitats.	High
Sauromys petrophilus Robert's flat-headed bat	Occurrence record in the region	LC	Crevice dwelling species, roosting in rock crevices, as well as other crevices in buildings.	Open-air forager, capable of flying in high, open areas.	High
Eidolon helvum African straw-coloured fruit bat	Occurrence record in the region	LC	Little known about active roosts in South Africa, in other areas this species roosts in trees.	Feeds on fruit and flowers, will forage up to 60km from their roosts	High
Miniopterus natalensis Natal long-fingered bat	Occurrence record in the region	LC	Cave and hollow dependent. Caves/mines present in the larger area. Will also roost in small groups or individually in culverts and other hollows.	Clutter-edge forager. May forage in more open terrain during suitable weather.	Medium-High
Myotis tricolor Temminck's Myotis	Occurrence record within 100km of the region	LC	Usually roosts gregariously in caves. Caves/mines present in the larger area. Sometimes culverts or other hollows.	Clutter-edge forager. May forage in more open terrain during suitable weather.	Medium-High
Pipistrellus reuppellii Rüppell's Pipstrelle	Occurrence record within 100km of the region	LC	Presumed to roost under rocks and in buildings.	Clutter-edge forager, often hunts over water.	Medium-High
Laephotis capensis Cape serotine	Occurrence record in the region	LC	Roosts in the roofs of houses and buildings, and also under the bark of trees.	It appears to tolerate a wide range of environmental conditions from arid semi-desert areas to montane grasslands, forests, and savannahs. But is predominantly a medium height clutter edge forager.	Medium
Eptesicus hottentotus Long-tailed serotine	Occurrence record in the region	LC	It is a crevice dweller roosting in rock crevices, as well as other crevices in buildings. Exposed rocky cliffs.	It generally seems to prefer foraging on the clutter edge of vegetation, such as the vegetated drainage areas and also over open water sources such as farm dams.	Medium

Species name Common name	Occurrence in region	Conservation status (Red List Regional Listing 2016)*	Possible roosting habitat on or near the region	Possible foraging habitat utilised on or near the region	Likelihood of risk of fatality (MacEwan *et al.* 2020; Animalia evaluation)
Nycteris thebaica Egyptian slit-faced bat	Occurrence record in the region	LC	Roosts in aardvark burrows, culverts under roads, the trunks of dead trees and rocky hollows.	Tends to avoid open grasslands. May occur in the thickets that may be found in the vegetated drainage areas.	Low
Rhinolophus clivosus Geoffroy's horseshoe bat	Occurrence record in the region	LC	Roosts in caves and mine adits. Caves/mines present in the larger area. May utilise man-made hollows, aardvark burrows or hollows formed by rocky boulder koppies.	Associated with a variety of densely vegetated habitats including the limited thickets that may be found in the vegetated drainage areas.	Low
Rhinolophus capensis Cape Horseshoe Bat	Occurrence record in the region	LC	Roosts in caves, dark lofts and disused mines, avoids houses.	Clutter forager – forage in the canopy of trees and in orchards close to water.	Low
Rhinolophus damarensis Damara Horseshoe Bat	Occurrence record in the region	LC	Roosts in natural caves and mines.	Clutter forager – vegetation important for foraging.	Low
Cistugo seabrae *Angolan Hairy Bat*	Occurrence record in the region	NT	Very little is known about the roosting behaviour of this species. Suspected to roost in buildings.	Clutter-edge forager, observed circling low around trees and bushes to hunt.	Low
Cistugo lesueuri Lesueur's Hair Bat	Occurrence record within 100km of the region	LC	Roosts in rock crevices usually near water.	Clutter-edge forager – vegetation important for foraging.	Low

5. SENSITIVITY ANALYSIS

The bat sensitivity assessment classified areas according to their relative importance for roosting, foraging, and conservation value. This classification provides a framework for identifying locations where development may present higher risks to bat populations.

Areas of **Very High sensitivity** are characterised by exceptional roosting or foraging potential, very high levels of bat activity, and/or the possible presence of species of conservation concern (e.g., Vulnerable, Endangered, or Data Deficient). From a bat conservation perspective, such areas are generally unsuitable for development of GH_2 and associated renewable energy because of the significant risks they pose to bat populations.

High sensitivity areas include habitats with strong roosting or foraging potential and consistently high levels of bat activity. These areas are likely to present considerable risks to bats, and renewable energy development within them is generally discouraged.

Medium sensitivity areas are associated with moderate roosting or foraging potential, moderate or uncertain levels of bat activity, and/or the potential presence of Near Threatened or Rare species. While development may be possible, site-specific assessments during the EIA phase of a renewable energy facility remain essential to confirm impacts and identify robust mitigation measures.

Low sensitivity areas are characterised by limited roosting or foraging opportunities, low bat activity, and the absence of conservation-important species. These areas are considered more compatible with renewable energy development, though sensitivity mapping will still be refined at the EIA stage to confirm site-level risks.

Roost Investigation zones: Within these zones, it is critical to conduct further field investigations during the EIA phase of a renewable energy project to verify species presence, colony size, and roost significance.

Roost Caution zones: During the EIA process, any identified roosts must be explicitly considered. The study design and data analysis should make appropriate provision to determine if species present in the applicable roost may be impacted by the proposed project.

Figure 5-1 depicts the sensitive areas of the region, based on features identified to be important (**Table 5-1**) for foraging and roosting of bat species that most commonly occur in the region. **Table 5-2** describes the implications of the sensitivity and risk criteria for GH_2 and associated renewable energy developments. More specific information relating to feature buffers is provided in **Table 5-3**.

Table 5-1: Description of parameters used in the construction of the sensitivity map

Sensitivity	Sensitivity Feature	Motivation
Very High Sensitivity and buffers	Open water sources and other perennial watercourses (Order 2, 3, 4 and 7 in catchment area)	Available water and moisture will attract insect food. Fruit bats are also more likely to utilise riparian vegetation for roosting and even foraging if fruit is available seasonally.
	Wetlands	Available water and moisture will attract insect food.
	Coastline	Available moisture and tidal pools will attract insect food.
	Protected areas within the Namakwa region	Floral and faunal biodiversity may be higher in protected areas resulting in a higher abundance of natural food sources for different species of bats found in the Namakwa Region.
	Bat roosts	Areas where bats congregate are particularly important since many individual bats may be impacted simultaneously.
High Sensitivity and buffers	Limestone geology	These formations are highly susceptible to the development of extensive cave systems. As caves provide ideal roosting habitat for bats, it is possible that undiscovered roosts may occur within these areas.
Medium Sensitivity and buffers	Non-perennial watercourses (Order 1 in catchment area)	Seasonally available moisture may attract insect food
Low Sensitivity	The remainder of the study region not delineated by buffers	
Roost Investigation zone	Bat roost buffer	A zone that may be utilised extensively by bats around a bat roost. The size of this zone is based on the colony size, type of roost and/or species occupying the roost.
Roost Caution zone	Bat roost buffer	A zone that may be utilised by bats around a bat roost. The size of this zone is based on the colony size, type of roost and/or species occupying the roost.

Table 5-2: The significance of sensitivity map (risk) categories for GH_2 and associated renewable energy developments

Sensitivity areas	Significance for GH2 and associated renewable energy developments
Very High Sensitivity and buffers	These areas are 'no-go' zones and GH_2 with associated renewable energy developments may not be proposed in these areas and their buffers.
High Sensitivity and buffers	The risks assessed in Section 6 for each identified impact must be considered for this sensitivity tier in relation to the identified Consequence description for each development scenario.
Medium Sensitivity and buffers	The risks assessed in Section 6 for each identified impact must be considered for this sensitivity tier in relation to the identified Consequence description for each development scenario.
Low Sensitivity	The risks assessed in Section 6 for each identified impact must be considered for this sensitivity tier in relation to the identified Consequence description for each development scenario.
Roost Investigation zones	Within these zones, it is critical to conduct further field investigations during the EIA phase of a renewable energy project to verify species presence, colony size, and roost significance.
Roost Caution zones	During the EIA process, any identified roosts must be explicitly considered. The study design and data analysis should make appropriate provision for roost location, species, and potential impacts to determine if species present in the applicable roost may be impacted by the proposed project.

Table 5-3: Specific buffer details of features highlighted in the sensitivity map.

Sensitivity Category	Feature	Buffer Distance
Very High Sensitivity	Protected areas	None
	Wetlands	500m
	NFEPA River orders 2, 3 and 4	500m
	NFEPA River order 7	5km
	Coastline	1km
	Bat roosts (as per Table 4-2)	500m, 2.5km and 20km
High Sensitivity	Limestone	None
	Coastline	5km
	NFEPA River order 2	500m
	NFEPA River order 7	10km
Medium Sensitivity	Coastline	10km
	Non-perennial watercourses	500m
Roost Investigation zones	Bat roosts	10km, 20km and 30km
Roost Caution zones	Bat roosts	50km

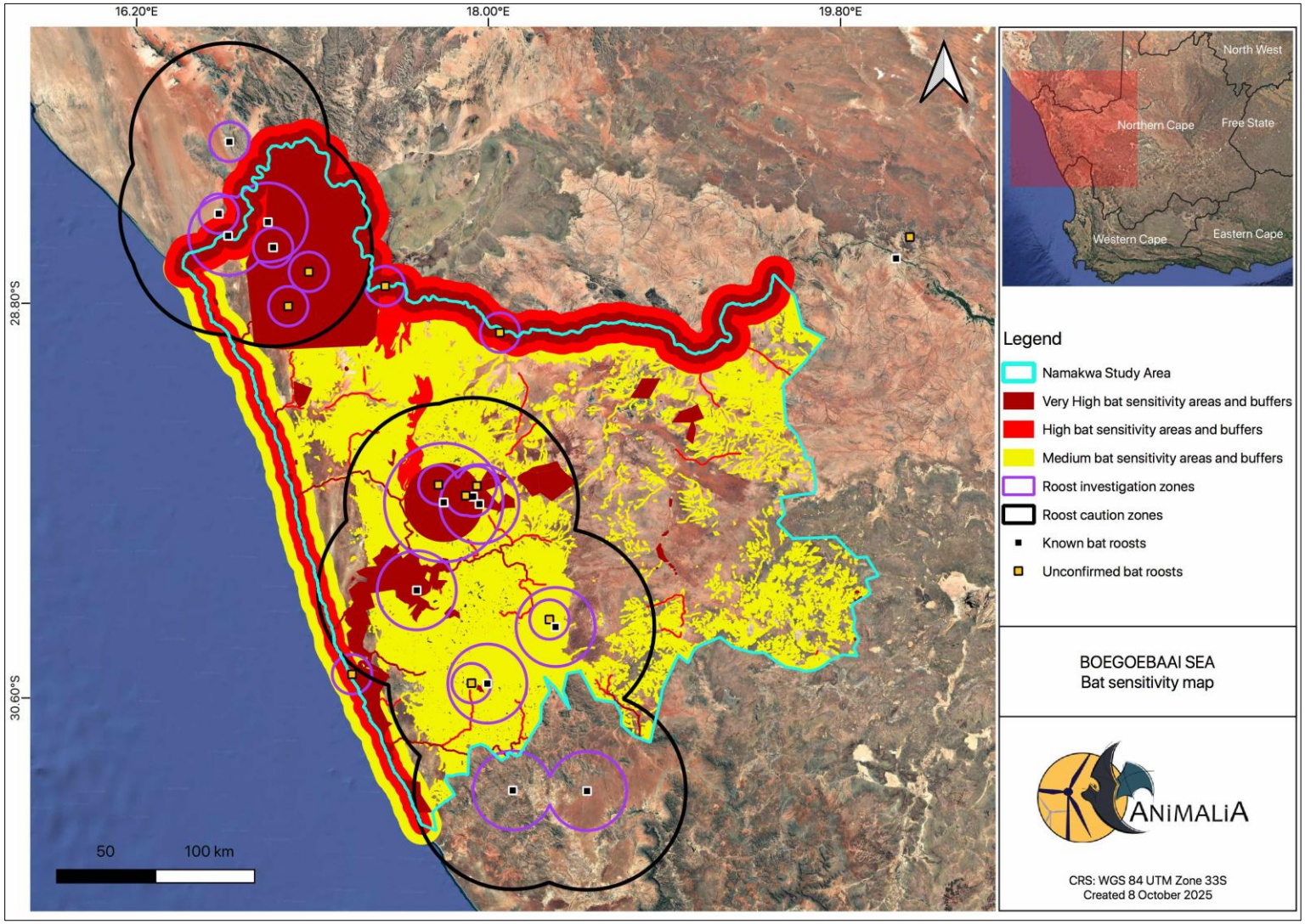

Figure 5-1: Bat sensitivity map of the Namakwa study region, showing Very High, High, Medium and Low sensitivity zones and their buffers. As well as Roost Investigation and Roost Caution zones.

6. RISK ASSESSMENT

6.1 General approach

This chapter undertakes a systematic risk assessment of the impacts to bats relating to the different scenarios for GH_2 development. Risks are assessed by evaluating the probability of events occurring in relation to the severity of their potential positive or negative consequences (i.e., likelihood × consequence; **Figure 6-1**).

To ensure a transparent and systematic approach, consequence ratings have been defined in this chapter for each of the three identified bat impacts, as presented in

Table 6-1. The corresponding risk and opportunity categories (Very Low to Very High) are described in CSIR (2024).

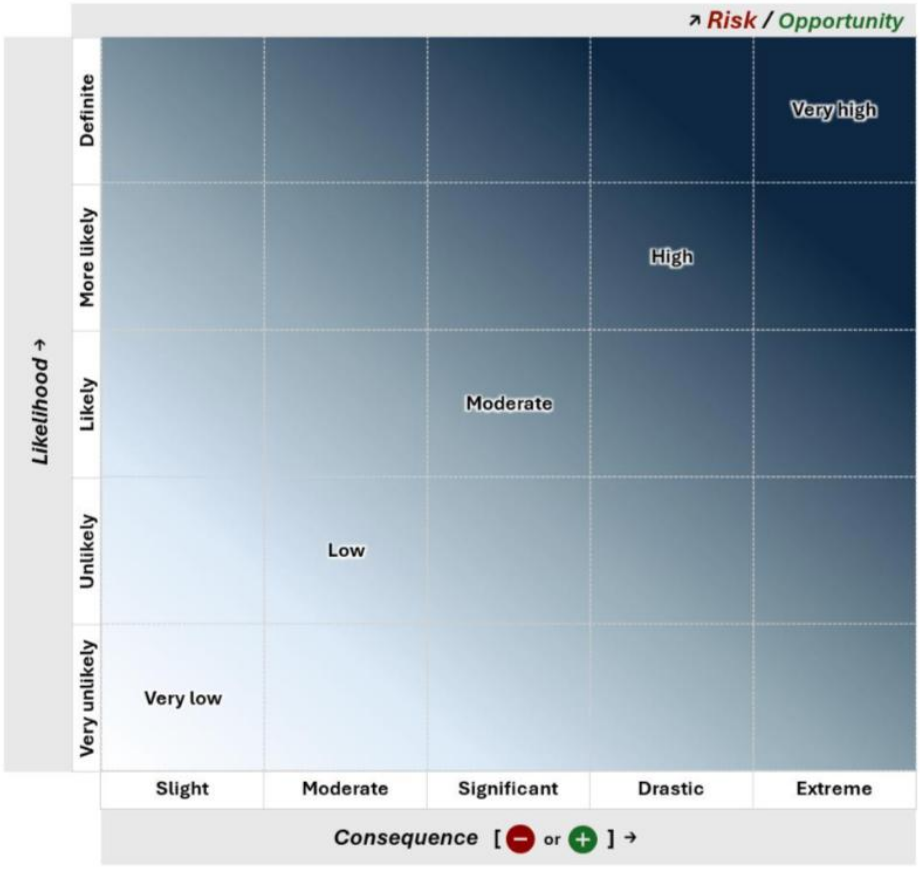

Figure 6-1: Schematic illustrating the qualitative assessment of Risk and Opportunity, derived by multiplying the likelihood of an impact (positive or negative) by the severity of its consequences for a specific theme.

Table 6-1: Description of negative consequences as defined for bats based on expert judgement. Consequence categories as per CSIR (2024) requirements

Negative consequence	Impact		
	Destruction / disturbance of bat roosts	**Bat foraging habitat loss**	**Bat mortalities**
Slight	Slight disturbance of bat roosts in habitat with very low density of micro roosts. Rehabilitation and mitigation not required.	Low density of foraging habitat loss, pertaining to widespread bat foraging habitat. Rehabilitation of foraging habitat not required.	Rare mortality events with barely perceivable bat population or ecological consequences. Required human intervention not anticipated.
Moderate	Disturbance of bat roosts in habitat with a low density of micro roosts, and very rare occurrences of macro roosts disturbance. Rehabilitation is achievable and mitigation is practical.	Moderate density areas of foraging habitat loss, pertaining to widespread bat foraging habitat. Rehabilitation of foraging habitat not required in most cases.	Moderate bat mortalities, but within sustainable levels. Human intervention may possibly be required from time to time.
Significant	Disturbance or destruction of roosts in habitat with a medium density of micro roosts, or significant disturbance of a macro roost. Rehabilitation of roosts possible, mitigation required.	High density areas of foraging habitat loss, pertaining to important bat foraging habitat. Will require rehabilitation of foraging habitat.	Significant bat mortalities which will require mitigations and human intervention on a reactive basis to keep mortalities at sustainable levels.
Drastic	Complete destruction of roosts in habitat supporting a medium density of micro roosts, or severe disturbance of a macro roost. Resulting in displacement or mortalities of bats utilising the roost. Rehabilitation of roosts not possible, mitigation costly.	Higher density areas of foraging habitat loss, pertaining to critical habitat supporting a high diversity of bats. May cause long term species-specific displacement for decades, or lower local bat population numbers significantly. Will require costly and long-term rehabilitation of foraging habitat.	Unacceptably high bat mortalities requiring proactive and active, costly human intervention over decades to prevent unsustainable mortalities, consequent bat population collapse, and severe epigean (above ground) or hypogean (subterranean) ecosystem disruptions. Even after human intervention mortalities may still remain unacceptably high.
Extreme	Complete destruction of bat roosts in areas with a high density of micro roosts, or destruction of a macro roost. Resulting in displacement or mortalities of bats utilising the roosts. Rehabilitation of roosts not possible, mitigation not effective.	Large continuous areas of foraging habitat loss that may be permanent or lasting for decades, pertaining to critical habitat supporting a high diversity of bat species and/or habitat critical for specific species. Resulting in complete species-specific displacement of bats and localised consequent negative ecological effects. Rehabilitation of foraging habitat may be unsuccessful.	Unsustainable mortalities leading to bat population collapse, and consequent severe disruption of epigean (above ground) ecosystems, and collapse of subterranean/hypogean (cave) ecosystems. Human intervention may not be successful. Commonly occurring species with a Least Concern conservation status may become locally extinct or threatened.

The risks of potential impacts for each development scenario are discussed below.

6.2 Disturbance and/or destruction of bat roosts during construction

6.2.1 Impact description

Probable roosting spaces within the region are most likely associated with man-made structures such as houses and farm buildings along with natural features including fissures in rocks, and less prevalent hollows in trees or loose bark. The construction of GH_2, solar PV facilities, wind energy facilities (WEFs), and associated infrastructure (e.g., turbines, panels, roads, substations, power lines, offices, and maintenance buildings) may result in the disturbance or permanent loss of these roosting habitats. The severity of impacts depends on the type and sensitivity of the roost or roosting habitat and its proximity to development activities.

6.2.2 Mitigation measures

No proposals for renewable energy or GH_2 developments should be allowed within the Very High sensitivity areas indicated in the sensitivity analysis map in this report, and the risk assessment for each impact and sensitivity tier should be considered on a regional management level when GH_2 and renewable energy facilities are proposed. Additionally, adhering to site-specific bat specialist sensitivity maps created during EIA studies will also assist in mitigating this risk. If undiscovered bat roosts are encountered during the construction phase of renewable energy faculties, the respective Environmental Compliance Officer (ECO) must be notified immediately and a bat specialist consulted to advise the appropriate action.

6.2.3 Impact assessment

aTable 6-2 highlights the formal ratings of the above impact, considering their relevance across areas of varying bat sensitivity (Very High to low as mapped in Figure 5-1), for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2). Impact ratings are assessed independently for scenarios with and without the implementation of the recommended mitigation and management measures described above.

aTable 6-2: Assessment of potential impacts associated with the destruction or disturbance of bat roosts

Negative Impact	Scenario	Spatial receiving environment (sensitivity tier)	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Destruction/disturbance of bat roosts	S0: Baseline	Very High	Significant	Likely	MODERATE	N/A	N/A	N/A
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	VERY HIGH
	S0: Baseline	High	Significant	Likely	MODERATE	N/A	N/A	N/A
	S1: Small GH_2		Drastic	More Likely	HIGH	Drastic	Likely	MODERATE
	S2: Big GH_2		Drastic	Definite	HIGH	Drastic	More Likely	HIGH
	S0: Baseline	Medium	Moderate	Unlikely	LOW	N/A	N/A	N/A
	S1: Small GH_2		Significant	Likely	MODERATE	Significant	Unlikely	LOW
	S2: Big GH_2		Drastic	More Likely	HIGH	Drastic	Likely	MODERATE
	S0: Baseline	Low	Slight	Very Likely	VERY LOW	N/A	N/A	N/A
	S1: Small GH_2		Moderate	Unlikely	LOW	Slight	Very Likely	VERY LOW
	S2: Big GH_2		Moderate	Likely	LOW	Moderate	Unlikely	LOW

6.3 Displacement due to foraging habitat loss and fragmentation due to solar PV panel or wind turbine construction and operation

6.3.1 Impact description

Construction activities will result in both permanent and temporary loss of foraging habitat. Permanent loss will occur through the clearing of vegetation for GH_2 and associated renewable energy infrastructure, while temporary loss may arise from storage areas and the movement of heavy vehicles during construction. In addition, construction-related disturbances such as elevated levels of light and noise may lead to the temporary or permanent displacement of more sensitive bat species.

6.3.2 Mitigation measures

No proposals for renewable energy or GH_2 developments should be allowed within the Very High sensitivity areas indicated in the sensitivity analysis map in this report, and the risk assessment for each impact and sensitivity tier should be considered on a regional management level when GH_2 and renewable energy facilities are proposed. Additionally, adhering to site-specific bat specialist sensitivity maps created during EIA studies will also assist in mitigating this risk. Construction activities should be confined to designated areas for the storage of materials, equipment, and vehicles, and all vehicle movements should be restricted to established access routes. Any areas disturbed during construction should be rehabilitated following completion, using appropriate ecological restoration techniques.

6.3.3 Impact assessment

Table 6-3 highlights the formal ratings of the above impact, considering their relevance across areas of varying bat sensitivity (Very High to low as mapped in Figure 5-1), for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2). Impact ratings are assessed independently for scenarios with and without the implementation of the recommended mitigation and management measures described above.

Table 6-3: Assessment of potential impacts associated with the loss and fragmentation of bat foraging habitat

Negative Impact	Scenario	Spatial receiving environment (sensitivity tier)	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Bat foraging habitat loss	S0: Baseline	Very High	Significant	Likely	MODERATE	N/A	N/A	N/A
	S1: Small GH_2		Drastic	Definite	HIGH	Drastic	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	VERY HIGH
	S0: Baseline	High	Significant	Likely	MODERATE	N/A	N/A	N/A
	S1: Small GH_2		Drastic	More Likely	HIGH	Drastic	Likely	MODERATE
	S2: Big GH_2		Drastic	Definite	HIGH	Drastic	More Likely	HIGH
	S0: Baseline	Medium	Moderate	Unlikely	LOW	N/A	N/A	N/A
	S1: Small GH_2		Significant	Likely	MODERATE	Significant	Unlikely	LOW
	S2: Big GH_2		Drastic	More Likely	HIGH	Drastic	Likely	MODERATE
	S0: Baseline	Low	Slight	Very Likely	VERY LOW	N/A	N/A	N/A
	S1: Small GH_2		Moderate	Unlikely	LOW	Slight	Very Likely	VERY LOW
	S2: Big GH_2		Moderate	Likely	LOW	Moderate	Unlikely	LOW

6.4 Bat fatalities due to collision or barotrauma caused by wind turbines during foraging and migration

6.4.1 Impact description

Collisions with turbine blades and barotrauma pose a significant risk to resident bat populations, with potential impacts persisting over the operational lifetime of the facility. Effective management and mitigation of this risk are therefore essential. During operational periods, artificial lighting can attract insects and, consequently, foraging bats, increasing the likelihood of turbine-related mortality where lights are positioned near turbines. Similarly, the creation of artificial water bodies, such as stormwater retention areas, may draw bats into proximity with turbines, further elevating collision risk. Renewable energy and GH_2 infrastructure may also inadvertently provide artificial roosting opportunities; where these occur near turbines, the potential for bat mortality is significantly increased.

Fruit bats may occur in the region near rivers, some natural food sources and agricultural activities (e.g. date farms), and may commute large distances seasonally following available fruit and other natural food sources such as nectar. Fruit bats are not detected during acoustic based bat EIA studies since they don't echolocate. This increases their risk of collision if wind farm design does not accommodate these commuting routes.

The bat species *Cistugo seabrae* (Angolan Hairy Bat) are occurring in the Namakwa Region with a Near Threatened conservation status, with less than 1000 individuals estimated. They are believed to have a low risk of impact by wind energy facilities, but are significantly understudied in behaviour, habitat preferences and risk to turbine collision.

Cave-dwelling bats provide a critical ecological function by supplying energy to cave ecosystems through their guano, which forms the basis of food webs in the absence of sunlight. Mortality of bats during migration between caves—whether due to collisions with turbine blades or barotrauma—can disrupt this energy input, potentially leading to the collapse of one or more cave ecosystems. These ecosystems are often isolated and contain unique, specialized biota, making them particularly vulnerable to the loss of bats. In the study region, migratory routes are currently unknown, and it is unclear whether such movements occur, increasing the uncertainty and potential risk of significant ecological impacts from turbine-related bat fatalities

6.4.2 Mitigation measures

The mitigation potential for this risk is high and involves various aspects.

Placement: No proposals for wind energy facility developments should be allowed within the Very High sensitivity areas indicated in the sensitivity analysis map in this report, and the risk assessment for each impact and sensitivity tier should be considered on a regional management level when wind energy facilities are proposed. Additionally, adhering to the site-specific bat sensitivity maps created during EIA studies will contribute to mitigating this risk.

Wind energy facility design:

Avoid creation of artificial foraging habitat: Lighting across all renewable energy infrastructure, including turbine bases, operations and maintenance buildings, and ancillary facilities, should be minimised while maintaining safety and security requirements. Aviation lighting must comply with applicable regulations. Exterior lighting should, where possible, be fitted with low-sensitivity motion sensors to switch off automatically when areas are unoccupied, preventing the formation of regular insect congregations. Where motion sensors are not feasible, lights should use wavelengths that attract fewer insects, typically "warm white," yellow, or amber, with a colour temperature below 4000 K. Floodlights should be hooded to limit illumination to only the areas required. Stormwater management plans should avoid creating artificial water bodies, ponds, or wetlands within turbine zones (defined as the turbine blade length plus relevant sensitivity buffers), as these could increase insect activity and, consequently, bat foraging activity near turbines.

Avoidance of artificial roosting habitat:

Buildings: All new buildings on site should be designed and constructed to prevent the formation of potential bat roosts. Roofs and wall junctions must be thoroughly sealed. Corrugated iron roofing, if used, must be sealed with a durable, flexible sealant (cement should be avoided due to potential loosening in wind). Thatched roofs should be avoided entirely. Bargeboards or sideboards mounted against walls should be avoided where possible; if unavoidable, these must also be sealed with a flexible sealant.

Culverts: New culverts should be designed to avoid creating ceiling hollows or voids that could serve as bat roosts. If any such voids are unavoidable, they must be filled flush with the culvert ceiling.

Inspection and eviction: During operational monitoring and mortality audits, all infrastructure should be inspected by a qualified bat specialist for the presence of artificial roosts. Any identified roosts should be safely evicted by a bat specialist during the appropriate season, ensuring that dependent pups are not present to prevent mortality.

Operational management: To reduce bat fatalities during operation, turbines may need to be curtailed or other mitigation (deterrents or shut down on demand) applied during periods of high bat activity identified in EIA studies, as recommended by the bat specialist that conducted the bat EIA assessment.

Operational monitoring: Continuous monitoring of bat fatalities should be conducted for the operational lifetime of facilities. Data collected should inform adaptive management measures, including additional curtailment or mitigation strategies where necessary, to ensure bat populations are protected. Operational bat mortality data or reports should be submitted to DFFE and SABAAP.

6.4.3 Impact assessment

Table 6-4 highlights the formal ratings of the above impact, considering their relevance across areas of varying bat sensitivity (Very High to Low as mapped in **Figure 5-1**), for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2). Impact ratings are assessed independently for scenarios with and without the implementation of the recommended mitigation and management measures described above.

Table 6-4: Assessment of potential impacts associated with bat mortalities due to collision or barotrauma when foraging and/or migrating

Negative Impact	Scenario	Spatial receiving environment (sensitivity tier)	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Bat mortalities	S0: Baseline	Very High	Drastic	More Likely	HIGH	N/A	N/A	N/A
	S1: Small GH_2		Extreme	Definite	VERY HIGH	Extreme	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	VERY HIGH
	S0: Baseline	High	Significant	More Likely	MODERATE	N/A	N/A	N/A
	S1: Small GH_2		Drastic	More Likely	HIGH	Drastic	Likely	MODERATE
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	More Likely	HIGH
	S0: Baseline	Medium	Moderate	Likely	LOW	N/A	N/A	N/A
	S1: Small GH_2		Significant	More Likely	MODERATE	Moderate	Likely	LOW
	S2: Big GH_2		Drastic	Likely	MODERATE	Significant	Likely	MODERATE
	S0: Baseline	Low	Moderate	Likely	LOW	N/A	N/A	N/A
	S1: Small GH_2		Significant	Likely	MODERATE	Significant	Unlikely	LOW
	S2: Big GH_2		Significant	More Likely	MODERATE	Significant	Unlikely	LOW

7. RECOMMENDED STRATEGIC MANAGEMENT ACTIONS

The following strategic management actions are recommended to develop and progress knowledge required to more effectively manage the impacts of renewable energy and GH_2 development over the long term in the Namakwa Region. Additionally, a strong focus is placed on avoiding Very High risk areas at the proposal stage (pre-EIA) of such developments.

7.1 Recommendations to inform national policy

1) Bat mortality monitoring reports from operational wind energy facilities must be shared with both DFFE and designated individuals at SABAAP. This will enable the continuous development of more efficient mitigation measures and recommendations during wind energy facility planning phases.

2) An updated national scale SEA spatial risk analysis must be conducted to identify areas where GH_2, PV and/or wind energy facilities may not be proposed for development. To prevent EIA studies and applications from being initiated in Very High risk areas.

7.2 Recommendations to inform regional planning

1) No proposals for renewable energy or GH_2 developments may be allowed within the Very High sensitivity areas indicated in the sensitivity analysis map in this report (**Figure 5-1**), and the risk assessment for each impact and sensitivity tier should be considered on a regional management level when GH_2 and renewable energy facilities are proposed.

2) A research program should be initiated with appropriately skilled specialists/academic researchers to establish the migratory routes of cave dwelling bat species inhabiting caves/mines within or near the Namakwa Region.

7.3 Recommendations for future EIA studies

1) Bat preconstruction EIA studies for wind energy facilities must be a minimum of 12 months (as per details stipulated in the current Best Practice Guidelines, MacEwan *et al.*, 2020), but ensuring that at least 75% of the rainy season must be covered with acoustic bat activity data collection. This is due to the high seasonality and drastic climatic fluctuations experienced in arid to semi-arid environments. The rainy season may in some cases last less than a month, therefore the bat EIA study design must identify this predicted period beforehand and make provision to ensure bat activity monitoring during this period.

2) Potential fruit bat activity must be considered during the bat EIA study design, noting the proximity and occurrence of agricultural activities (e.g. date farms) and/or natural sources of food (e.g. nectar from succulents) in relation to the proposed wind energy facility. The bat EIA study methodology must make provision for establishing the presence/absence and/or monitoring of non-echolocating fruit bats.

3) The bat species *Cistugo seabrae* (Angolan Hairy Bat) are occurring in the Namakwa Region with a Near Threatened conservation status, with less than 1000 individuals estimated. They are believed to have a low risk of impact by wind energy facilities, but are significantly understudied in behaviour, habitat preferences and risk to turbine collision. Bat preconstruction EIA study methodology must make provision for the consideration of occurrences and possible impacts on the Near Threatened bat species *Cistugo seabrae* (Angolan Hairy Bat) found in and around the Namakwa Region.

4) It is critical for Roost Investigation zones around bat roosts to receive further field investigations during the EIA phase of a renewable energy project to verify species presence, colony size, and roost significance.

5) If a proposed renewable energy project is located within a Roost Caution zone, the identified roost must be explicitly considered during the EIA process. The study design and data analysis should make appropriate provision for roost location, species, and potential impacts to determine if species present in the applicable roost may be impacted by the proposed project.

7.4 Recommendations to enhance positive impacts and reduce negative impacts

1) No proposals for renewable energy or GH_2 developments may be allowed within the Very High sensitivity areas indicated in the sensitivity analysis map in this report (**Figure 5-1**), and the risk assessment for each impact and sensitivity tier should be considered on a regional management level when GH_2 and renewable energy facilities are proposed.

2) Preservation of floral and faunal biodiversity in non-transformed habitats is crucial to preserving the biodiversity of the natural food sources of different species of bats found in the Namakwa Region.

3) Initiate research programs and projects to contribute data and knowledge required for the long-term positive benefit of bat conservation in the Namakwa region.

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APPENDIX 1: SPECIALIST INFORMATION

Specialist Company Name:	Animalia Consultants (Pty) Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	100%
Specialist name:	Werner Marais			
Specialist Qualifications:	MSc Biodiversity & Conservation			
Professional affiliation/registration:	SACNASP *Pr.Sci.Nat* (Zoological Science)			
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APPENDIX 2: DECLARATION BY THE SPECIALIST

I, _____Werner Marais_____, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
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Signature of the Specialist

Animalia Consultants (Pty) Ltd

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CHAPTER 2c

Fauna

CHAPTER 2c: Fauna

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I, Corné Niemandt, declare, that the work presented in this report is our own and has not been influenced in any way by the developer or the EAP. At no point has the developer asked me as specialists to manipulate the results in order to make it more favourable for the proposed development. I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP) and the EIA Regulations (2014, as amended). I have the necessary qualifications and expertise in conducting this specialist report.

Corné Niemandt

Executive Summary

The Namakwa Region Strategic Environmental Assessment (SEA) was conducted to evaluate the potential impacts of the proposed GH2 production coupled with technologies and infrastructure required to create the electricity and water inputs, on regional fauna communities and ecological processes. The assessment considered various environmental factors, including loss of critical ecosystem functioning, fauna species of conservation concern, and broader biodiversity implications including collapsing of key drivers and processes. Given the ecological sensitivity of the regional area, the study aimed to provide a detailed understanding of the potential risks and necessary mitigation measures.

The research methodology included a comprehensive desktop assessment, utilising GIS mapping, literature reviews, and secondary data sources to identify critical biodiversity areas and species at risk. The study revealed that the region falls within three major biomes: the Succulent Karoo, Nama Karoo, and Desert biomes, with high levels of endemism and biodiversity significance and to a smaller degree isolated patches of Fynbos embedded in the Succulent Karoo. Several species of conservation concern, including mammals, reptiles, and amphibians, were identified within the project area, highlighting the ecological importance of the region.

The anticipated environmental impacts include habitat fragmentation, disruption of ecological corridors and migratory pathways, increased predation risks due to infrastructure, and increased roadkill incidents. Additionally, the proposed renewable energy developments may pose risks to avian and bat populations due to wind turbine collisions and altered thermal conditions affecting burrowing species.

To mitigate these impacts, several recommendations have been proposed, including the establishment of wildlife corridors, buffer zones around wetlands, and the implementation of wildlife-friendly infrastructure such as fauna underpasses and overpasses. The strategic placement of wind and solar farms, sustainable water management, and climate adaptation strategies are also crucial to ensuring the long-term ecological sustainability of the region.

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Glossary

Critical Biodiversity Area (CBA): an area that must be maintained in a good ecological condition (natural or semi-natural state) in order to meet biodiversity targets. CBAs collectively meet biodiversity targets for all ecosystem types, as well as for species and ecological processes that depend on natural or semi-natural habitat that have not already been met in the protected area network. CBAs are identified through a systematic biodiversity planning process in a configuration that is complementary, efficient and avoids conflict with other land uses where possible.

Cumulative impact: in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities.

Ecosystem: a dynamic complex of animal, plant and micro-organism communities and their non-living environment interacting as a functional unit.

Ecosystem threat status: A measure of how threatened an ecosystem is, based on how much of the ecosystem's original area remains intact relative to three different thresholds or "tipping points". These thresholds indicate the points at which it is estimated that the ecosystem would undergo fundamental change, either in terms of biodiversity pattern or ecological processes. Ecosystems are categorised as critically endangered, endangered, vulnerable or least threatened.

Endemic: Restricted or exclusive to a particular geographic area, occurring nowhere else. Endemism refers to the occurrence of endemic species.

Extent of occurrence (EOO): the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy; and in short is the species' contemporary distribution range.

Habitat: The area or environment occupied by a species or groups of species, due to the particular set of environmental conditions that prevails there.

IUCN Red List Categories and Criteria: the threatened species categories used in Red Data Books and Red Lists have been in place for almost 30 years. The IUCN Red List Categories and Criteria provide an easily and widely understood system for classifying species at high risks of global extinction, so as to focus attention on conservation measures designed to protect them.

IUCN Red List status: the conservation status of species, based on the IUCN Red List categories and criteria.

Mitigation: means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible.

Range-restricted species: the presence of terrestrial flora, vertebrate and invertebrate fauna with a global population extent of occurrence (EOO) of 10 000 km^2 or less.

Species of conservation concern (SCC): includes all species that are assessed according to the IUCN Red List Criteria as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Data Deficient (DD) or Near Threatened (NT), as well as range-restricted species which are not declining and are nationally listed as Rare or Extremely Rare [also referred to in some Red Lists as Critically Rare].

Threatened species: species that are facing a high risk of extinction. Any species classified in the IUCN categories CR, EN, VU, is a threatened species.

1. INTRODUCTION

The Transnet National Ports Authority has embarked on the determination of the feasibility for the development, construction, and operation of a deep-water port with associated landside port facilities at Boegoebergbaai, Northern Cape. The proposed new port development is primarily for the enablement of the Northern Cape's Provincial Economic Development strategy including the Green Hydrogen (GH_2) Strategy and expanding the mining and industrial base in the Northern Cape.

Green hydrogen is hydrogen gas (H_2) that is produced using renewable energy sources—typically solar or wind power—through a process called electrolysis. In this process, water (H_2O) is split into hydrogen (H_2) and oxygen (O) using an electric current, and when that electricity comes from renewable sources, the resulting hydrogen is considered "green."

Green hydrogen production, at the scale envisaged, is a diverse and multifaceted process with many direct and indirect impacts, both positive and negative. All programme components (including their interconnected transport corridors) would require vast areas of land surface, as well as other resource intensive inputs, all proposed in a sparsely populated but ecologically sensitive arid region. Existing land uses in the study area include conservation, agriculture, fisheries, tourism, and mining.

A Strategic Environmental Assessment (SEA) has been initiated through a collaboration between the South African National Energy Development Institute (SANEDI), Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA), and Transnet National Ports Authority (TNPA) (the Project Steering Committee (PSC)). The Council for Scientific and Industrial Research (CSIR) has been appointed to undertake an independent SEA. The overarching purpose of the SEA is to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai Port, SEZ, and wider Namakwa region in a sustainable manner.

Bios Diversitas Consultants has been appointed to conduct the SEA's faunal component for the proposed Boegoebaai Port and Special Economic Zone (WP1 report dated May 2025) and the wider Namakwa region (WP2 i.e., this report).

2. SCOPE OF THIS STRATEGIC ASSESSMENT – WORK PACKAGE 2 (WP2)

2.1 Study Area

The spatial scope for the WP2 Faunal Assessment is delimited by four local municipalities: the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities, including the Boegoebaai port precinct and SEZ (hereafter the 'Regional Area'; Figure 1).

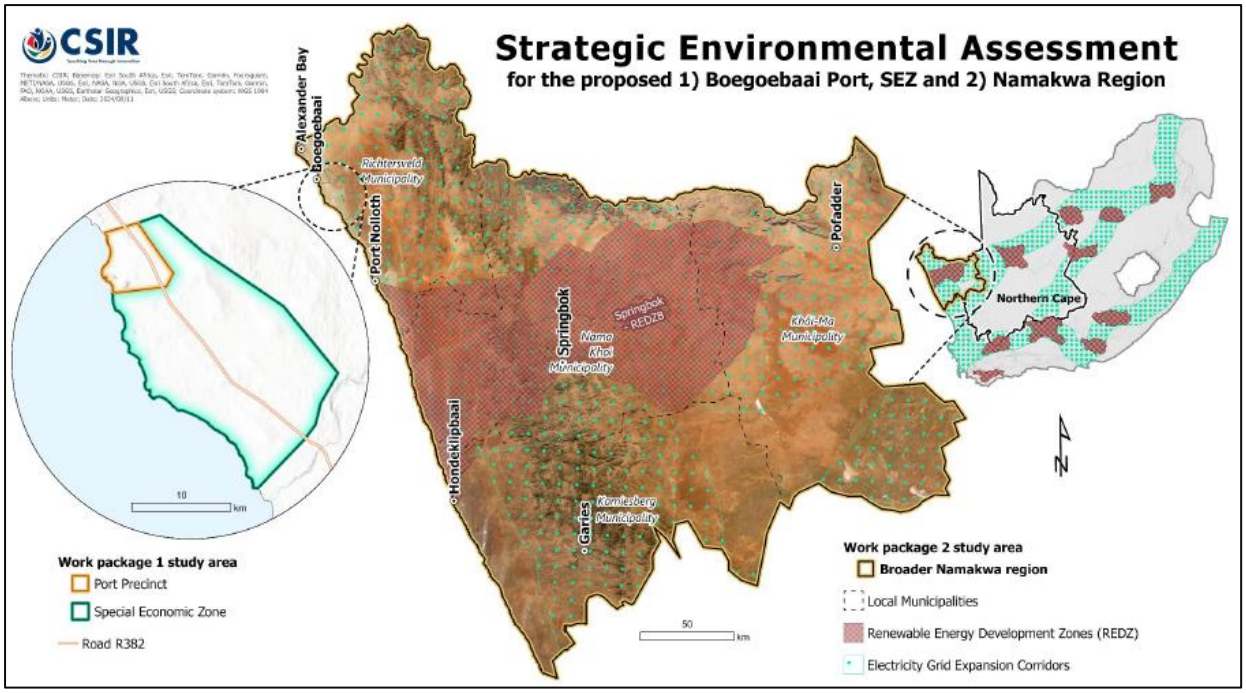

Figure 1: The spatial extent of the two SEA Work Packages with this report focusing on the Work Package 2 study area i.e., the Broader Namakwa Region (*Source*: CSIR, 2025).

The Northern Cape targets include an initial 1.2 GW of electrolyser capacity to be completed by 2028, scaling up to 5 GW by 2030, and reaching 40 GW by 2050. As part of South Africa's ambition to become a player in the globally emerging green hydrogen market, a substantial programme of greenfield infrastructure has been proposed in the Northern Cape consisting of three main components:

i. New deepwater port at Boegoebaai, dry and liquid bulk berths, and multi-purpose terminals.

ii. Mixed-use SEZ located in the region adjacent to the proposed Boegoebaai port.

iii. Expansive regional renewable energy (wind and solar PV) generation and transmission infrastructure.

GH_2 production, at the scale envisaged in the Northern Cape, will be a diverse and multifaceted process with many direct and indirect impacts, both positive and negative. The technologies and infrastructure required to create the electricity and water inputs, such as wind turbines and solar PV panels, seawater desalination plants (plus the hundreds of kilometres of linear infrastructure), are major infrastructure developments (Figure 2), with a complex array of social and environmental impacts. If undesirable impacts are not properly avoided and mitigated in the project planning phases, individually or in accumulation, they could result in unacceptable social and ecological consequences.

The long-term port layout for Phase 1B has been designed with built in flexibility, allowing it to adapt to future shifts in commodity mix, operational requirements, and planning priorities. The masterplan anticipates that exports will continue to focus on Phase 1A commodities, while accommodating potential growth in other GH_2 derivatives such as methanol, naphtha, and e-kerosene.

From 2035, combined exports of green ammonia, methanol, naphtha, and e-kerosene are projected to reach 2.15 Mtpa. Looking ahead to 2050, TNPA intends to extend the breakwater to enable additional multi-purpose and liquid bulk berths. This expansion will include new port infrastructure such as the Boegoebaai Container Terminal (BCT), a ship repair yard, and enlarged stockpiling warehouse capacity.

Enclosed warehouses will be implemented for dust suppression, ensuring manganese remains fully covered during storage and conveyor belt transport. The broader expansion will also require enhanced rail connectivity, road over rail bridges, and upgraded rail marshalling and tippler facilities.

Ancillary infrastructure required in support of the port and the SEZ include:

- Additionally, infrastructure for the disposal and management of chemical and hazardous waste generated by the port and SEZ.
- Domestic water and waste infrastructure throughout the port and SEZ.
- Utility water infrastructure between throughout the port and SEZ.
- Internal roads, pipelines, ICT, security, and office infrastructure.
- Accommodation for workers during the construction and (potentially) operations phases.

All programme components, including their interconnected transport corridors, will require substantial areas of land surface, as well as other resource intensive inputs, all proposed in a sparsely populated but ecologically sensitive region. Existing, and potentially competing, land uses in the region include conservation, agriculture, fishing, tourism, mining, and other subsistence livelihoods.

The scope of the SEA focusses on all the positive and negative social / ecological impacts associated with a regional GH2 economy in the Northern Cape. Two GH_2 development scenarios are considered in relation to (or in addition to) a dynamic baseline which includes other development and change trends in the region over a 25-year time horizon from 2025 to 2050.

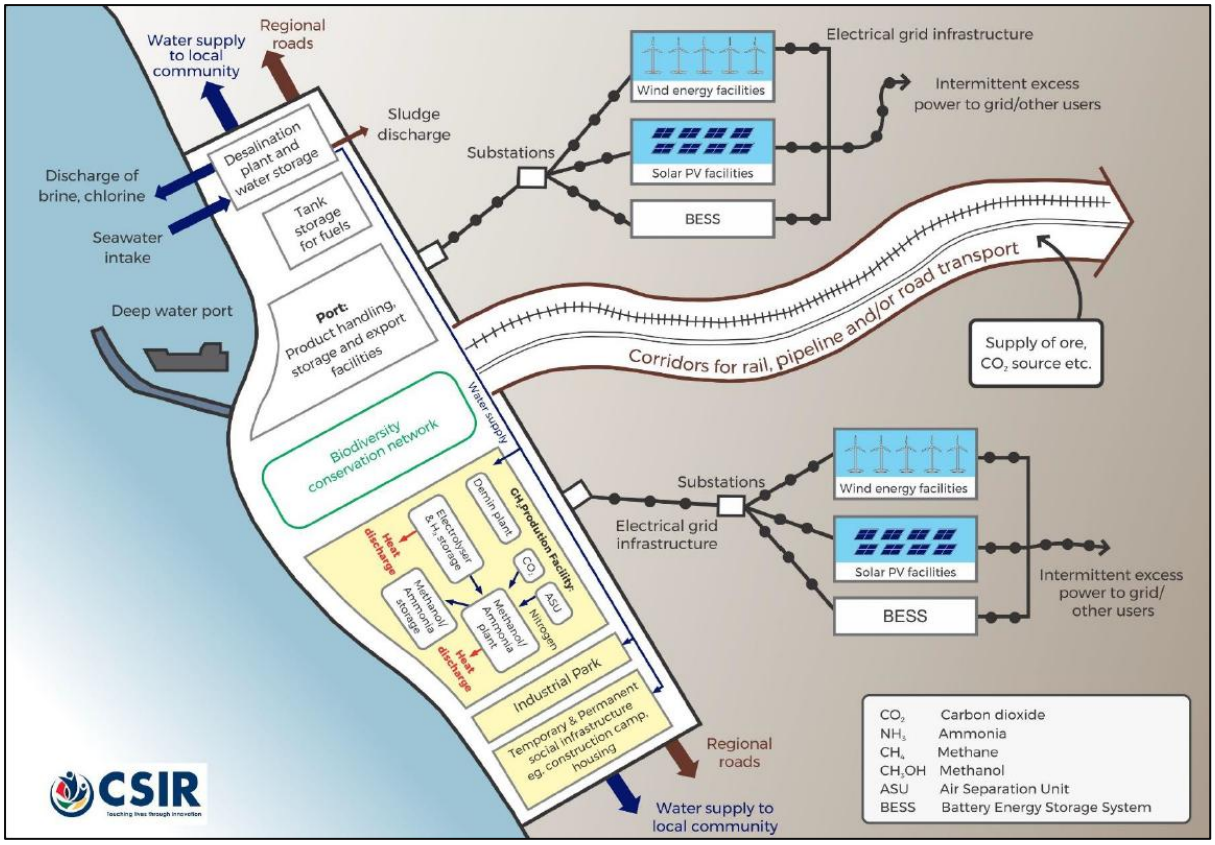

Figure 2: Schematic of the typical main infrastructure components for the Northern Cape regional GH2 programme (notional drawing, not to scale; *source*: CSIR briefing note).

2.2 GH_2 development scenarios for assessment

Two GH_2 development scenarios will be assessed, each compared to an existing dynamic baseline, where no GH_2 development occurs but other anthropogenic and climate changes continue, described as follows:

SCENARIO 0 – DYNAMIC BASELINE (2023 – 2050): Boegoebaai Port and SEZ remains undeveloped. No GH_2 is produced in the Northern Cape. The region proceeds on current social (e.g. migration, unemployment), ecological, climatic (e.g. desertification, storm surges, coastal flooding etc.) and developmental trends, including all other non-GH2 activities (e.g renewable energy development). The Namakwa region's economy proceeds to be shaped by mining (i.e., diamonds, zinc, copper), agriculture (mainly livestock), fishing, and a growing renewable energy sector, alongside seasonal tourism linked to the Namaqualand wildflower displays.

SCENARIO 1 – "SMALL GH_2" (by 2035): The Boegoebaai Port and SEZ are developed and a 5 GW electrolyser producing 0.5 metric tonnes per annum (mtpa) GH_2 and derivatives supported by 10 GW of renewable energy (the scenario assumes 60% solar / 40% wind).

SCENARIO 2 – "BIG GH_2" (by 2050): The Boegoebaai Port and SEZ are developed and GH_2 development is upscaled to a 40 GW electrolyser producing a total of 4 mtpa GH_2 and derivatives supported by 80 GW of renewable energy (assume 60% solar / 40% wind).

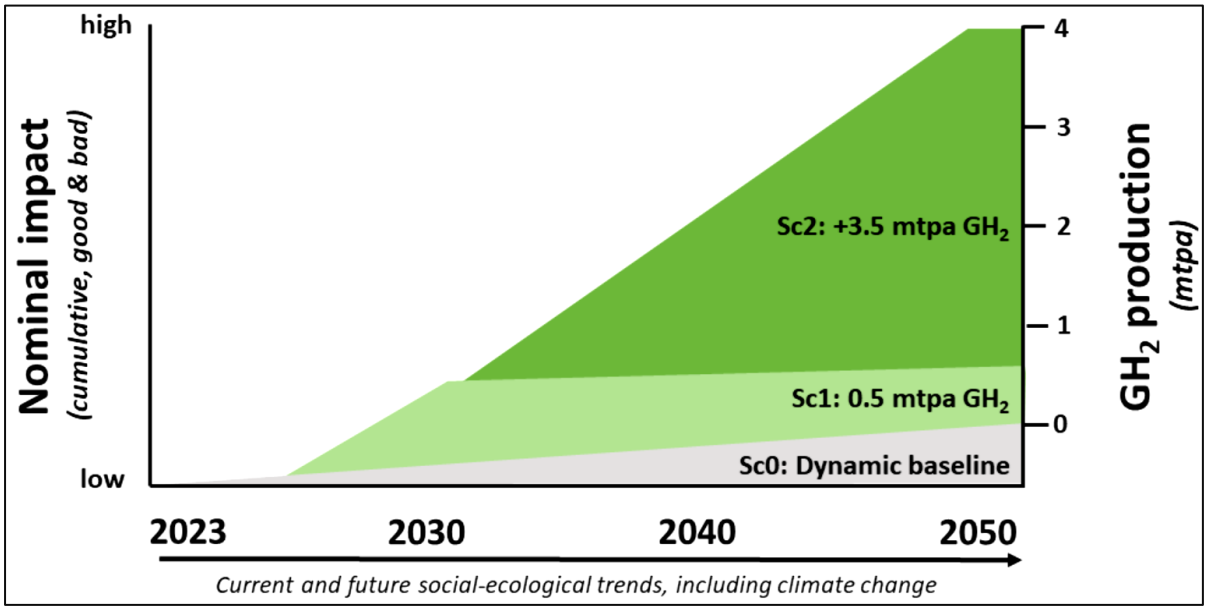

Figure 3: Indicative diagram of the scenarios approach for assessing cumulative impacts (*Source*: CSIR, 2025).

2.3 Infrastructure types impacting animals within the broader Namakwa Region

2.3.1 Renewable energy and electrical grid infrastructure

While some wind and solar PV generation will be located near the SEZ, the sensitivity of the local environment and potential coastal impacts (e.g., corrosion) mean that most power will come from dispersed renewable projects—often several hundred kilometres away—each requiring its own environmental impact assessment (EIA) (**Table 1**). Electricity will be supplied to the GH_2 production plant via a mix of new and existing transmission and distribution infrastructure (**Table 2**).

In these cases, solar PV and wind generation facilities including battery storage systems will be developed and permitted by third parties, meaning the hydrogen developer may not control the entire value chain. The project owner may purchase power from these third parties, acquire and operate the projects directly, and negotiate with the utility to wheel electricity through existing or newly built grids. Permitting will typically be split: the hydrogen developer will secure approvals for the electrolyser, ammonia plant, desalination plant, and, in some cases, export port facilities, while generation and transmission infrastructure will be permitted by other entities such as Independent Power Producers (IPPs) and Eskom.

Table 1: Brief description of the main renewable energy infrastructure aspects.

Renewable energy	Aspect	Description
Wind	Turbines	Rotor with blades, nacelle, tower, sizes 4-8 MW, hub height 150-180 m, blade length ~100 m
	Associated infrastructure	Foundations (~32 m^2), access roads, battery energy storage system (BESS), on-site electrical system, substation, transmission lines, construction camp, operations and maintenance facilities, meteorological masts, communication towers.
Solar PV	Solar panels	Monocrystalline/polycrystalline silicon cells, panel height ~6m, fixed or dual-axis tracking, single or bifacial modules.
	Associated infrastructure	Inverters, mounting structures, BESS, foundations, access roads, electrical system, substations, transmission lines, electrical components, construction camp, operations and maintenance facilities.

Renewable energy—wind and solar—facilities and associated powerline infrastructure can impact animals mainly through habitat loss or alteration from facility footprints; disturbance from noise, lighting, and human activity, alter ecologiocal processes and collision risks with facilities, particularly fences. Poorly sited wind or solar installations can displace sensitive species or increase mortality due to roadkill's in areas of suitable habitat and high-use corridors. Fences may also create barrier effects, disrupting wildlife corridors and migratory routes, and access to key foraging or breeding areas.

2.3.2 Green hydrogen plants

Green hydrogen plants are the core production hubs that turn water and renewable electricity into a storable, transportable, and versatile clean fuel — making them central to both the green hydrogen value chain and the broader renewable energy transition. Green hydrogen plants are the conversion engines that link renewable energy generation to a wide range of low-carbon applications, while also accelerating renewable deployment, enabling deep decarbonisation, and creating new economic opportunities.

Green hydrogen plants themselves don't usually pose the same direct displacement risks to animals such as permanent infrastructure including solar PV panels, wind turbines and hardstands or fences — but they can still have significant, often indirect, impacts because they are rarely stand-alone facilities. They are typically part of a much larger infrastructure footprint that includes renewable generation, transmission, water supply, and export logistics. The green hydrogen plant is often the anchor for a web of associated infrastructure. While the plant's core process is relatively benign to birds, its enabling components — renewable generation, transmission, water supply, and export facilities — can create substantial risks to animals if not carefully sited, designed, and managed.

2.3.3 Desalination plants

Desalination plants are a critical enabling link in many large-scale green hydrogen projects, especially in coastal or arid regions where freshwater is scarce, but renewable energy potential is high. Desalination plants make it possible to turn abundant seawater into the ultra-pure feedstock electrolysers need, unlocking green hydrogen production in water-scarce but renewable-rich regions—while also offering opportunities for community water supply and integrated, low-carbon infrastructure.

Desalination plants can affect animals primarily through habitat disturbance during construction and operation, noise and lighting impacts that may disrupt breeding or foraging behaviour, and direct and indirect effects from associated marine infrastructure. Coastal intakes and brine discharge can alter

nearshore ecosystems, potentially reducing prey availability for animals favouring the littoral active zone, while increased human activity and vessel traffic may disturb breeding and foraging sites.

2.3.4 Roads, rail and pipelines

Transport infrastructure such as roads, railways, and gas pipelines can impact fauna through habitat loss and fragmentation, disturbance from noise, vibration, and lighting, and increased collision risk with vehicles, trains, or fencelines. Linear corridors may also create barrier effects, altering wildlife corridors, migration routes, and access to feeding or breeding areas, while construction and maintenance activities can disrupt breeding and foraging. In sensitive habitats, these impacts can be significant, especially for low-manoeuvrability or fossorial species.

The following transport infrastructure is planned in the broader Namakwa Region:

- New pipelines for the bulk transportation of GH_2 to and from Namibia, Saldanha Bay (Scenario 1) and Prieska (Scenario 2).
- New rail between the Boegoebaai Port and Kenhardt connecting to the existing Saldanha-Sishen railway route.
- Upgrade and expansion of roads to and from Alexander Bay.
- Roads associated with the construction, operation and maintenance of new renewable energy facilities, railways and pipelines.

2.3.5 Masts and towers

Masts and towers are the vertical backbone of green hydrogen infrastructure — from capturing the wind that powers electrolysers, to gathering the climate data that underpins investment decisions, to enabling the communications and control systems that keep complex, distributed renewable-hydrogen networks running smoothly.

Masts and towers can impact fauna mainly through habitat loss if placed in sensitive areas, displacement, collision risk, and nocturnal species attracted to or disoriented by lights. Careful siting, design, and proper marking can reduce these risks.

Table 2: GH_2 development scenario quantifications (Scenario 1 and Scenario 2) for the broader Namakwa regional assessment (*Source*: CSIR, 2025).

	Aspect	Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	15 ha per 1 GW
	GH2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mpta GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mpta)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	57	454	1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28	227	0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mpta)
	Desalination output volume	Ml/day	36	286	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 operational.
	Desalination footprint	ha	7	57	5 Ml/day output needs 1 ha
	Desalination discharge	Ml/day	48	387	Ratio of desalinated water to brine discharge water to be 42.5:57.5. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine).
	Pipeline intake volume	Ml/day	84	672	Output + discharge
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	*GW*	*6*	*48*	60 % solar : 40 % wind
	RE footprint - solar	*ha*	*12 000*	*96 000*	0,5MW/ha
	RE extent - solar		*12 000*	*96 000*	Footprint = extent
	RE facilities - solar	*no of facilities*	*6*	*48*	Clusters of 1 GW facilities
	RE capacity - wind	*GW*	*4*	*32*	60 % solar : 40 % wind
	RE footprint - wind	*ha*	*4 000*	*32 000*	1 MW/ha
	RE extent - wind	*ha*	*40 000*	*320 000*	0,1 MW/ha
	RE facilities - wind	*no of facilities*	*3*	*21*	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 600	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	1 200	20 m servitude
	Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.
	Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)
	Main infrastructure components footprint	**ha**	**21 082**	**142 240**	

Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; Ml/day = million litres per day; km = kilometre

3. RESEARCH APPROACH AND METHODOLOGY

3.1 Defining the Research Problem

- **Spatial scope (Regional Area):** It's delimited by four local municipalities; the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities within the Namakwa District Municipality, including the Boegoebaai port precinct and SEZ.
- **Focus**: The SEA focusses on all the positive and negative social / ecological impacts associated with a regional GH2 economy in the Northern Cape.
- **Scope**: Fauna component as part of the overall Terrestrial Ecological Assessment within the SEA framework, with a strong focus on desktop and spatial data.

3.2 Research Design

The study will adopt a spatially focused assessment to ensure high-resolution environmental sensitivity mapping. The design will include:

- **GIS Mapping**: Integration of spatial data from existing surveys and secondary sources into a Geographic Information System (GIS).
- **Literature review**: Review of existing fauna assessments and databases for the region.

3.3 Data Collection

3.3.1 Primary Data Requirements

No detailed on-site fauna assessments will be undertaken for this SEA.

3.3.2 GIS

Existing data layers from various sources were incorporated into QGIS (open source) to establish how the proposed developments and associated activities interact with important terrestrial biodiversity features. Emphasis was placed on the following spatial datasets:

- Vegetation Map of South Africa, Lesotho and Swaziland (SANBI, 2024).
- Northern Cape Critical Biodiversity Areas (Northern Cape Department of Environment and Nature Conservation, 2016).
- National Protected Area Expansion Strategy (NPAES, 2018).
- Red List of Ecosystems (RLE) for terrestrial realm for South Africa - Original extent (SANBI, 2022[a]).
- RLE for terrestrial realm for South Africa – remnants (SANBI, 2022[b]).
- Protected and Conservation areas of South Africa (South Africa Protected Areas Database-SAPAD; South Africa Conservation Areas Database-SACAD)[1].

[1] http://dea.maps.arcgis.com/apps/MapTools/index.html?appid=2367540dd75148e8b6eaeab178a19d3a

3.3.3 Literature Review and Secondary Data

- Review of existing environmental and ecological datasets, biodiversity databases, and scientific literature.
- Relevant books and publications providing information on distribution ranges and/or conservation status of fauna species was consulted to review predictions of SCC occurrence at local scale.
- Previous SEA and EIA reports related to the PA.
- The National Red List[2] was utilised to provide the most current account of the regional conservation status of fauna species.
- The IUCN Red List of threatened species (IUCN, 2024) for global conservation statuses[3].
- Spatial data from the South African National Biodiversity Institute (SANBI), provincial biodiversity conservation authorities (Northern Cape Department of Environment and Nature Conservation), and related institutions.
- iNaturalist, the Global Biodiversity Information Facility (GBIF), the Virtual Museum (VM) of African Mammals, Frog Atlas of Southern Africa and Reptile Atlas of Africa was used to source observation data in the area to generate expected species lists[4].

3.4 Species of conservation concern

The Red List of threatened species generated by the IUCN provided the global conservation status of mammals, reptiles and amphibians. However, regional conservation status assessments performed following the IUCN criteria are generally the most relevant and sourced for each group as follows:

- Reptiles: Bates *et al.* (2014, as amended).
- Amphibians: Southern African Frog Re-Assessment Group (SA-FRoG) (2015); Du Preez & Carruthers (2017).
- Mammals: Child *et al.* (2016).

Take Note: This version of the report represents the final version in terms of recent information being made available on the unpublished 2025 National Red List. The listing of threatened fauna and/ or fauna SCC are based on information received up until and including 7 May 2025. Any further changes will not be reflected in this report.

The conservation status categories defined by the IUCN (Figure 4), which are considered here to represent species of conservation concern[5] (SCC), are the "threatened" categories defined as follows:

- **Critically Endangered (CR)** - Critically Endangered refers to species facing immediate threat of extinction in the wild.
- **Endangered (EN)** - Endangered species are those facing a very high risk of extinction in the wild within the foreseeable future.

[2] http://speciesstatus.sanbi.org/
[3] https://www.iucnredlist.org/
[4] It must be noted that the VM closed its operations at the end of 2024.
[5] Species of conservation concern have a high conservation importance in terms of preserving South Africa's high diversity and include not only threatened species, but also those classified in the categories Extinct in the Wild (EW), Regionally Extinct (RE), Near Threatened (NT), Critically Rare, Rare, Declining and Data Deficient - Insufficient Information (DDD).

- **Vulnerable (VU)** - Vulnerable species are those facing a high risk of extinction in the wild in the medium-term.

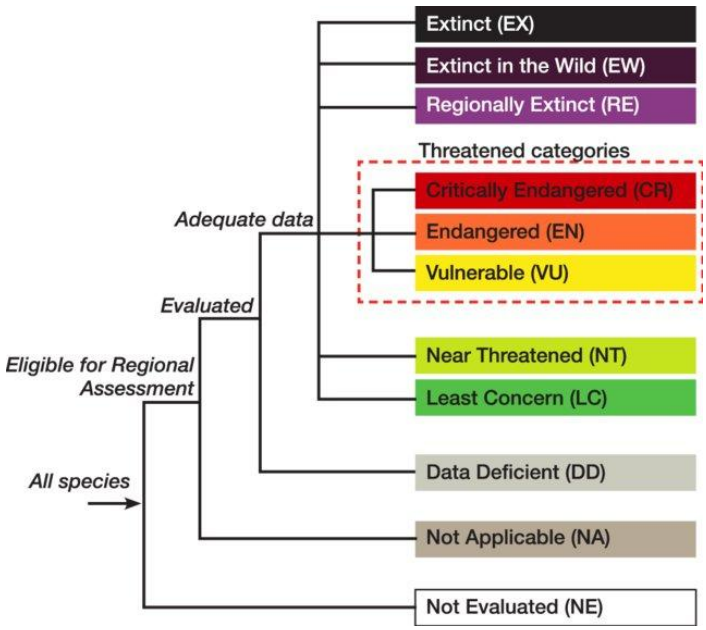

Figure 4: Schematic representation of the structure of the IUCN Red List Categories (IUCN 2012).

Other measures of conservation status include species listed under the following:

- National listed threatened or protected species (TOPS) in terms of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004).
- Convention on International Trade in Endangered Species (CITES; International).

3.5 Assumptions and Limitations

Using secondary data for a fauna desktop assessment, especially in remote regions of the Northern Cape involves several limitations and assumptions. These can impact the reliability and applicability of the assessment findings:

General Project Details

- It is assumed that all third-party information acquired is correct (e.g., GIS data and scope of work).
- Focus is on mammals, reptiles and amphibians, and will exclude avifauna, bats and water-dependent marine mammals which are addressed in separate assessments.
- It is assumed the proposed development's scale and scope are unlikely to shift significantly during the study period.

Data Gaps and Incompleteness:

- Access to reliable secondary data sources in the absence of field surveys.

- Available secondary data might not cover all species or habitats in the area, especially lesser-studied or cryptic species.
- Historical data may lack recent trends or population dynamics due to environmental changes or human activities.
- Potential lack of up-to-date or detailed secondary data, particularly for less-studied species or habitats in the region.

Spatial Resolution Issues:

- Full coverage of the regional area is constrained in the databases, particularly in remote areas. Accordingly, there may be gaps in the secondary data.
- Secondary data may have broad spatial scales that do not align with the finer resolution required for site-specific assessments.
- Habitat or species distribution maps may not accurately reflect microhabitats present in the area.

Temporal Limitations:

- Older datasets may not reflect current conditions due to climate change, habitat destruction, or ecological shifts.
- Migration or seasonal variations in species distribution may not be captured in static datasets.

Bias in Data Sources:

- Secondary data may overrepresent certain areas or species due to researcher interest or accessibility.
- Surveys may exclude nocturnal, fossorial, or migratory species, leading to underrepresentation.

Lack of Contextual Information:

- Secondary data often lack behavioural, ecological, or physiological context needed to assess the specific impacts on fauna.

Inconsistency in Data Quality:

- Differences in data collection methods, accuracy, and sampling effort across studies can lead to inconsistencies.

Static Conditions:

- It is assumed ecological and environmental conditions have remained relatively stable since the data were collected.

Species-Habitat Relationships:

- Documented species-habitat relationships are valid for the region at the time of the assessment, despite potential variations in habitat quality or connectivity.

To mitigate against these limitations, it is recommended that the desktop review be complemented with targeted field surveys for site-specific validation based on proposed areas. In addition, cross-check findings with taxa experts with local knowledge as well as recent regional studies. Furthermore, a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions.

4. DESKTOP RESULTS

4.1 Biomes and Biodiversity Hotspot

The Regional Area falls into eleven bioregions in three major biomes, the Succulent Karoo (along the west coast stretching inland), the Nama Karoo (eastern section of the Regional Area) and the Desert (northern section along the lower Orange River), as well as small, isolated sections of the Fynbos embedded in the Succulent Karoo. Almost the entire Desert biome (> 99%) falls within this assessment regional scope, making it a higher priority for protection from development in terms of meeting biodiversity targets and maintaining ecosystem processes.

The Desert Biome are arid ecosystems shaped by climatic, geological, and biological processes. These areas are globally recognised for their high biodiversity, extreme climatic conditions, and unique adaptations of flora and fauna. Within South Africa, it stretches from the Atlantic coast between Alexander Bay (near the mouth of the Orange River) and Visagiesfontein (Buchu / Boegoe Berg twins) and penetrate inland following the course of the lower Orange River as far as the vicinity of Pofadder and Onseepkans in northern Bushmanland. It is characterised by its low and unpredictable rainfall (between >50- and <250 mm), extreme temperatures (high daytime temperatures (often > 40°C in summer) contrast with very cold nights) and both winter- and summer-rainfall areas. This provides for a wide spectrum of adaptations to the arid environment, and high endemism

The Succulent Karoo biome, recognised as one of the world's 34 biodiversity hotspots (the World's only arid hotspot) and one of only three in South Africa. It is known for its high endemism in plants, reptiles, insects and small mammals. This globally significant landscape is a priority for conservation efforts led by both national and international organisations, aiming to protect its unique and highly diverse ecosystems. Namaqualand is recognised internationally as a global centre for both reptile and insect diversity and endemism (Driver et al., 2003) that is particularly vulnerable to climate change where a minimum decline in species richness of 41% is predicted for the Succulent Karoo biome. Understanding the biodiversity and ecology of Namaqualand requires an examination of the physical and biological factors that have shaped its regional biota over time. Additionally, both historical and current patterns of human occupation and land use play a crucial role in influencing contemporary biodiversity dynamics.

4.2 Regional Vegetation and Threatened Ecosystems

The Regional Area is unique as it is located within 69 vegetation types and four biomes (SANBI 2024), and 5 threatened ecosystems listed as Critically Endangered (CR) under the revised Red List of Ecosystems (2021). The five CR threatened ecosystems include:

- AZd 1 Namib Seashore Vegetation
- AZd 2 Namaqualand Seashore Vegetation
- SKs 1 Richtersveld Coastal Duneveld
- Dn 1 Alexander Bay Coastal Duneveld
- Dn 2 Namib Lichen Fields

Namib Seashore Vegetation AZd 1 – Critically Endangered [A3, B1(i), B2(i)]

The Namib Seashore Vegetation occupies a narrow strip along the southern Namib Desert (one of the oldest and most arid deserts of the world), extending into the Northern Cape province of South Africa only marginally where it reaches its southernmost distribution limit on the Holgat River (just south of the PA). This ecoregion is characterised by its unique adaptations to a harsh coastal environment, where the Atlantic Ocean meets one of the driest terrestrial ecosystems on Earth.

The landscape is dominated by slightly sloping sandy beaches and adjacent moving and fixed coastal dunes (Strandveld Formation) and occasional coastal cliffs. Vegetation is dominated by dwarf shrubs up to 1 m tall and spiny grasses on the windblown dunes and small succulent dwarf shrubs dominating exposed rocky cliffs on the seafront. Adaptations such as to obtain moisture from the frequent coastal fogs rather than from rainfall are key in this environment.

The Namib seashore vegetation supports a variety of wildlife adapted to extreme conditions, potentially including:

- Grant's Golden Mole (*Eremitalpa granti granti*): A rare and highly specialised burrowing mammal that navigates through sandy dunes.
- Cape fur seals (*Arctocephalus pusillus pusillus*): Found along the coast, especially near rocky outcrops and beaches.
- Reptiles: Fog-dependent geckos and lizards, including the web-footed gecko (*Pachydactylus rangei*), a desert specialist.

National land cover data show that Namib Seashore Vegetation has experienced extensive spatial declines of approximately 95% since 1750. It is narrowly distributed with high rates of habitat loss in the past 28 years (1990-2018), mainly due to diamond mining and coastal development, placing the ecosystem type at risk of collapse.

Richtersveld Coastal Duneveld SKs 1 – Critically Endangered [B1(i)]

The Richtersveld Coastal Duneveld (SKs 1) is a unique and ecologically significant landscape along the Atlantic Ocean coast from a point between the Boegoe (Buchu) Twins and Alexander Bay to about halfway between Port Nolloth and Kleinzee along a broad belt of 1–12 km within the Northern Cape province of South Africa. The north-south extension is 104 km. It forms part of the globally recognised Succulent Karoo biome, a biodiversity hotspot known for its remarkable array of endemic species. It is characterised as generally flat with some large, gently rolling coastal dunes. On the active dunes, depending on the aspects of the slopes and on the phase of deflation and sedimentation, different plant communities occur.

Despite its arid conditions, the Richtersveld Coastal Duneveld supports an array of fauna uniquely adapted to its challenging environment:

- Namaqua chameleon (*Chamaeleo namaquensis*): A desert-adapted chameleon that thrives in sandy habitats.
- Brown hyena (*Parahyaena brunnea*): An elusive predator that roams the coastal areas, scavenging for food.
- Cape fur seals (*Arctocephalus pusillus pusillus*): Found along the coastal edge, particularly in rocky zones and sand dunes.
- Geckos and lizards: Fog-dependent reptiles like the web-footed gecko (*Pachydactylus rangei*) and desert-adapted skinks inhabit the sandy dunes.

Ecosystems functioning

Similar to other Mole-rats (*Cryptomys hottentotus* and *Georychus capensis*), the Namaqua Dune Mole-rat is an important eco-engineer and plays a role in modifying soil properties and increasing the humic content of the sands in which it occurs.

Threats

Diamond mining is a key pressure on this ecosystem type, with 176.68 km^2 of the ecosystem directly impacted by mining activity. The vegetation unit is narrowly distributed with high rates of habitat loss in the past 28 years (1990-2018), placing the ecosystem type at risk of collapse. Sustained conservation efforts are essential to protect its unique landscapes and species for future generations.

Namaqualand Seashore Vegetation AZd 2 – Critically Endangered B2(i)

The Namaqualand Seashore Vegetation, part of the Succulent Karoo biome, is a distinctive ecological unit located along the coastal fringes of South Africa's Namaqualand region. This vegetation type is characterized by its unique arid landscape with a high diversity of succulent plants, including vygies, stonecrops, and other dwarf shrubs, which bloom spectacularly after winter rains. It is narrowly distributed with high rates of habitat loss in the past 28 years (1990-2018), placing the ecosystem type at risk of collapse.

Landscape and Vegetation Features

The landscape of the Namaqualand Seashore is predominantly composed of coastal dunes, sandy beaches, and rocky shores. The soils are generally sandy, with varying degrees of salinity, influenced by proximity to the ocean and tidal actions. The vegetation is adapted to withstand harsh coastal conditions, including high winds, salt spray, and limited freshwater availability. The vegetation structure is often low-growing and sparse, reflecting adaptations to the challenging coastal conditions.

Potential Habitat for Important Fauna Species

This vegetation type provides critical habitat for various fauna:

- **Birds**: Coastal birds, including migratory species, rely on these habitats for nesting and feeding.
- **Invertebrates**: A diverse array of insects and other invertebrates inhabit the coastal vegetation, playing essential roles in pollination and nutrient cycling.
- **Reptiles**: Certain lizard species are adapted to the sandy and rocky coastal environments.

Important Ecosystem Processes

The Namaqualand Seashore Vegetation supports several key ecosystem processes:

- **Sand Stabilisation**: Vegetation helps stabilize sand dunes, preventing erosion and protecting inland areas.
- **Nutrient Cycling**: Plant and animal interactions contribute to nutrient cycling, maintaining soil fertility. Shell beds on the beach are a by-product of nutrient-rich upwelling coastal waters along the West Coast known for their high biomass productivity.
- **Biodiversity Support**: The unique flora provides habitat and food sources for a variety of species, supporting overall biodiversity.

Understanding and preserving the Namaqualand Seashore Vegetation is vital for maintaining the ecological integrity of South Africa's coastal regions and ensuring the survival of the unique species that depend on this habitat.

Alexander Bay Coastal Duneveld – Critically Endangered A3, B1(i), B2(i)

The Alexander Bay Coastal Duneveld is a distinctive vegetation type located along South Africa's northwestern coastline, specifically near Alexander Bay in the Northern Cape Province. This area is characterized by unique landscape and vegetation features, faces certain environmental threats, holds particular conservation status, supports important fauna species, and maintains critical ecosystem processes.

Landscape and Vegetation Features

The Alexander Bay Coastal Duneveld is situated within the Desert Biome, as classified by Mucina and Rutherford (2006). The landscape is predominantly composed of sandy coastal forelands extending from the mouth of the Orange River to Cap Voltas, south of Alexander Bay. This region features flat sand shields

occasionally interrupted by dunes, typically forming broad, flat "whale-back" structures. Steep dune crests and valleys are rare, but where they occur, the vegetation reflects the variation in topography.

The sands in this region are primarily yellow, wind-blown sediments of coastal origin, predating the white dune sands found further west. These sands are remnants of an ancient mobile dune field that stabilized over time due to climatic improvements and increased vegetation cover following the last glaciation. Despite stabilization, the structure of the south-north-oriented dune ridges and associated valley systems remains discernible. Local erosion and sedimentation processes have created saline valleys with silty or loamy soils, enhancing habitat diversity. Currently, wind erosion occurs only minimally.

Vegetation in this area is adapted to the arid, coastal conditions, with species exhibiting xerophytic (drought-resistant) and halophytic (salt-tolerant) traits. The flora includes various succulents and shrubs capable of surviving in sandy, saline soils. Notably, the region supports unique lichen fields, which are sensitive to environmental disturbances.

Known Threats

National land cover data show that Alexander Bay Coastal Duneveld has experienced extensive spatial declines of approximately 92% since 1750. It is narrowly distributed with high rates of habitat loss in the past 28 years (1990-2018), placing the ecosystem type at risk of collapse.

The Alexander Bay Coastal Duneveld faces several environmental threats:

- **Mining Activities**: The extraction of diamonds and other minerals has led to habitat destruction and fragmentation. Mucina et al. (2006) report that a significant portion of the Richtersveld Coastal Duneveld has been transformed by diamond mining, indicating similar pressures may exist in the Alexander Bay area.

- **Climate Change**: Alterations in temperature and precipitation patterns may impact the delicate balance of this desert ecosystem.

- **Human Disturbance**: Activities such as off-road driving and unregulated tourism can damage sensitive habitats, including lichen fields.

Conservation Status

The conservation status of the Alexander Bay Coastal Duneveld is of concern due to the aforementioned threats. The area is recognized for its unique biodiversity, and efforts are underway to mitigate environmental impacts. However, specific conservation measures and the extent of protected areas within this vegetation type require further documentation.

Potential Habitat for Important Fauna Species

This vegetation type provides habitat for various fauna species adapted to arid coastal environments:

- ***Breviceps macrops* (Desert Rain Frog)**: This species has been recorded in the vicinity, relying on sandy habitats for burrowing.

- **Avian Species**: The area supports bird species adapted to desert and coastal conditions, some of which may be endemic or migratory.

- **Invertebrates**: The unique lichen fields and sandy soils provide niches for specialized insects and other invertebrates.

Important Ecosystem Processes

The Alexander Bay Coastal Duneveld supports several critical ecosystem processes:

- **Sand Stabilization**: Vegetation plays a crucial role in stabilizing sand dunes, preventing erosion and maintaining landscape integrity.

- **Microhabitat Formation**: The presence of lichen fields and varied dune structures creates microhabitats that support diverse organisms.

- **Nutrient Cycling**: Despite the arid conditions, nutrient cycling occurs through the decomposition of organic matter, supporting plant growth.

Understanding and preserving the Alexander Bay Coastal Duneveld is vital for maintaining the ecological integrity of South Africa's coastal desert regions and ensuring the survival of the unique species that depend on this habitat.

Namib Lichen Fields Dn 2 – Critically Endangered B1(i), B2(i)

The Namib Lichen Fields, designated as Dn 2, are a unique vegetation type located in the coastal regions of the Northern Cape Province, South Africa, near Alexander Bay. This area is characterized by its distinctive lichen-dominated landscapes, which are integral to the Desert Biome. Namib Lichen Fields is narrowly distributed with high rates of habitat loss in the past 28 years (1990- 2018), placing the ecosystem type at risk of collapse.

Landscape and Vegetation Features

The Namib Lichen Fields are situated on coastal plains with sandy and gravelly substrates. The climate is hyper-arid, with fog being the primary source of moisture, creating ideal conditions for lichen proliferation. The vegetation is predominantly composed of terricolous (ground-dwelling) lichens, forming extensive and diverse communities. These lichen fields are among the most extensive globally, with species adapted to extreme aridity and reliant on fog for hydration.

Known Threats

The Namib Lichen Fields face several significant threats:

- **Mining Activities**: The region has been subjected to diamond mining, leading to habitat destruction and fragmentation.

- **Off-Road Vehicle Disturbance**: Unregulated off-road driving can cause physical damage to the delicate lichen crusts, leading to long-term ecological impacts.

- **Climate Change**: Alterations in fog patterns and increased temperatures may affect lichen vitality and distribution.

Conservation Status

The Namib Lichen Fields are recognized as a South African Heritage Site due to their ecological significance. Despite this designation, they remain one of the most threatened habitats globally, primarily due to mining activities. Conservation efforts are needed to mitigate these threats and preserve this unique ecosystem.

Potential Habitat for Important Fauna Species

While the Namib Lichen Fields are predominantly lichen-dominated, they provide habitat for specialized fauna:

- **Invertebrates**: Various arthropods, including mites and insects, inhabit the lichen fields, contributing to nutrient cycling and soil health.
- **Reptiles**: Certain lizard species may utilize the lichen fields for foraging and shelter.

Important Ecosystem Processes

The Namib Lichen Fields support critical ecosystem processes:

- **Soil Stabilization**: Lichens bind soil particles, preventing erosion by wind and water.
- **Nutrient Cycling**: Lichens contribute to nutrient inputs in these nutrient-poor environments through nitrogen fixation and organic matter accumulation.

4.3 DFFE Screening Tool

The Namakwa Region is classified partially as HIGH, partially as MEDIUM and partially as LOW sensitivity according to the Animal Species Theme of the DFFE Screening Tool (**Figure 5**). The Namakwa Region also contains confirmed habitat for species of conservation concern (SCC) as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, Government Notice 1150 of 30 October 2020). SCCs are listed on the IUCN Red List of Threatened Species (2025) or South Africa's National Red List (2025) as Critically Endangered, Endangered, Near Threatened or Vulnerable. Refer to Section 4.5 Priority Fauna of Conservation Importance in Namaqualand for more details on animal SCC.

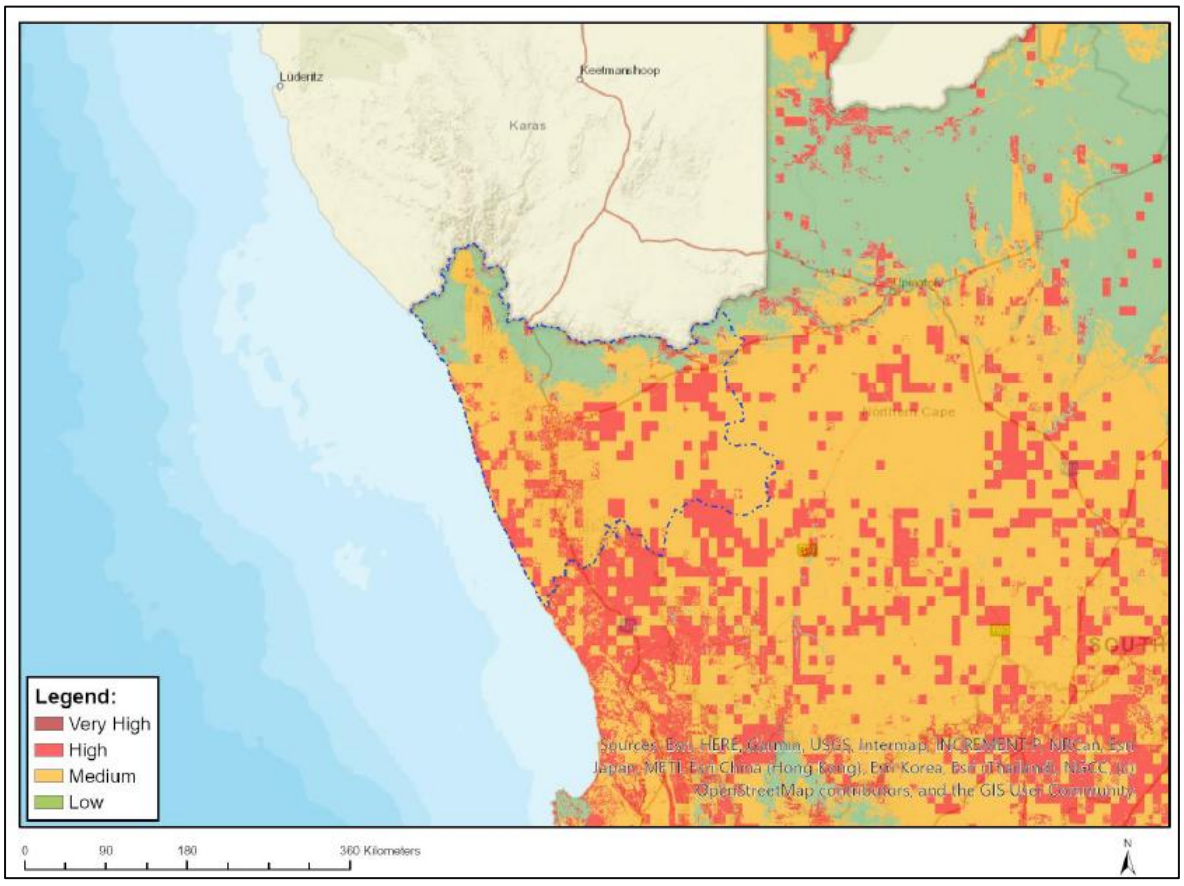

Figure 5: The sensitivity of the Namakwa Region as it relates to the Animal Species Theme (*Source*: DFFE Screening Tool, 2025).

4.4 Faunal Communities and Guilds of Namaqualand: Mammals, Reptiles, and Amphibians

Namaqualand is home to sensitive ecosystems that support a diverse range of fauna communities, including endemic, range-restricted, and migratory species.

In ecological terms, a **community** refers to a group of interacting species within a particular habitat, while a **guild** is a subset of species that exploit similar resources in a similar way. Below is an expanded discussion on the faunal communities and guilds of **mammals, reptiles, and amphibians** in Namaqualand (take note that information at this level of assessment is coarse and detailed impact assessments are required at a species level once projects have been identified for development). Due to the diversity of habitats and environments present, the site has a diverse and rich faunal community.

Namaqualand's faunal communities and guilds play essential roles in ecosystem functioning. While some species show moderate adaptability to human-altered environments, many are highly specialized and sensitive to habitat destruction. Conservation efforts should focus on habitat preservation, mitigation of human-wildlife conflict, and sustainable land-use planning to ensure the survival of these ecologically important communities.

As a crowdsourced species identification system, iNaturalist is an online social network of people sharing biodiversity information to help each other learn about nature. It helps you to identify the plants and animals around you while generating data for science and conservation. It also operates as an organism occurrence recording tool where access to observational data collected by iNaturalist users can be utilised by members. It is not a repository for external data, and as such there are limitations to its use. If the PA is under sampled owing to its location from major cities/towns, accessibility or observer bias, the quality and quantity of data should be considered in this context. Accordingly, a larger area should be searched for to obtain an observed and expected list of species which could intersect the PA.

For this project, the Namakwa Region was selected as the boundary for WP2. Filters applied included selecting amphibians, reptiles, mammals and invertebrates to obtain the distribution map for these taxa groups within the Namakwa Region (**Figure 6**).

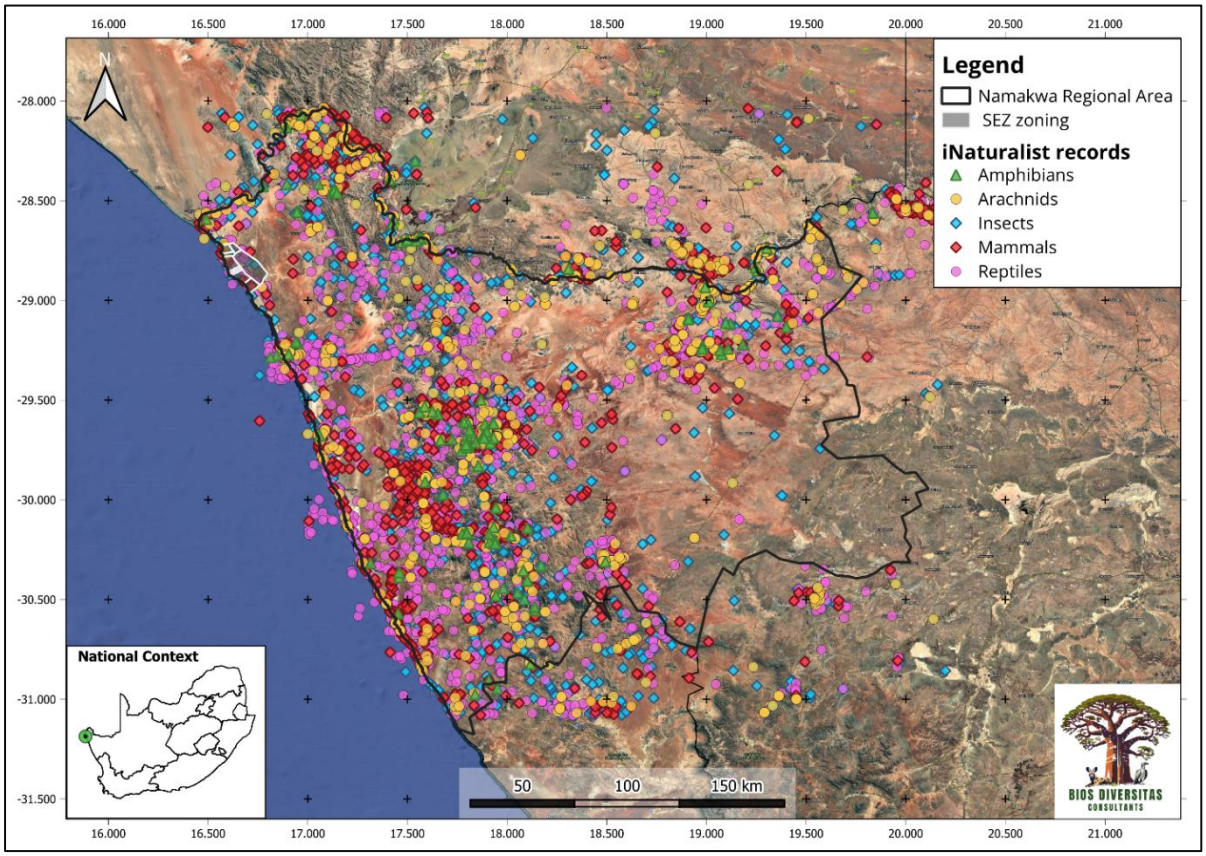

Figure 6: Fauna species records for the regional area (*Source*: iNaturalist).

4.4.1 Mammals

There are roughly 69 mammal species[6] in the Regional Area, including several endemic species such as the Critically Endangered De Winton's golden mole (*Cryptochloris wintoni*), Van Zyl's golden mole (*Cryptochloris zyli*) and the Namaqua dune mole rat (*Bathyergus janetta*). Furthermore, five species are known only from the dunes of the central Namaqualand coast. Some of these species occur in protected areas such as the Namaqua National Park.

Major concentrations of large mammals once roamed the Nama - and Succulent Karoo. These populations have now disappeared with mainly smaller herds of gemsbok (*Oryx gazella*), mountain zebra (*Equus zebra*) and springbok (*Antidorcas marsupialis*) still present today. Within the Namakwa region (Succulent Karoo and adjoining Nama-Karoo / desert systems), the most **ecologically important mammal groups** are those that drive energy flow, soil processes and trophic dynamics rather than just the "big" species.

Small Mammal Guild (Rodents and Shrews)

This group includes striped mice, gerbils, molerats and elephant shrews (sengis). They are major seed predators and dispersers, key prey for carnivores and raptors, and important ecosystem engineers through burrowing, which affects soil aeration, infiltration and nutrient cycling. Research has suggested that the nutrient-rich soil patches around *Parotomys brantsii* burrows may facilitate the re-vegetation of mine dumps. Sengi species are thought to be important ecosystem and cultural services as they are included in San art and are therefore subject to local folklore.

- **Species Examples:** Namaqua Rock Mouse (*Micaelamys namaquensis*), Hairy-Footed Gerbil (*Gerbilliscus paeba*), Brants's Whistling Rat (*Parotomys brantsii*), Western Rock Sengi (*Elephantulus rupestris*), and the Lesser Dwarf Shrew (*Suncus varilla*).
- **Habitat:** Occurs across arid shrublands, rocky outcrops, and sandy plains.
- **Ecological Role**:
    - Seed dispersal for native plant species.
    - Primary prey for mesopredators such as owls, jackals, and small carnivores.
- **Threats & Adaptability:**
    - Moderately adaptable; some species can persist in disturbed landscapes, but habitat fragmentation and agricultural expansion reduce their numbers.

Burrowing Mammal Guild including fossorial insectivores and herbivores

These burrowers are critical for soil turnover and microhabitat creation in coastal dunes and sandy plains, and golden moles in particular are top invertebrate predators below ground.

- **Species Examples:** De Winton's Golden Mole (*Cryptochloris wintoni*), Van Zyl's Golden Mole (*Cryptochloris zyli*), Cape Golden Mole (*Chrysochloris asiatica*), Cape Ground Squirrel (*Xerus inauris*), and Namaqua Dune Mole-Rat (*Bathyergus janetta*).
- **Habitat:** Prefers sandy and semi-arid environments with loose soil for digging.
- **Ecological Role:**
    - Aerates soil, influencing vegetation growth.
    - Creates microhabitats for reptiles, insects, and other small mammals.
- **Threats & Adaptability:**

[6] excluding bats, domestic animals such as dogs and horses, and marine mammals.

- Poorly adaptable to hard surface developments such as roads, mines, and urbanization, which destroy burrow networks.

Carnivore Guild (Small and Medium-Sized Predators)

Because large predators are scarce, mesocarnivores are especially important in Namakwa. Typical species in the Richtersveld–Namaqua system include black-backed jackal, Cape fox, bat-eared fox and leopard as the remaining apex carnivore, with mongooses and suricates (meerkats) also widespread. These mammals regulate small-mammal populations, scavenge, and help control insects (e.g. termites and beetles for bat-eared fox and suricate), maintaining trophic balance in otherwise plant-dominated systems.

- **Species Examples:** Bat-Eared Fox (*Otocyon megalotis*), Cape Fox (*Vulpes chama*), Aardwolf (*Proteles cristata*), Leopard (*Panthera pardus*), Meerkat (*Suricata suricatta*) and African Wildcat (*Felis lybica*).

- **Habitat:** Semi-arid shrublands, rocky terrain, and grasslands.

- **Ecological Role:**
  - Regulates populations of rodents, insects, and small vertebrates.
  - Aardwolves specialize in termite consumption, playing a role in controlling insect populations.
- **Threats & Adaptability:**
  - Some species (e.g., Bat-Eared Fox) adapt well to farmland, but roadkill and habitat degradation pose serious threats.

Herbi-browsers and grazers (antelope and rock specialists)

Open plains and rocky slopes support springbok, gemsbok, red hartebeest (often reintroduced), Hartmann's mountain zebra, klipspringer, steenbok, duiker, and rock hyrax.

As selective grazers and browsers, these mammals shape vegetation structure and productivity, drive nutrient redistribution, and provide carrion and prey for carnivores. On rocky slopes, klipspringer and hyrax link steep, plant-rich microhabitats to higher trophic levels.

- **Species Examples:** Springbok (*Antidorcas marsupialis*), gemsbok (*Oryx gazella*), red hartebeest (*Alcelaphus buselaphus*), Hartmann's mountain zebra (*Equus zebra hartmannae*), steenbok (*Raphicerus campestris*), common duiker (*Sylvicapra grimmia*) and Grey rhebok (*Pelea capreolus*).

- **Habitat:** low, shrub-dominated plains, gravel flats and sandy duneveld, often on gently undulating terrain with sparse grass and dwarf shrubs, as well as rocky escarpments and inselbergs.

- **Ecological role:** Grazers crop grasses and ephemeral forbs, maintaining grazing lawns and influencing the balance between grassy patches and shrub-dominated areas; affect recruitment and growth of particular plant species, especially palatable shrubs and succulents; core prey base for the region's carnivores and raptors.

- **Threats & Adaptability:** habitat loss, overgrazing, fragmentation and climate-related stress. Fencing and artificial water points have altered historic movement patterns.

4.4.2 Reptiles

Reptile diversity is relatively high with approximately 115 species, of which roughly 45 species are endemic including several extremely range-restricted Namaqualand reptiles. Almost all the endemics are geckos and lizards, representing about a quarter of the nearly 60 gecko and lizard species in the Succulent Karoo hotspot. These endemics include seven species of girdled lizards of the genus Cordylus, including the

armadillo girdled lizard (*Cordylus cataphractus*), which has a heavily armoured body and spiny tail and is known for rolling into a tight ball when threatened.

Tortoise diversity is very high here, with seven taxa, two of which are endemic: the Namaqualand tent tortoise (*Psammobates tentorius trimeni*) and the Namaqualand speckled padloper (*Homopus signatus signatus*).

Attractive species such as chameleons, lizards and tortoises are also vulnerable to collection for use as pets or illegal trade, and the increased accessibility resulting from the new roads that will be constructed as part of the development would raise the risk for these species.

Arid tortoises (padlopers, angulate & tent tortoises)

Species Examples: Namaqua speckled padloper *Homopus signatus signatus* – the world's smallest tortoise, endemic to the Succulent Karoo. Angulate tortoise *Chersina angulata* and Western tent tortoise *Psammobates tentorius trimeni* recorded in Namaqua National Park.

Ecological role: slow, long-lived herbivores and browsers on succulents, forbs and small shrubs; they move seeds and nutrients across the landscape via dung and track networks and form important prey for larger carnivores and people historically.

Namakwa importance: they're flagship endemics of the Succulent Karoo and good indicators of intact, lightly grazed rocky and sandy habitats. Overgrazing, roadkill and illegal collection for the pet trade are key pressures.

Desert-Adapted Lizard Guild

- **Species Examples:** Namaqua Sand Lizard (*Pedioplanis namaquensis*), Western Three-Striped Skink (*Trachylepis occidentalis*), and Cape Cobra (*Naja nivea*).
- **Habitat:** Arid plains, rocky outcrops, and sandy dunes.
- **Ecological Role:**
    - Predators of insects, spiders, and small vertebrates.
    - Prey for raptors and carnivorous mammals.
- **Threats & Adaptability:**
    - Some species can tolerate modified landscapes, but habitat destruction limits available basking and foraging grounds.

Burrowing and Fossorial Reptile Guild

- **Species Examples:** Karoo Sand Snake (*Psammophis notostictus*), Spotted Sand Lizard (*Meroles suborbitalis*), and Namaqua Dwarf Adder (*Bitis schneideri*).
- **Habitat:** Sandy and loose-soil environments.
- **Ecological Role:**
    - Regulates insect and small vertebrate populations.
    - Important prey for desert-adapted birds and mammals.
- **Threats & Adaptability:**
    - Poorly adaptable; habitat modification that compacts soil prevents burrowing.
    - Increased vehicle activity leads to higher mortality rates.

Rock-Dwelling Reptile Guild

Territorial, site-faithful insectivores that structure arthropod communities on rock outcrops and provide a key food source for snakes, jackals, caracal and cliff-nesting raptors. Their basking and retreat behaviour ties them tightly to the thermal and structural properties of the rock.

- **Species Examples:** Flat Lizard (*Platysaurus broadleyi*), Namaqua Plated Lizard (*Gerrhosaurus typicus*), Peers' girdled lizard (*Namazonurus peersi)*, Karoo girdled lizard (*Karusasaurus polyzonus*), Southern Rock Agama (*Agama atra)* and Common Spiny Agama (*A. hispida)*.

- **Habitat:** Rocky hills, granite outcrops, and cliffs.

- **Ecological Role:**

    - Key insectivores.
    - Prey for raptors and small carnivores.

- **Threats & Adaptability:**

    - Quarrying, mining, and heavy disturbance of outcrops that destroy rocky refuges can cause local collapses.
    - Can persist in undisturbed rocky areas.

Chameleons and other shrub / dune specialists

- **Species examples:** Namaqua chameleon *Chamaeleo namaquensis*, a terrestrial, desert-adapted chameleon of western South Africa that forages across sandy plains and even into intertidal zones.

- **Ecological role:** top-end arthropod predators in low shrubs and dunes, taking large insects and small vertebrates and themselves forming prey for snakes and birds. Because they are visually oriented and slow-moving, they are sensitive to habitat structure (shrub cover, dune integrity).

- **Namakwa importance:** they're a charismatic indicator of healthy duneveld and shrubland and are especially vulnerable to off-road vehicles, collection and intensive tourism in coastal areas.

Snakes (top reptile predators)

- **Species examples:** Cape cobra *Naja nivea*, puff adder *Bitis arietans*, many-horned adder *B. cornuta*, mole snake *Pseudaspis cana*, skaapstekers *Psammophylax rhombeatus* and house snakes *Boaedon capensis*.

- **Ecological role:** apex reptile predators regulating rodents, lizards and sometimes birds, stabilising small-mammal populations and linking below-ground productivity (rodents) to higher trophic levels.

- **Namakwa importance:** snakes are often the main vertebrate predators in more degraded or livestock-dominated parts of Namakwa where large carnivores are scarce. Persecution, road mortality and habitat fragmentation can simplify snake communities and release rodent populations.

4.4.3 Amphibians

Amphibians are poorly represented in the region with just over 15 species. Most of these species are frogs with some toads, including two endemic frogs, the Desert Rain Frog (*Breviceps macrops*) and Branch's Rain Frog (*Breviceps branchi)*, which occurs along the Namaqualand coast of South Africa.

Rain Frog Guild

The most distinctive and ecologically important amphibian group in Namakwa is the burrowing rain frogs (genus *Breviceps*). They are specialised, round-bodied fossorial frogs that live in loose sands of the Succulent Karoo and coastal dunes and emerge mainly during or after rain to feed and breed.

- **Species Examples:** ranch's Rain Frog (*Breviceps branchi),* Namaqua Rain Frog (*Breviceps namaquensis*), Desert Rain Frog (*Breviceps macrops*).
- **Habitat:** Fossorial in sandy shrublands and dunes. Burrows in sandy soils, emerging after rainfall.
- **Ecological Role:**
    - Controls insect populations. Key nocturnal predators of ants, termites and other small arthropods.
    - Important in nutrient cycling in soil ecosystems and soil processes.
- **Threats & Adaptability:**
    - Poorly adaptable to development; soil compaction and habitat destruction limit their breeding areas.
    - Localised habitat loss from agricultural expansion and development.

Seasonal Pool Amphibian Guild

- **Species Examples:** Cape Sand Frog (*Tomopterna delalandii*), Clicking Stream Frog (*Strongylopus grayii*).
- **Habitat:** Ephemeral rain-fed pools and seasonal wetlands.
- **Ecological Role:**
    - Plays a key role in ecosystem nutrient flow.
    - Tadpoles serve as food for birds and reptiles.
- **Threats & Adaptability:**
    - Highly vulnerable to climate change and altered hydrology.
    - Poor adaptability to artificial water sources.

Sand frogs of ephemeral pans and sand rivers

The sand frogs (genus *Tomopterna*) are an ecologically important group, which key into temporary surface water after rain, especially in sandy riverbeds and shallow pans. Tadpoles graze on algae and organic films, helping to process nutrient pulses in ephemeral pools, while adults are active, opportunistic predators of terrestrial and aquatic invertebrates around these waterbodies.

The standout species for Namakwa is the Namaqua sand frog (*Tomopterna branchi)*. This species was only recently described (Wilson & Channing, 2019) and is known from the Buffels River drainage in Namaqualand, where it is associated with Namaqualand Hardeveld vegetation units of the Succulent Karoo biome.

Functionally, *T. branchi* and congeners link episodic rainfall and surface runoff to both aquatic and terrestrial food webs: dense choruses and larval stages follow heavy rains, providing short-lived but intense prey pulses for birds, small carnivores and other predators. Because they depend on ephemeral natural pools and unaltered sand-river hydrology, they are vulnerable to river regulation, groundwater abstraction, overgrazing of catchments and disturbance of sandy channels by mining or roads. Protection of natural flood regimes and avoidance of pan infilling or bulldozing is therefore important for maintaining this amphibian group.

Arid-zone toads in ephemeral terrestrial pools

Small arid-zone toads (e.g. *Poyntonophrynus* and *Sclerophrys* species) that breed in shallow, short-lived depressions after heavy rain form an important ecological group across upland plains and hardveld. They can rapidly colonise muddy puddles and pans, where large numbers of tadpoles strip algal films and organic matter, speeding up decomposition and nutrient cycling, and then metamorphose quickly before pools dry.

These toads are mobile and relatively tolerant of moderate disturbance, so they often dominate amphibian assemblages in grazed or moderately transformed rangelands, providing a resilient insect-control service around settlements, farmsteads and roads. Their main threats are loss of suitable breeding depressions through compaction, paving or cultivation, and exposure to pollutants (herbicides, pesticides, road runoff) in small, rain-fed pools.

4.4.4 Invertebrates (mainly insects, arachnids, mollusks)

Key invertebrate processes and communities in the Namakwa region are best understood as functional guilds that underpin plant reproduction, soil formation, decomposition and food-web dynamics in this arid landscape. Namaqualand is recognised internationally as a global centre for insect diversity and endemism within the broader Succulent Karoo hotspot, alongside its exceptional plant and reptile diversity. Invertebrates are therefore central to how the system works, even if they are often under-represented in EIAs.

In the Namaqualand region, invertebrates play crucial ecological roles in various processes and communities. Invertebrate diversity is quite high and supports on the order of a thousand species (c. 1050 species), and evidence suggests that more than half of the species in some insect groups are local endemics. Of the more than 70 species of scorpions found in the Succulent Karoo, nearly 20 are endemic. The Desert Biome includes an abundant insect fauna which includes many tenebrionid beetles, some of which can utilise fog water.

Perhaps the most unusual invertebrates found in the hotspot are the long-tongued flies (*Memestrinidae*), which can have mouthparts up to 50 millimetres long. The flies are the exclusive pollinators of 28 different plant species in Namaqualand. Below are some key invertebrate processes and communities:

Key Invertebrate Processes

1. **Pollination** – Many plant species in Namaqualand rely on invertebrates for pollination, particularly long-tongued flies (Memestrinidae), which have evolved exclusive pollination relationships with certain plants. The winter–spring wildflower displays of the Namakwa region depend heavily on insect pollinators: bees, pollen wasps, bee flies, butterflies, moths and beetles. A particularly important group is the monkey beetles (Scarabaeidae: Hopliini), which are specialised pollinators of many Aizoaceae and Asteraceae species typical of Namaqualand daisy fields and succulent shrublands. Studies in the Succulent Karoo at Paulshoek show that monkey beetles are major pollinators in both grazed and ungrazed areas, with bees, pollen wasps and bee flies providing complementary pollination services.

2. **Key Ecosystem Engineers** – Below ground and at the soil surface, ants and termites, together with various burrowing beetles and other invertebrates, act as key ecosystem engineers. Harvester ants such as *Messor capensis* build low, conical mounds in Karoo shrublands composed of soil and plant material; through seed harvesting, nest-building and soil transport they create nutrient-rich patches and strongly influence seed banks and micro-topography. Termites play a similar and often larger role; in the Greater Cape Floristic Region (which includes the Succulent Karoo), species such as *Microhodotermes viator* are recognised as keystone engineers that move large quantities of soil and plant material, altering infiltration, nutrient distribution and the development of characteristic “heuweltjie” mounded landscapes.

3. **Decomposition and Nutrient Cycling** – Detritivore communities such as dung beetles, carrion beetles, saprophagous flies, springtails and mites contribute to the breakdown of organic material, aiding in nutrient cycling. Arthropods found in lichen fields assist in soil formation and

decomposition. Dung beetles and other scavengers also link vertebrate herbivore and carnivore assemblages to soil processes by processing faeces and carcasses, reducing parasite loads and creating microsites of enhanced fertility used by germinating plants.

4. **Soil Stabilization** – Many invertebrates, such as burrowing insects and scorpions, contribute to maintaining soil health by aerating the ground and preventing erosion.

Key Invertebrate Communities

1. **Lichen-Associated Arthropods** – The Namib Lichen Fields support various invertebrates, including mites and insects that inhabit the crust-like lichen formations, contributing to ecosystem stability.

2. **Scorpions and Spiders** – Namaqualand hosts at least 70 species of scorpions, with nearly 20 endemics to the region, indicating a high level of specialisation in arid ecosystems.

3. **Beetles and Ants** – These species play a role in seed dispersal and soil turnover. Many desert-adapted beetles exhibit fog-basking behaviours to collect water.

The invertebrate communities of Namaqualand are crucial to the region's ecological integrity, supporting primary productivity, decomposition, and predator-prey dynamics (solifuges (sun-spiders), ground beetle predators and a rich spider fauna, these predators exert strong top-down control on insect and small arthropod populations) in an arid environment. These functions are highly sensitive to land-use change, overgrazing, mining, soil disturbance, pesticide use and hydrological alteration and should therefore be explicitly recognised as core ecological processes in baselines, sensitivity mapping and impact assessment for the Namakwa region.

4.5 Priority Fauna of Conservation Importance in Namaqualand

This section expands on key fauna of high conservation importance in the Namakwa region, focusing on taxa that are endemic, range-restricted, or otherwise sensitive to disturbance expected from GH2-enabling infrastructure. Part of the Namaqualand is an arid global biodiversity hotspot and is recognised as a centre of diversity and endemism for reptiles, amphibians and many invertebrate groups, in addition to its flora.https://the-eis.com/elibrary/sites/default/files/downloads/literature/Succulent_Karoo_Hotspot briefing book.pdf?utm_source=chatgpt.com For EIA purposes, “priority fauna” here are those that (i) are listed as threatened or Data Deficient on national or global Red Lists, (ii) are range-restricted to Namaqualand / the Succulent Karoo, and (iii) are closely associated with habitats targeted by development (coastal dunes, sand rivers, rocky outcrops, etc.). Where suitable habitat occurs in or near a local development footprint, these taxa should trigger specific baseline surveys and impact assessment.

4.5.1 Mammals

At least seven (7) mammal SCC occur within the study area, of which *Cryptochloris wintoni, Eremitalpa granti granti* and *Bathyergus janetta* are considered the most sensitive to development and species of high conservation value (refer to **Figure 7**). According to Dr Samantha Theron from the EWT’s Drylands Conservation Programme, a new *Eremitalpa* lineage that was detected near Groenriviermond has not yet been described as further surveys are required before it can properly describe as a species or subspecies and to conduct threat assessment. A survey is being planned for July 2026.

Cryptochloris wintoni – Critically Endangered

The De Winton’s Golden Mole occurs on coastal dunes and adjacent sandy areas in Strandveld of the Namaqualand coastal plain of the Northern Cape (Bronner 2013). The species is known from only the type locality at Port Nolloth, Northern Cape Province and has recently been rediscovered after 86 years. Mynhardt et al. (2024) indicated that this species may be widespread in the area, ranging from Lambert’s Bay in the south to Visagiesfontein (which is part of the study area), beyond Port Nolloth in the north, giving an indication that the species may be more widespread. The species has been recorded by eDNA samples along the coast at Visagiesfontein (Mynhardt et al. 2024). Further surveys are required in order to update the species distribution range (Dr. S. Theron (EWT), personal communication, 11 November 2025).

Accordingly, the presence of the species must be established through appropriate survey techniques during the EIA application phases for the project and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects located along the coast of the Namakwa region (**Figure 7**).

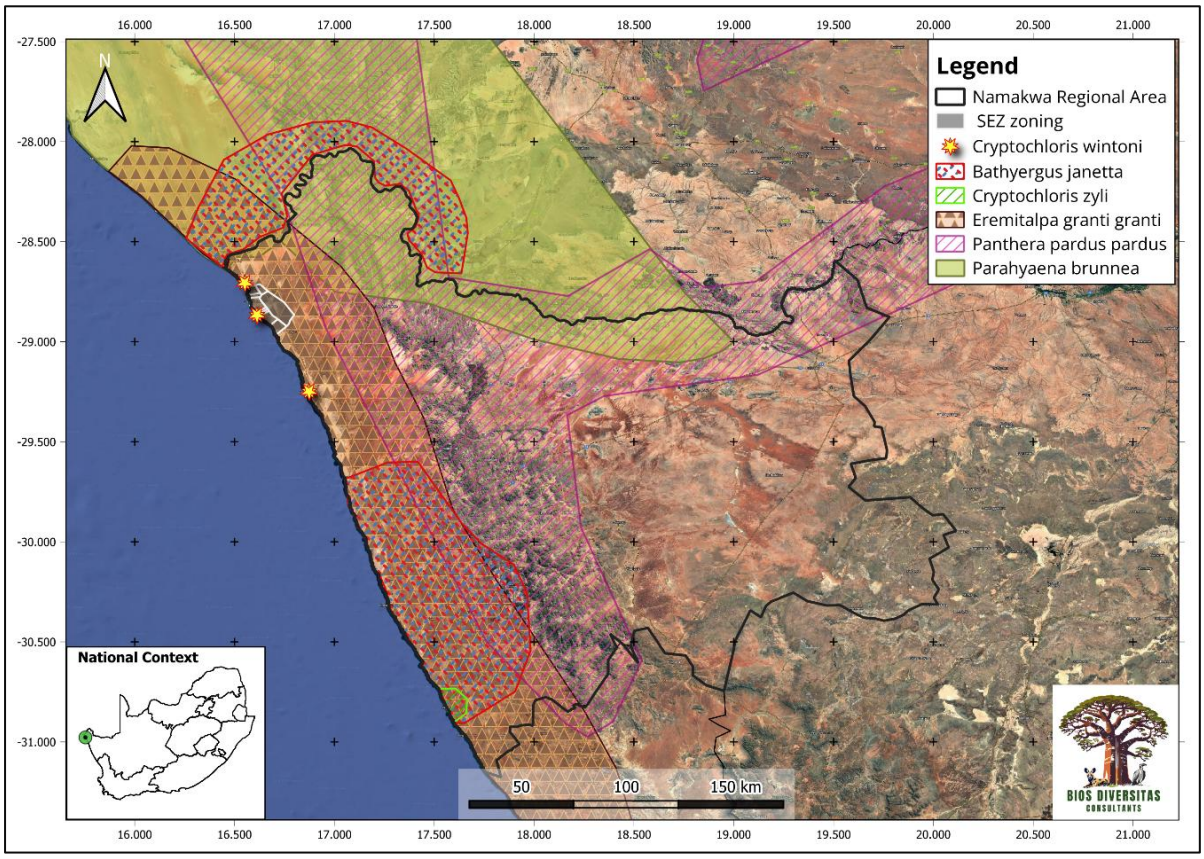

Figure 7: IUCN distribution range for threatened mammal species in relation to the Project Area.

Eremitalpa granti granti – Vulnerable

Grant's Golden Mole is endemic to southern Africa, with its distribution primarily focused on the arid and semi-arid regions of the western parts of the Northern Cape and Namibia. Within the Northern Cape, its range is concentrated in the Succulent Karoo Biome and along coastal dunes. Its range overlaps with sandy habitats extending into desert-like environments, including the Namaqualand coastal areas (Port Nolloth and possibly as far north as Alexander Bay). Further surveys are required in order to update the species distribution range (Dr. S. Theron (EWT), personal communication, 11 November 2025).

Grant's Golden Mole is a remarkable example of adaptation to extreme environments, but its narrow habitat requirements and sensitivity make it vulnerable to human and environmental changes. The species has been recorded with eDNA samples along the coast at Visagiesfontein and further south (Mynhardt *et al*. 2024). The presence of the species must be established through appropriate survey techniques during the EIA application phases for the project and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects.

Bathyergus janetta – Uplisted to Endangered A4(a)

Namaqua Dune Mole-rat has recently been uplisted to Endangered (2025 National Red List) owing to climate change and the threat of continued habitat destruction of three isolated subpopulations. The

species is located along the southern coastline of the Namakwa region between Port Nolloth and Groenrivier. Accordingly, proposed development along this coastline must established the species presence through appropriate survey techniques during the EIA application process and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects.

4.5.2 Reptiles

Psammobates tentorius trimeni – Endangered

Western Tent Tortoise is restricted to the winter-rainfall region dominated by dwarf succulent shrubs and annuals, concentrated in the Namaqualand Sandveld and Richtersveld Bioregions and extends peripherally into the Namaqualand Hardeveld Bioregion. This subspecies is assessed to be Endangered under criterion A4ce (Hofmeyr et al. 2018a) owing to continuous detrimental impacts on its sensitive habitat as discussed below.

The range of P. t. trimeni is small and restricted to a few vegetation units of the western Succulent Karoo, which are under continued pressure from multiple impacts from overgrazing, destructive or illegal mining, and unsustainable land use involving ploughing of natural veld for fodder cropping, uncontrolled harvesting of natural products, and irresponsible tourism activities in sensitive areas (Bourne et al. 2012).

The species occurs mainly towards the interior and western section of the Namakwa region from north to south, covering large sections of land earmarked for development or already developed. The presence of the species must be established through appropriate survey techniques during the EIA application phases for proposed projects. Accordingly, all proposed developments within the species range must established the species presence through appropriate survey techniques during the EIA application process and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects.

Chersobius signatus – Endangered

Speckled Cape Tortoise is a very small tortoise endemic to South Africa, largely restricted to rocky outcrops in the Succulent Karoo of north-western South Africa, including Namaqualand. It is listed as Endangered with ongoing declines and strong pressure from habitat degradation (overgrazing, cultivation, roads, mining) and illegal collection for the pet trade. The species is strongly associated with koppies and rocky ridges where it feeds on small succulents.

The most northerly records are from the Richtersveld (Bauer and Branch 2001; iNaturalist record 507286, May 2018). The species occurs predominantly in the winter rainfall region of the northwestern Succulent Karoo and Fynbos biomes from a few metres above sea level on the West Coast to elevations of around 1,000 m in the interior at Springbok, Loeriesfontein-Calvinia, and the Cederberg Range. It can be found in low to medium-high Namaqualand succulent blomveld and heuweltjieveld, and fynbos and strandveld shrub vegetation. The species shows a particular preference for rocky terrain (Loehr 2002), which includes typical Namaqualand and Hardeveld granite koppies in the north.

Any proposed development within the species range must established the species presence through appropriate survey techniques during the EIA application process and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects.

Bitis schneideri – Near Threatened (Regionally); Least Concern (Globally)

Namaqua Dwarf Adder is endemic to southern Africa and found from the mouth of the Olifants River in the Western Cape, South Africa, northwards to Lüderitz Bay in southwestern Namibia (Branch 1998, Bates et al. 2014). The species is considered well protected, has a moderately sized distribution (15,300 km^2) and a large extent of occurrence (EOO = 27,100 km^2) that shows no evidence of decline in extent.

The species is a habitat specialist with a small distribution across a region of South Africa (**Figure 8**) that is impacted by habitat transformation due to mining and urbanisation, but the habitat loss is relatively small

compared to the species overall range. Accordingly, the species is considered Least Concern globally (Tolley et al. 2019). It inhabits semi-vegetated sandy desert areas, mostly close to the coast. These snakes occur at high population densities, experience relatively high annual mortality (Maritz and Alexander 2012), which is counter-balanced by frequent reproduction (Maritz and Alexander 2013). They are generalist predators that consume a wide range of small-bodied vertebrates (Maritz and Alexander 2014).

Proposed developments must established the species presence through appropriate survey techniques during the EIA application process and the EWT's Drylands Conservation Programme must be consulted for updated information relevant at the time of future assessments. If recorded, the presence of the species likely represents a fatal flaw to projects.

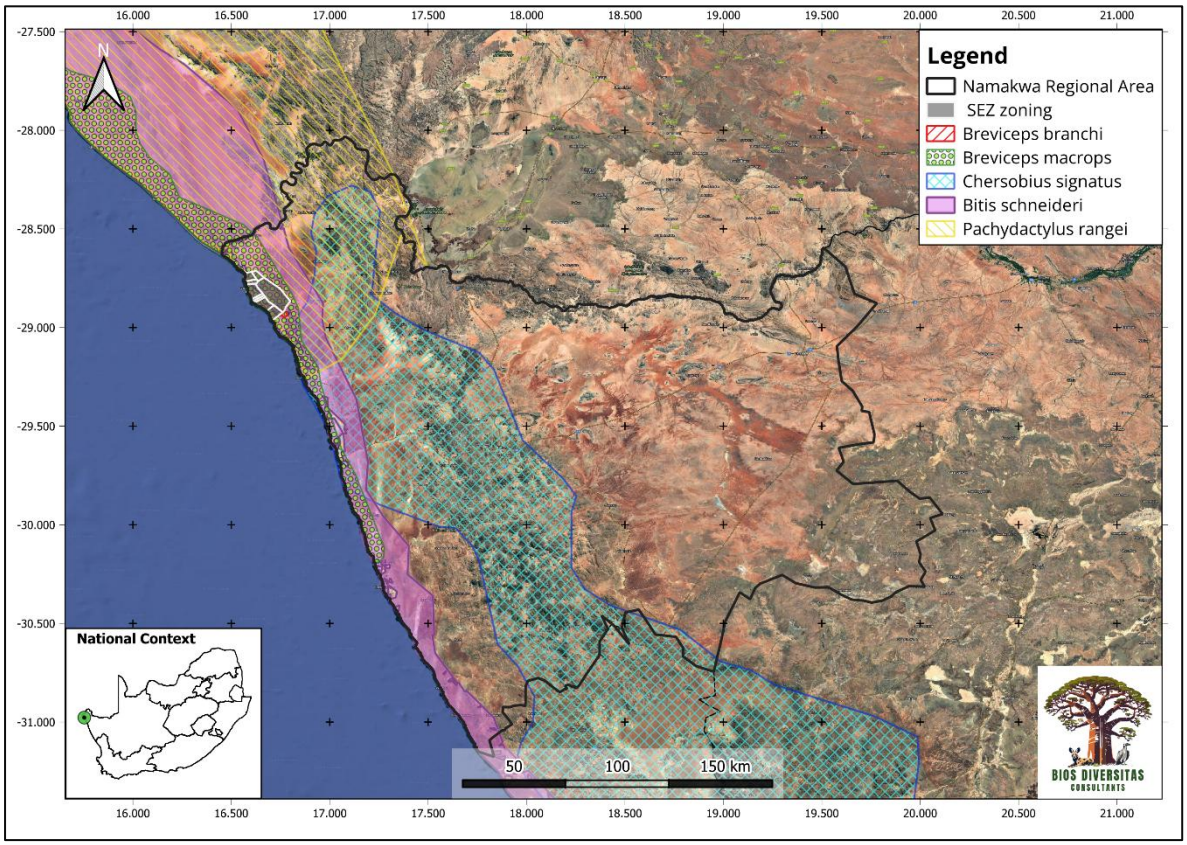

Figure 8: IUCN distribution range for threatened reptile and amphibian species in relation to the Project Area.

4.5.3 Amphibians

Breviceps macrops – Vulnerable

Desert Rain Frog has been uplisted from Near Threatened to Vulnerable (SANBI 2025) owing to changes in government policy that will increase approved mining in the region. The species occupies a narrow coastal strip along the northwestern Namaqualand coast, from Alexander Bay (2816CB) southward as far as the farm Skulpfontein north of Koingnaas (3017AB). Distribution data for this species are scarce, as much of the area it occupies lies within diamond-mining concessions and is not easily accessible. The available data are restricted mainly to areas lying outside the mining concessions and are therefore incomplete

Breviceps branchi – not evaluated

Branch's Rain Frog is not evaluated but is a species of high conservation value and endemic. The vegetation is classified as Northern Richtersveld Yellow Duneveld, which is part of the Succulent Karoo Biome. It presumably occupies arid sandy habitats similar to B. *namaquensis*. The breeding ecology and

breeding biology has not been recorded but is presumably similar to other *Breviceps* species that deposit eggs in shallow burrows (Channing 2001). The species is fossorial and breeds by direct development and is not associated with water. The species known from a single locality, near the Holgat River on the coast of Namaqualand, Northern Cape Province, South Africa. Since its description from a single specimen (Channing 2012), only three other records have been made in the same proximity of the type locality. Based its occurrence in one locality, its extent of occurrence (EOO) is 10 km^2; however, the true limits of its range are uncertain.

5. THREATS AND ADAPTABILITY TO NEW DEVELOPMENTS

Namaqualand's unique fauna faces several anthropogenic threats due to increasing development pressures, including mining, agriculture, renewable energy projects, urban expansion, and climate change. While some species exhibit adaptability, many are highly specialised and struggle to survive in modified environments. The main threats are indicated below:

- **Mining & Agriculture:** Many endemic species are poorly adapted to large-scale habitat alteration.
- **Renewable Energy (Wind & Solar Farms):** Can disrupt migratory corridors and foraging habitats, especially burrowing animals and species with restricted ranges.
- **Roads and Traffic-Related Mortality:** roads disrupt movement corridors and migration routes of larger mammals and dispersal pathways of smaller species especially burrowing animals, and act as death traps for many animals, especially slow-moving tortoises and smaller mammals.
- **Climate Change:** Many species are highly specialized for Namaqualand's climate, making adaptation difficult.

Future development should prioritise conservation and responsible tourism over industrial activities that could be more appropriately located inland, a strategy for sustainable development that protects natural assets while fostering economic growth. A more strategic approach to land use management and planning is essential to curb coastal sprawl and promote compact, nodal developments.

At the United Nations Biodiversity Conference in 2022, South Africa and other countries committed to the Kunming-Montreal Global Biodiversity Framework (GBF), which aims to conserve at least 30% of the world's terrestrial, inland water, coastal and marine areas by 2030. The agreement, also called 30 x 30 (Thirty by Thirty), specifically respects the rights and involvement of indigenous peoples and local communities. To achieve 30% by 2030 would mean a dramatic growth in South Africa's existing conservation lands: an additional 14 million hectares (equivalent to eight Kruger National Parks) must be added to the 16 million hectares now under formal protection.

Currently, there are several existing or planned renewable energy developments within the Namakwa region, as indicated in **Figure 9** below. Many of these developments already intercept animal SCC ranges and known locations, increasing their risk to future developments.

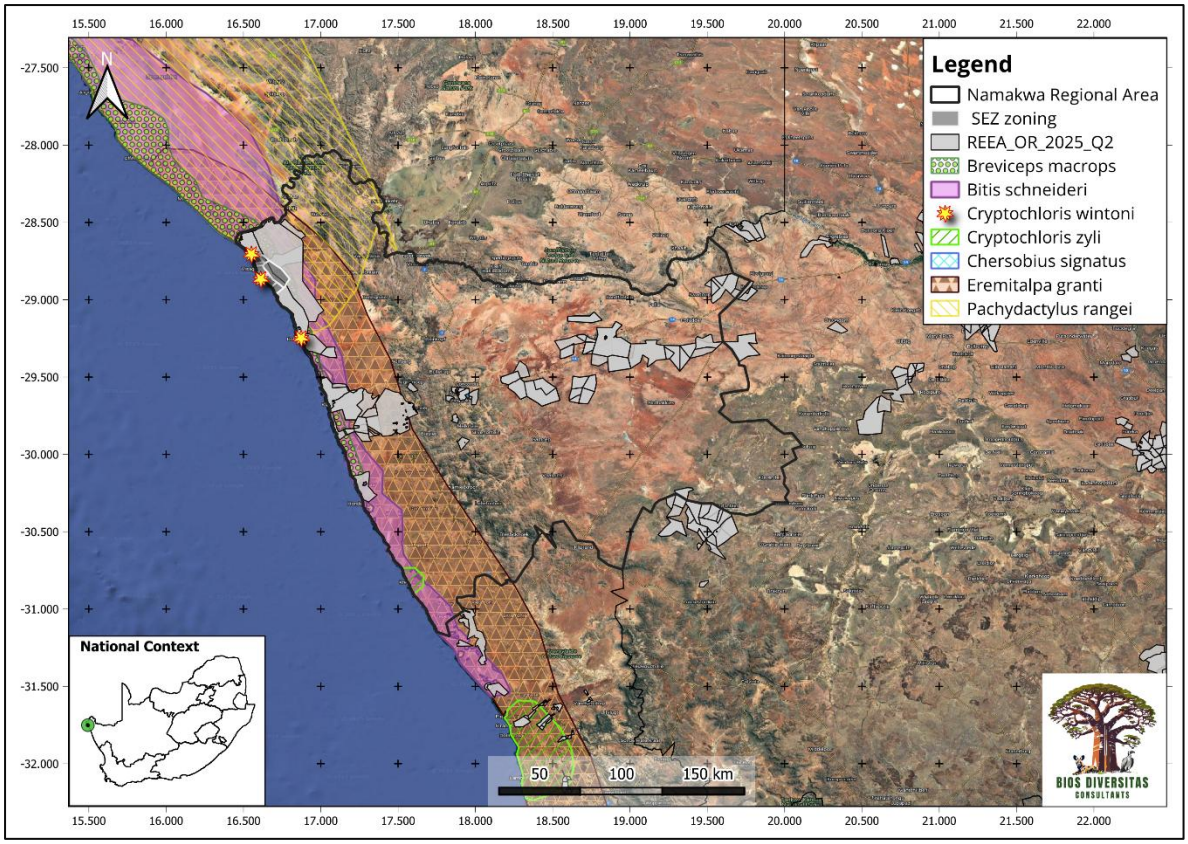

Figure 9: Renewable energy developments in relation to the Project Area.

Below is a breakdown of the key threats and how different faunal communities and guilds respond to them.

5.1 Habitat Destruction and Fragmentation

Threat Overview

- Large-scale land clearing for mining, agriculture, and infrastructure leads to habitat loss.
- Linear infrastructure, such as roads, railways, pipelines, fences, and power lines, disrupt movement corridors and migration routes of larger mammals (such as Brown Hyena, Aardwolf, Caracal, Bat-Eared Foxes) and dispersal pathways of smaller species (such as mole-rats, moles, tortoises and burrowing lizards) especially burrowing animals.
- Open-cast mining and sand extraction destroy critical burrowing and breeding habitats.

Impacts and Adaptability by Faunal Group

Mammals

- Highly mobile species (e.g., Cape Fox, Bat-Eared Fox) can adapt to fragmented landscapes but suffer increased road mortality.
- Small burrowing mammals (e.g., Namaqua Dune Mole-Rat) are highly sensitive as their entire ecosystem is underground-dependent.

Reptiles

- Rock-dwelling lizards and snakes are highly vulnerable, as quarrying removes their habitats entirely.
- Burrowing species (e.g., Namaqua Dwarf Adder) depend on loose sandy soils, which are compacted by land clearing, reducing survival.

Amphibians

- Rain frogs and seasonal breeders rely on specific ephemeral water bodies that can be destroyed or altered by human activities.
- Highly sensitive to habitat loss due to limited dispersal ability.

5.2 Mining and Extractive Industries

Threat Overview

- Namaqualand has rich mineral deposits (diamonds, copper, tungsten, and lithium), making mining a major land-use concern.
- Mining creates dust pollution, alters hydrology, and depletes surface and groundwater resources.
- Toxic runoff and tailings affect water quality in the few seasonal streams that support amphibians and freshwater invertebrates.

Impacts and Adaptability by Faunal Group

Mammals

- Highly mobile species (e.g., jackals, caracals) may shift territories, but mining fences can limit movement.
- Bats suffer loss of roosting caves and disruption of foraging areas due to light pollution.

Reptiles

- Slow-moving species (e.g., tortoises, burrowing lizards) cannot escape destruction during mining operations.
- Destruction of rocky outcrops eliminates microhabitats for skinks and geckos.

Amphibians

Mining alters seasonal water availability, which can cause complete reproductive failure in species that rely on rainfall-triggered breeding events.

5.3 Renewable Energy Developments (Wind and Solar Farms)

Threat Overview

- Wind farms pose collision risks for raptors, bats, and migratory birds.
- Large-scale solar farms require extensive land clearing, altering thermal conditions and affecting ground-dwelling reptiles and amphibians.

Impacts and Adaptability by Faunal Group

Mammals

- Nocturnal predators like Cape Fox and Aardwolf can adapt if habitat loss is minimal, but increased human activity and light pollution affect their behaviour.
- Habitat loss and fragmentation due to large-scale solar farms clearing extensive land, and fences which hinders species movement and potential hazards.

Reptiles

- Large-scale solar farms could change ground temperature, affecting burrowing species like sand lizards and egg incubation in species with temperature-dependent sex determination (e.g., some lizards and snakes).
- Burrowing reptiles may suffer from habitat degradation as land is flattened and compacted.

Amphibians

- Wind and solar farms disrupt natural water runoff, potentially eliminating critical breeding pools.
- Artificial structures can provide shading refuges for some species, but overall impact is negative due to habitat loss.

5.4 Water Abstraction and Drainage Alteration

Impact:

- Reduces availability of seasonal wetlands and ephemeral pools, essential for amphibians, reptiles, and water-dependent mammals.
- Affects vegetation critical for insect populations, which in turn impacts species that rely on them for food.
- Example: The Namaqua Rain Frog relies on moist soil conditions for burrowing; water loss increases desiccation risks.

Most Affected Groups:

- **Amphibians:** Namaqua Rain Frog, Clicking Stream Frog.
- Semi-aquatic reptiles: Karoo Sand Snake.
- **Insectivorous mammals:** Aardwolf (depends on termite availability).

5.5 Agriculture and Overgrazing

Threat Overview

- Expansion of livestock farming and irrigated crops depletes groundwater resources, leading to desertification.
- Overgrazing by sheep and goats reduces plant cover, increasing soil erosion and eliminating small mammal burrows.

- Use of pesticides and rodenticides affects carnivores and scavengers via secondary poisoning.

Impacts and Adaptability by Faunal Group

Mammals

- Rodents and insectivores suffer as ground cover declines.
- Carnivores (e.g., Caracal, Jackal) are often persecuted by farmers due to livestock predation, leading to population declines.

Reptiles

- Herbivorous tortoises struggle due to the loss of plant diversity.
- Overgrazing compacts soil, making it unsuitable for burrowing species like sand lizards.

Amphibians

- Pesticide runoff contaminates seasonal breeding pools, reducing reproduction rates.
- Loss of wetland vegetation decreases protection from predators and desiccation.

5.6 Urban Expansion and Infrastructure Development

Threat Overview

- Small towns in Namaqualand are expanding, leading to increased human-wildlife conflict.
- Road networks fragment habitats, increasing wildlife-vehicle collisions.
- Roads also cause edge effects, increasing exposure to predation and human disturbance.
- Artificial lighting disrupts nocturnal species, affecting hunting, navigation, and breeding.

Impacts and Adaptability by Faunal Group

Mammals

- Some species (e.g., Rock Hyrax, Genets) adapt to urban edges, but larger mammals (e.g., Caracal, Brown Hyena) struggle.
- Leading cause of mortality for many species, especially slow-moving and nocturnal animals (Aardwolf, Bat-Eared Fox, Cape Hedgehog).

Reptiles

- Roadkill is a major threat to slow-moving reptiles like tortoises and adders.
- Increased predation by domestic pets (dogs and cats) impacts lizard and snake populations.
- Species such as the Puff Adder, which relies on thermoregulation by basking on warm roads, is frequently killed by vehicles.

Amphibians

- Artificial drainage systems often fail to support natural breeding cycles.

- Seasonal breeding frogs that migrate to ephemeral pools.
- Urban pollution reduces water quality, making many areas unsuitable for frog reproduction.

5.7 Climate Change

Threat Overview

- Namaqualand is experiencing rising temperatures and decreasing rainfall.
- Droughts and altered seasonal patterns affect water availability, impacting both plants and animals.

Impacts and Adaptability by Faunal Group

Mammals

- Herbivores struggle as drought reduces food availability.
- Insectivores (e.g., bats and aardwolves) suffer as insect populations decline due to extreme heat.

Reptiles

- Temperature-dependent sex determination in reptiles may skew sex ratios, reducing reproductive success.
- Desert-adapted lizards may tolerate some warming, but extreme heat can push species beyond physiological limits.

Amphibians

- Tadpoles may not survive shortened breeding seasons due to rapid drying of temporary water bodies.
- Heat stress affects survival rates of adults.

6. DRIVERS AND PROCESSES

Below are some of the key drivers and processes shaping these regions.

Key Drivers:

Climate (Aridity & Rainfall Patterns)

- The western section towards the coastal region has a winter rainfall regime (100–300 mm annually), which is crucial for its flowering plant diversity.
- Moving more inland eastwards, the regime changes to a summer or perennial rainfall area.
- Namaqualand experiences highly variable and unpredictable rainfall, influencing plant germination and animal activity.
- Coastal fog provides moisture, supporting unique plant and lichen growth.

Geology & Soils

- The region has ancient, weathered soils with low nutrient levels, favouring specialised plants adapted to nutrient-poor environments.
- Quartz patches and varied soil types create microhabitats supporting endemic species.

Fire & Disturbance

- The Fynbos areas require fire but is not a major ecological driver in the rest of the Regional Area.
- Instead, disturbances like grazing, trampling by animals, and human activities influence vegetation patterns.

Biodiversity & Endemism

- The region boasts over 6,000 plant species, with around 40% being endemic.
- Specialized pollination systems (e.g., beetle and fly pollination) play a critical role in plant reproduction.

Herbivory & Land Use

- Historically, springbok and other migratory herbivores shaped vegetation through grazing.
- Today, livestock farming (sheep & goats) is a major land use, affecting plant communities and soil stability.

Climate Change & Desertification

- Rising temperatures and shifting rainfall patterns threaten the fragile ecosystem.
- Desertification due to overgrazing and land degradation is an ongoing concern.

Key Ecological Processes:

Phenology (Seasonal Growth & Flowering)

- Many plants in the region have dormant periods, responding to seasonal rainfall with rapid growth and flowering.

Drought Tolerance & Succulence

- Succulent plants (e.g., Mesembryanthemaceae) store water in fleshy tissues, allowing survival in dry conditions.

Fog and Dew Utilization

Some species, like lichens and certain succulents, absorb water from fog, an essential moisture source in dry years.

Seed Banks & Opportunistic Germination

- Many plants maintain persistent seed banks, germinating only when conditions are favourable.
- Some seeds require specific environmental triggers (e.g., temperature shifts or rain pulses).

Pollination & Seed Dispersal

- Insect pollination, especially by beetles, flies, and bees, is critical for many plant species.

- Rodents, ants, and birds aid in seed dispersal, ensuring plant regeneration.

Soil Crusts & Microbial Activity

- Biological soil crusts (formed by lichens, mosses, and bacteria) help stabilize soil and retain moisture.
- Soil microbes play a role in nutrient cycling and support plant growth in nutrient-poor conditions.

Human Influence & Conservation

- Agriculture, mining, and urban expansion have transformed parts of the landscape.
- Conservation efforts, including protected areas (e.g., Namaqua National Park), aim to safeguard biodiversity.
- Ecotourism and sustainable land-use practices help balance conservation with local livelihoods.

6.1 How Development Hinders Migration Pathways and Movement of Fauna

The Namakwa region has historically supported important migratory routes for fauna, although many have been disrupted due to human activities, roads, fencing, and habitat changes. Some key migratory patterns include:

Antelope Movements, especially Springbok migrations

Historically, massive herds of springbok (*Antidorcas marsupialis*) migrated across Namaqualand and the Karoo in response to rainfall and vegetation changes. These migrations involved hundreds of thousands of animals moving in search of better grazing, much like the great Serengeti migration. While large-scale migrations have largely ceased due to fences and human settlements, some localized seasonal movements still occur.

Species like gemsbok (*Oryx gazella*) and steenbok (*Raphicerus campestris*) have adapted to the arid environment, often deriving moisture from their food and conserving water efficiently. While they do not migrate in the same large-scale manner as springbok, they do move seasonally between different grazing areas.

Cape Porcupine (*Hystrix africaeaustralis*)

While not migratory in the strict sense, Cape porcupines in Namaqualand tend to follow seasonal food availability, often shifting their foraging territories in response to rainfall and plant growth.

Reptile Movements (Tortoises and Snakes)

The Namaqualand speckled padloper (*Homopus signatus*), one of the world's smallest tortoises, shows seasonal movement patterns related to temperature and food availability. Some snake species, like the puff adder, also change locations seasonally.

Habitat Fragmentation and Barriers to Movement

Impact:

- Developments create physical barriers that prevent animals from accessing breeding, foraging, and refuge areas.
- Linear infrastructure (roads, railways, fences, pipelines) disrupts migration routes of larger mammals and dispersal pathways of smaller species.

- Example: Caracals and Bat-Eared Foxes face restricted movement due to fencing and habitat conversion.

Most Affected Groups:

- **Large mammals:** Brown Hyena, Aardwolf, Caracal.
- **Small mammals and burrowers:** Namaqua Dune Mole-Rat, Cape Golden Mole (require connected underground habitats).
- **Reptiles:** Slow-moving tortoises and burrowing lizards that cannot cross developed areas.

Roads and Traffic-Related Mortality

Impact:

- WVCs are a leading cause of mortality for many species, especially slow-moving and nocturnal animals.
- Roads also cause edge effects, increasing exposure to predation and human disturbance.
- Example: The Puff Adder, which relies on thermoregulation by basking on warm roads, is frequently killed by vehicles.

Most Affected Groups:

- Reptiles: Tortoises, Adders, Skinks.
- Nocturnal mammals: Aardwolf, Bat-Eared Fox, Cape Hedgehog.
- Amphibians: Seasonal breeding frogs that migrate to ephemeral pools.

Renewable Energy Developments and Disruption of Flight Paths

Impact:

- Wind farms cause direct mortality for migratory and foraging bats and raptors through collision with turbines.
- Large-scale solar farms alter ground temperatures, affecting burrowing species like sand lizards.
- Example: Wind farms along the West Coast pose a collision risk for migratory raptors like Black Harriers and Pale Chanting Goshawks.

Most Affected Groups:

- Bats: Natal Long-Fingered Bat, Egyptian Free-Tailed Bat.
- Birds of prey: Black Harrier, Lanner Falcon.
- Burrowing reptiles: Namaqua Dwarf Adder, Sand Lizards.

Water Abstraction and Drainage Alteration

Impact:

- Reduces availability of seasonal wetlands and ephemeral pools, essential for amphibians, reptiles, and water-dependent mammals.

- Affects vegetation critical for insect populations, which in turn impacts species that rely on them for food.
- Example: The Namaqua Rain Frog relies on moist soil conditions for burrowing; water loss increases desiccation risks.

Most Affected Groups:

- Amphibians: Namaqua Rain Frog, Clicking Stream Frog.
- Semi-aquatic reptiles: Karoo Sand Snake.
- Insectivorous mammals: Aardwolf (depends on termite availability).

Climate Change and Altered Seasonal Migrations

Impact:

- Rising temperatures affect water availability and plant phenology, altering breeding and migration timing.
- Species that rely on specific seasonal triggers (e.g., rainfall-dependent breeding frogs) are at risk of reproductive failure.
- Example: The Cape Sand Frog depends on ephemeral pools that dry out faster due to climate change, reducing tadpole survival rates.

Most Affected Groups:

- Frogs and amphibians: Breeding cycles depend on rainfall.
- Migratory birds: Raptors and insect-eaters struggle with declining insect numbers.
- Desert-adapted reptiles: Extreme heat pushes some species beyond thermal limits.

6.2 Strategies to Mitigate Impacts on Fauna Migration and Sensitive Ecosystems

Creation of Wildlife Corridors and Buffer Zones

- Establish ecological corridors between habitat patches to allow movement for migratory and wide-ranging species.
- Designate buffer zones around wetlands and ephemeral rivers.
- Example: Identifying and protecting traditional movement corridors used by Brown Hyenas.

Wildlife-Friendly Infrastructure

- Fauna underpasses and overpasses to reduce roadkill.
- Use wildlife-friendly fencing that allows smaller mammals and reptiles to pass through.
- Example: Open-bottom fences allow tortoises and lizards to move between fragmented areas.

Sustainable Water Management

- Maintain natural seasonal wetlands and restrict water abstraction in key breeding areas.
- Example: Protecting ephemeral pools ensures amphibian breeding success.

Strategic Wind and Solar Farm Placement

- Conduct biodiversity impact assessments before approving energy projects.
- Avoid siting wind farms in key raptor migration routes and bat foraging zones.
- Example: Black Harrier conservation measures around wind farms can reduce turbine-related deaths.

Climate Adaptation Strategies

- Artificial water sources for vulnerable species in drought-prone areas.
- Habitat restoration projects to improve climate resilience of ecosystems.
- Example: Replanting native vegetation in degraded areas can support insect populations, benefiting insectivorous species like aardwolves.

7. SENSITIVITY MAPPING

The faunal sensitivity of the Namakwa Region reflects the intersection of exceptional endemism, highly specialised habitat requirements, and intensifying development pressures characteristic of the Succulent Karoo biodiversity hotspot. The sensitivity map (**Figure 10**) illustrates a clear spatial gradient, with Very High Sensitivity concentrated along the coastal dune belt and lower Orange River corridor, transitioning to High and Medium Sensitivity across the inland plains. These patterns correlate strongly with the distribution of key fauna, particularly range-restricted reptiles, amphibians, invertebrate assemblages, and dune-dependent mammals.

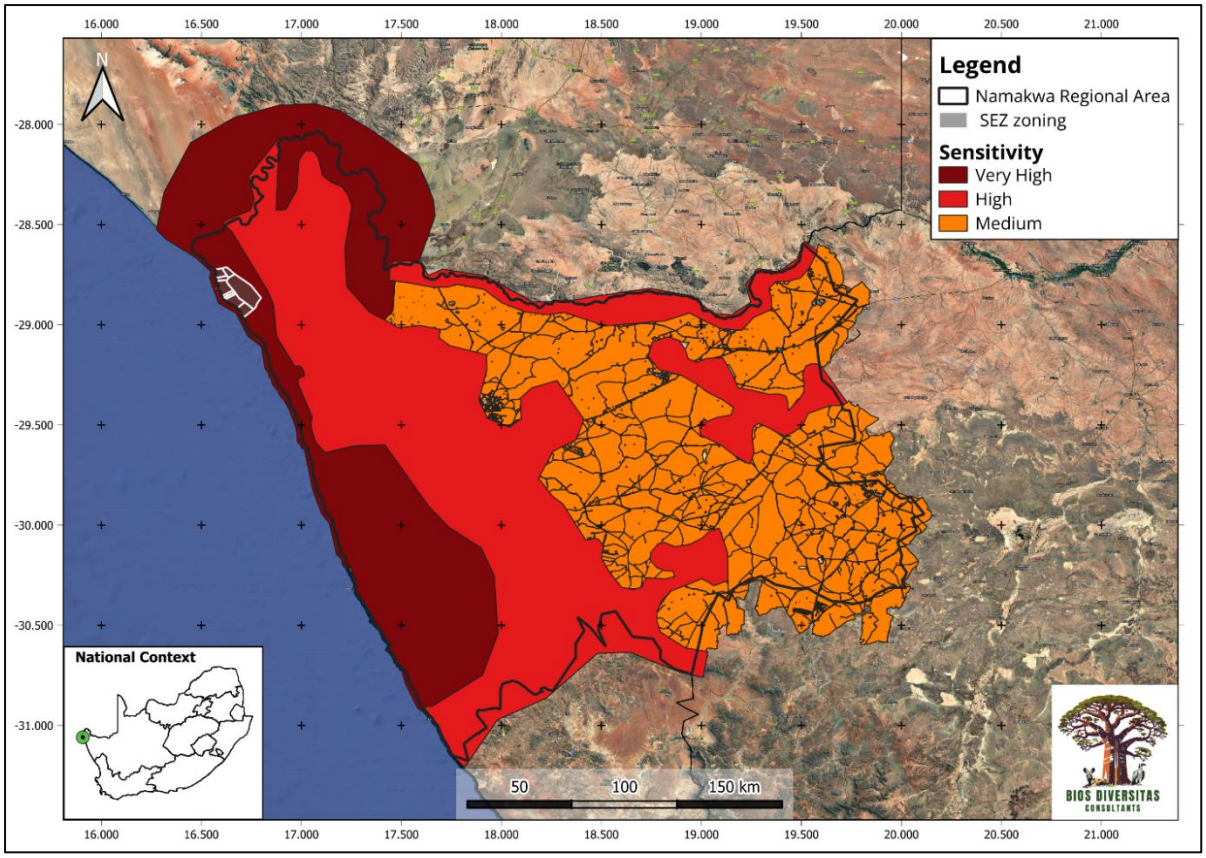

Figure 10: Faunal sensitivity map of the Namakwa Region study area.

Very High Sensitivity Areas

The coastal belt mapped as Very High Sensitivity coincides with the core habitat for several narrowly endemic and Red-Listed species, particularly those associated with loose aeolian sands and fog-dependent dune ecosystems. As such, any development in Very High Sensitivity areas carries a high probability of irreversible biodiversity loss, and EIAs must treat these locations as no-go or strict avoidance zones unless exceptional justification exists.

These include:

- De Winton's golden mole (*Cryptochloris wintoni*) – Critically Endangered
  Endemic to northern Namaqualand, dependent on intact coastal dunes. Surveys and Red List assessments highlight severe historic loss from coastal mining, with remaining habitat highly fragmented.

- Grant's Golden Mole *Eremitalpa granti granti* – Vulnerable
  Endemic to southern Africa, with its distribution primarily focused on the arid and semi-arid regions of the western parts of the Northern Cape, concentrated along coastal dunes. Its range overlaps with sandy habitats extending into desert-like environments, including the Namaqualand coastal areas (Port Nolloth and possibly as far north as Alexander Bay).

- Desert rain frog (*Breviceps macrops*) – Vulnerable (IUCN); Near Threatened (National)
  Restricted to a narrow dune belt between high-water mark and inland ridges. Its survival is tied to undisturbed sandy substrates, which explains the alignment of its predicted habitat with the Very High Sensitivity zone.

- **Branch's rain frog (*Breviceps branchi*) – Data Deficient, Micro-endemic**
  Known only from red sands near the Holgat River. Although the precise range remains unconfirmed, the species is strongly associated with the northern coastal duneveld also classified as Very High Sensitivity.

- ***Bathyergus janetta* – Uplisted to Endangered A4(a)**
  Recently been uplisted to Endangered (2025 National Red List) owing to climate change and the threat of continued habitat destruction of three isolated subpopulations. The species is located along the southern coastline of the Namakwa region between Port Nolloth and Groenrivier.

High Sensitivity Areas

High Sensitivity areas extend inland across Namaqualand Hardeveld, succulent shrublands, and rocky inselbergs, where important faunal SCCs and ecological processes occur.

Key fauna driving High Sensitivity designation:

- **Speckled padloper tortoise (*Chersobius signatus*) – Endangered (IUCN)** Confined to rocky outcrops in the Succulent Karoo. These outcrops align with High Sensitivity polygons, reflecting their irreplaceable microhabitats.

- **Girdled lizards (*Namazonurus* and *Karusasaurus* spp.)**
  Range-restricted rock specialists requiring unbroken koppie habitats.

- **Namaqua sand frog (*Tomopterna branchi*)** – Endemic
  Associated with ephemeral pools and sandy drainage lines in the Hardeveld. These hydrological features fall within the High Sensitivity inland tracts.

- **Ecological processes underpinning High Sensitivity**
  - High pollinator activity in flower-rich shrublands
  - Soil engineering by ants, termites and rodents
  - Seasonal amphibian breeding in natural pans
  - Critical refugia on koppies for reptiles and small mammals

Medium Sensitivity Areas

Medium Sensitivity regions cover much of the inland plains where faunal diversity, while still significant, includes more disturbance-tolerant assemblages. Areas can still be utilised by faunal SCC which are not range restricted and less likely to be impacted on by development.

These areas still support:

- Arid-zone toads
- Widespread sand lizards and skinks
- Mammalian generalists such as steenbok, hares and generalist rodents
- Generalist invertebrate assemblages

While these species are important ecologically, they have broader distributions and better tolerance of moderate habitat modification.

8. RISK ASSESSMENT

8.1 Definition of Consequence / Benefit Categories

For biodiversity and ecological impacts, risk is measured in terms of disruption of ecological processes, loss or degradation of ecosystems, and/or loss of species. The degree of risk (consequence) is assessed against thresholds for maintaining the functioning of all key ecological processes, maintaining a proportion of each ecosystem in good ecological condition, retaining all threatened species, and retaining a representative sample of all endemic or near-endemic species.

Whilst the regional assessment is aware of the total expected development footprint, there is no detail as to the location of the various development components under each scenario. So rather than attempting to articulate consequence in relation to the entire development scenario, it is considered at the site level in terms of what would the consequence be from a single development perspective. Therefore, thresholds of change are interpreted relative to a site and the consequence that the spatial scale of site-level impact would have on biodiversity in the landscape surrounding the site.

8.2 Risk Assessment Table

Given the spatial scale of both scenarios there are differences in the assessed consequence and likelihood between with and without mitigation (**Table 5**). Whilst biodiversity offsets do guarantee that a portion of the biodiversity being lost is placed into formal protection, this does not negate the fact that a significant amount of biodiversity has been permanently lost. The only difference between with and without mitigation comes in the interpretation of the significance of this loss in relation to biodiversity sensitivity categories and their contribution to achieving our biodiversity conservation goals. Areas that that have been identified as being necessary to achieve our conservation goals for biodiversity pattern or ecological processes attract a higher risk rating.

8.2.1 How Risk is Determined

In this SEA, risk is determined by evaluating the likelihood of an impact occurring and the potential effect or consequence of that impact on priority animal species occurring in the broader Namakwa Region (**Figure 11**). For this faunal specialist assessment—undertaken as part of WP2 of the SEA—the potential impacts to animals are considered to be all negative (-) in nature.

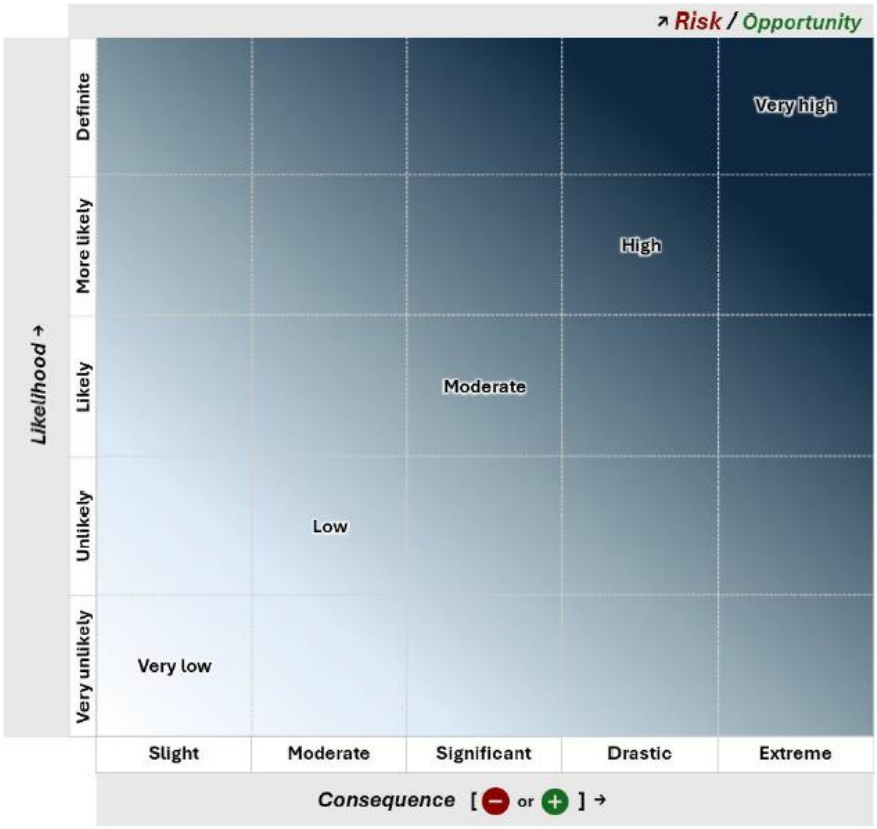

Figure 11: Risk and opportunity is qualitatively measured by multiplying the likelihood of an impact (negative or positive) by the severity of the consequence or benefit (*Source*: CSIR, 2025).

8.2.2 How Consequence is Determined

Consequence, also referred to as severity, refers to the potential outcome or effect if a risk or impact occurs. It is a key component in determining the overall level of risk and is assessed by evaluating the degree of harm or damage that could result.

In South African specialist assessments—particularly those aligned with guidelines stipulated by the Endangered Wildlife Trust, and in accordance with the Animal Species Specialist Protocol (GNR 320 of 2020) in terms of the 2014 NEMA EIA Regulations, as amended—consequence thresholds are generally distinguished along a gradient of magnitude, extent, duration and reversibility of an impact occurring, and resultant conservation importance.

These consequence thresholds (**Table 3**) are often applied in impact significance matrices where consequence is combined with likelihood to determine overall significance ratings. For fauna, the population viability context—including species' Red List status, range size, generation length, and sensitivity to the impact mechanism—is central to assigning the correct threshold.

Table 3: Consequence thresholds defined for determining potential risk of impact to fauna within the Namakwa Region.

Threshold	Consequence levels defined for impact on animals
Slight	Negligible to very low magnitude; localised; short-term; fully reversible; no measurable effect on population viability; affects only common/non-threatened/non-target species.
Moderate	Low to medium magnitude; local or limited regional extent; short- to medium-term; reversible with mitigation; may cause minor, non-sustained reductions in local abundance but no long-term viability risk.
Significant	Medium magnitude; regional extent or affecting key habitats; medium- to long-term; partially reversible; measurable reduction in local population size or productivity; medium risk to one or more animal SCC — Endemic and Near-Endemic species — but unlikely to threaten overall population persistence.
Severe	High magnitude; regional to national extent; long-term or permanent; largely irreversible; substantial reduction in population size or productivity; high risk to one or more faunal species of conservation concern — Vulnerable and Near-Threatened species—potentially affecting viability of local or metapopulations.
Extreme	Very high magnitude; national or global extent; permanent and irreversible; threatens survival of Endangered and Critically Endangered faunal species or leads to local extinction; affects critical habitats for Endangered and Critically Endangered faunal species.

8.2.3 How Risk Categories are Defined

Risk to fauna in the Namakwa Region is assessed for each identified impact, considering the different types of faunal habitat characteristic of the study area and incorporating the fauna SCC selected for this risk assessment. Table 4 outlines the predefined risk categories utilised in this faunal risk assessment.

Table 4: Predefined risk categories applicable to the faunal Risk Assessment for this SEA

Risk (-) level	Category description
VERY LOW	Almost indiscernible negative impact
LOW	Slight negative impact, limited extent, and short duration, well within tolerance levels
MODERATE	Substantial impact, but less than major; within tolerance levels and below limits of acceptable change
HIGH	Major consequences, approaching tolerance and limits of acceptable change
VERY HIGH	Extremely negative impact, persistent/long lasting impact, beyond tolerance and limits of acceptable change

8.2.4 Risk Assessment with and without Mitigation

Table 5 shows the risk associated with the potential negative (-) impacts to priority faunal species determined for each development scenario—S0: Baseline Scenario, S1: Small scale GH_2 development, and S2: Big scale GH_2 development—for each sensitivity criteria, both with and without mitigation management.

Table 5: Assessment of risks associated with the negative impacts of GH2 on biodiversity. Risk with mitigation is assumed to be mitigation without avoidance.

Negative Impact	Scenario	Spatial receiving environment	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Displacement due to Habitat loss & fragmentation	S0: Baseline	Very High	Severe	More Likely	HIGH	Significant	More Likely	MODERATE
	S1: Small GH_2		Extreme	Definite	VERY HIGH	Severe	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Severe	Definite	VERY HIGH
	S0: Baseline	High	Significant	More Likely	HIGH	Moderate	More Likely	MODERATE
	S1: Small GH_2		Severe	Definite	VERY HIGH	Significant	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Severe	Definite	VERY HIGH
	S0: Baseline	Medium	Moderate	Likely	MODERATE	Moderate	Unlikely	LOW
	S1: Small GH_2		Moderate	More Likely	HIGH	Significant	Likely	MODERATE
	S2: Big GH_2		Significant	More Likely	HIGH	Significant	More Likely	HIGH
	S0: Baseline	Low	Moderate	Likely	MODERATE	Moderate	Unlikely	LOW
	S1: Small GH_2		Significant	More Likely	HIGH	Moderate	Likely	MODERATE
	S2: Big GH_2		Significant	More Likely	HIGH	Significant	Likely	MODERATE
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very High	Significant	More Likely	HIGH	Moderate	Likely	MODERATE
	S1: Small GH_2		Severe	Definite	VERY HIGH	Significant	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Severe	More Likely	HIGH
	S0: Baseline	High	Significant	More Likely	MODERATE	Moderate	Likely	MODERATE
	S1: Small GH_2		Severe	Definite	VERY HIGH	Significant	More Likely	MODERATE
	S2: Big GH_2		Severe	Definite	VERY HIGH	Extreme	Definite	HIGH
	S0: Baseline	Medium	Moderate	Likely	MODERATE	Moderate	Unlikely	LOW
	S1: Small GH_2		Significant	More Likely	HIGH	Moderate	Likely	MODERATE

Negative Impact	Scenario	Spatial receiving environment	Without mitigation			With mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S2: Big GH_2		Severe	More Likely	HIGH	Significant	Likely	MODERATE
	S0: Baseline	Low	Slight	Unlikely	LOW	Slight	Very unlikely	VERY LOW
	S1: Small GH_2		Significant	Likely	MODERATE	Moderate	Unlikely	LOW
	S2: Big GH_2		Significant	Likely	MODERATE	Significant	Likely	MODERATE
Changes to Ecological functioning and processes	S0: Baseline	Very High	Severe	More Likely	MODERATE	Moderate	Likely	MODERATE
	S1: Small GH_2		Extreme	Definite	VERY HIGH	Severe	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Extreme	Definite	VERY HIGH
	S0: Baseline	High	Significant	More Likely	MODERATE	Moderate	Likely	MODERATE
	S1: Small GH_2		Severe	Definite	VERY HIGH	Significant	More Likely	HIGH
	S2: Big GH_2		Extreme	Definite	VERY HIGH	Severe	More Likely	HIGH
	S0: Baseline	Medium	Significant	Likely	MODERATE	Moderate	Unlikely	LOW
	S1: Small GH_2		Significant	More Likely	HIGH	Moderate	Likely	MODERATE
	S2: Big GH_2		Severe	More Likely	HIGH	Significant	Likely	MODERATE
	S0: Baseline	Low	Slight	Unlikely	LOW	Slight	Very unlikely	VERY LOW
	S1: Small GH_2		Moderate	Likely	MODERATE	Slight	Unlikely	LOW
	S2: Big GH_2		Significant	Likely	MODERATE	Moderate	Likely	MODERATE

8.3 Recommended Management Responses for Risk Categories

The sensitivity mapping and risk categories used only provides a broad, strategic overview of the relative suitability and potential for development within and across the broader Namakwa Region. Even in areas of low sensitivity it is important that some form of project-level environmental impact assessment be undertaken to confirm and refine the outputs as presented in this SEA.

It is considered critical that implementation of one and/or more of the following recommended best practice measures be considered—where relevant—for the effective mitigation and management of negative impacts to fauna when GH_2-related development activities are proposed:

- Habitat management and restoration (reduce attractants for species to enter the development footprint).
- Once a preliminary or conceptual layout is available, conduct species specific assessments in optimal conditions for proposed developments.
- Conduct a least path model analysis for linear infrastructure (pipeline, railway, grid connections, roads etc.), especially through sensitive areas to determine the best route options with the lowest impacts on fauna.
- Not all linear infrastructure can avoid high and very high sensitivities, but measures such as making use of existing roads and where possible prioritising development within areas of medium and low sensitivity can reduce impacts significantly.
- Design any overhead cabling with associated pylons within and near (suggested within 1 km) areas of suitable habitat for threatened Tortoises so as to discourage crows from nesting on the structures and preying on them.
- Develop a Fauna Management Plan during the design phase and implement / adhere to the Plan during all phases of the project.
- Establish and implement an ongoing roadkill monitoring programme (inclusive of wildlife collisions record keeping) to inspect roads for injured and deceased fauna (including sensitive species and tortoises) due to the movement of vehicles to and from site.
- Reduce direct mortalities by allowing for fauna to cross the roads and bridges. Where applicable, include fauna underpasses under the roads (large culverts or large open-ended concrete pipes laid into the raised roads) in the design. Use these underpasses in conjunction with "fauna barriers" which prevent the most susceptible small fauna from crossing the roads on the surface by directing them towards the underpasses where they can cross under the roads safely. It is important to note that utilisation of underpasses is strongly dependent on animal body size (larger culverts are more successful) and the surrounding habitat.
- Undertake a detailed cumulative impact assessment for all planned developments.
- Monitoring, mitigation and proactive conservation beyond the facility footprint.

8.4 Mitigation Hierarchy and Policy Standards

- *Avoidance first*: Prioritise site screening to exclude high-risk features (e.g., golden mole habitats along the coast, other sensitive species habitats such as rocky outcrops and watercourses).
- *Design optimisation*: Require technology-specific design standards embedded as SDF/EMF overlays and standard EIA conditions.

- *Minimisation measures*: Implement recommended mitigation measures as included in the Environmental Management Programme (EMPr) for each proposed development application.

- *Offsets as last resort*: If residual impacts remain significant, apply like-for-like offsets with measurable, time-bound outcomes and independent verification (DFFE, 2023).

9. DISCUSSION AND CONCLUSION

The Namakwa Region, located mostly within the Succulent Karoo Biodiversity Hotspot, is of exceptional faunal importance (invertebrates, mammals, reptiles and amphibians) and is home to many threatened, endemic and range restricted faunal species. Spatial sensitivity mapping confirms extensive Very High and High sensitivity zones across the study area, particularly for habitat loss and transformation of natural vegetation related impacts.

The findings of this assessment emphasize the critical need for a balanced approach to development in the Regional Area. While the proposed port and SEZ hold significant economic potential, along with the regional development coupled with this, the ecological sensitivity of the Regional Area demands a robust environmental management strategy. The presence of threatened and endemic species underscores the necessity for targeted conservation efforts to minimize biodiversity loss.

Namaqualand's fauna relies on sensitive ecosystems and seasonal migration routes for survival. Multiple threats from human activities such as uncontrolled development disrupts pathways, leading to habitat loss, increased mortality, and reduced genetic diversity. While some species show adaptability, many are highly specialised and poorly equipped to survive in built-up and degraded environments. However, sustainable planning, important habitat protection, ecological corridors, climate adaptation strategies and wildlife-sensitive infrastructure can help mitigate these impacts, ensuring the long-term survival of Namaqualand's unique biodiversity.

The Regional Area extent consist of ~50% CBA 1 and CBA 2, as well as five threatened ecosystems, underscoring the ecological sensitivity of the region. While comprehensive mitigation measures can reduce the severity of some impacts, avoidance of highly sensitive features should be the first and best option. Accordingly, all development activities located within these sensitive areas must undergo environmental impact assessments, and the options of biodiversity offsets including the expansion of existing protected areas, must be considered and investigated upfront.

The project has potential benefits, including renewable energy production and socioeconomic development. These must however be weighed against the irreversible nature of biodiversity loss and the potential loss of ecosystem services provided by important ecosystems and biodiversity hotspots, which are vital for the maintenance of regional biodiversity, maintaining ecological drivers and processes to support local fauna communities, especially range restricted and endemic species.

Accumulating fine-resolution spatial data generated through on-site ground-truthing is strongly suggested as it will play a crucial role in shaping the future planning of any proposed development in the Regional Area as part of future Environmental Impact Assessments.

Given the high ecological sensitivity of the Regional Area, key ecosystem services and processes, the presence of fauna SCC, and high conservation value, large-scale proposed developments pose significant risks to biodiversity and ecosystem processes. While mitigation can reduce some of these risks through careful planning for sustainable development, it cannot fully eliminate the impacts on critical habitats and species, where avoidance is the only option. Accordingly, biodiversity offsets are likely to be a massive component of this Project moving forward.

All components of proposed developments need to consider site and technological alternatives, as well as designs which reduces impacts on the receiving environment. Sites with lower ecological sensitivities can achieve development goals with minimal environmental trade-offs. The Project requires a cautious approach with a strong emphasis on biodiversity conservation and maintaining conservation targets. It

should only proceed if it can demonstrate net ecological benefit or neutrality through rigorous mitigation strategies.

The risk assessment shows that without mitigation, both the Small GH_2 and Big GH_2 development scenarios present High to Very High risks to priority faunal species, especially in very high sensitivity areas. The Big GH_2 scenario carries the greatest cumulative risk, with potential severe to extreme consequences for threatened animal species. The Small GH_2 scenario could also have potential severe to extreme consequences for Endangered and Critically Endangered species if located primarily within their restricted habitat along the coast. Even with best practice mitigation, residual impacts remain significant in habitats, especially high and very high sensitivity for the priority faunal species assessed.

Based on the findings of this desktop assessment, scenario 1 (small GH2 by 2035) could be a viable option which requires detailed investigation and careful site selection as it could result in medium to high residual impacts which will require biodiversity offsets, while scenario 2 (big GH2 by 2050) may result in high residual impacts which will require biodiversity offsets. There are already a large number of renewable energy developments within the region, and effort should be made to incorporate some of them privately (not feeding into the national grid) for this project, which could reduce the overall impacts associated with the provision of electricity to the GH2 facility. The full 80 GW does not have to be green site developments.

9.1 Recommendations

To assess baseline studies which should include site sensitivity verification and data collection, the next steps and activities are recommended:

- Comprehensive baseline biodiversity surveys are required for impacted fauna SCC and threatened ecosystems as part of the EIA process.
- Conducting a comprehensive cumulative impact assessment for the region.
- Monitoring faunal populations during and after construction to assess the effectiveness of mitigation measures.
- Modify management practices based on monitoring outcomes and emerging challenges.
- Collaboration with taxa specific specialists and conservation organisations (such as EWT, SANBI) to refine impact assessments and conservation actions.
- Acquisition of all observation data from participating specialists and inclusion into the final complete dataset.
- Review of field reports from other disciplines and in particular, habitat descriptions and delineations of the botanical and soil specialists to more accurately and consistently describe and map fauna habitats.
- Obtain revised infrastructure layout from developer based on all defined habitat sensitivities and logistical considerations – developer is advised to plan infrastructure layout to avoid as much of the sensitive habitats as possible.
- Workshop with all participating specialists and developer to share understanding of project and discuss all potential impacts. Of particular importance is the necessity to understand the requirements of the developer related to SCC and their assumed versus actual occurrences. Should the developer wish to demonstrate a high degree of confidence for the absence of particular species in habitats within the Regional Area then additional surveys will be required and must be included in the impact assessment. At this stage it is recommended that it is better to assume the presence of SCC under the precautionary principle and develop appropriate mitigation and management considerations to limit any anticipated impacts, with avoidance mitigation being the best possible approach.

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CHAPTER 3

Terrestrial Biodiversity Offset Framework

CHAPTER 3: Terrestrial Biodiversity Offset Framework

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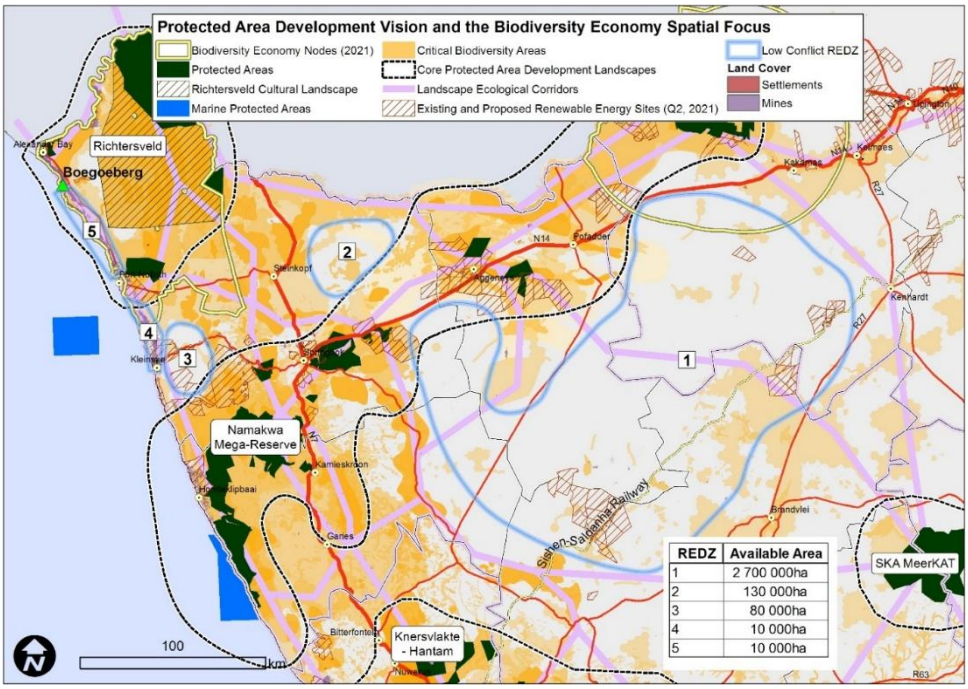

Figure S.1. A previous regional conservation development framework (SANParks 2019) overlain with the initial three large "low conflict" zones able to accommodate especially PV production (1-3) and two modest zones for Wind energy (4,5) on coastal mining scars for initial GH2 planning (NCEDA 2021). This study refines these areas to guide green hydrogen development away from areas demanding substantial offsets.

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Points of Departure & Assumptions

This report assumes that regulators and project proponents are familiar with the intention behind and, the optimal deployment of, biodiversity offsets[1]. It is also assumed that, beyond the formal regulatory Guideline (DFFE 2023), the general warnings around the constraints and pitfalls (e.g. Crous & Pryke 2024) and minimum criteria for biodiversity offsets (*e.g.* Pope *et a*l 2021) would be heeded as these are now internationally well established. Importantly, the challenge of using offsets to achieve certain desired outcomes (especially Net Gain Outcomes – zu Ermgassen *et al (*2023)) implies that for compliance with global financing standards, all efforts to avoid the impacts on 'Critical Habitat' must be taken. Offsets cannot be used to circumvent diligent and comprehensive adherence to the mitigation hierarchy.

The thematic scope of this Regional Biodiversity Offset Framework is restricted to terrestrial ecosystems (vegetation types), in terms of biodiversity features considered. It is limited by the challenges of framing (and assessing) biodiversity offset implications based on a suite of large-scale, semi-defined green hydrogen (GH_2) development scenarios. It is assumed that the footprint projections are reasonably accurate, although large scale infrastructure projects often underestimate the ultimate resulting impacts.

These developments would be in an area of high biodiversity sensitivity and competing landuses – some authorised, others not. Although an offset framework for the port precinct impacts (as a subcomponent of the regional-scale study) is potentially tractable (provided the guidance on location from the Port-specific SEA is heeded (i.e., Work Package 1 SEA)), the economic viability of the GH_2 development will demand large adjacent (including marine) and regional impacts, especially from renewable energy. These regional impacts are difficult to predict with the spatial resolution required for regulatorily- or lender-required offsetting. The sheer scale (~144 000 ha) alone of a medium to big GH_2 scenario is likely to be significant and trigger thresholds of environmental concern.

In the District there is ostensibly sufficient previously mined or otherwise damaged land, or land of relatively low biodiversity, cultural and ecosystem service value, on which to locate renewable wind energy infrastructure. A key point of departure is that the political will exists to resolve the long-standing issues of access, liability, illegal mining, and equity concerns around the coastal regions to accommodate a new infrastructure rollout and offset implementation process.

Inland, extensive areas of relatively low species richness could accommodate photovoltaic facilities (PV) with minimal biodiversity impact and hence low requirement for extensive offsets. In practice, however, the nature of the developments and linear infrastructure and the ancillary industries' impacts are almost certain to be of a scale and nature as to result in significant widespread biodiversity loss that is difficult - with current knowledge - to define and counterbalance.

Several assumptions had to be erected to assess the likely scope and location of much of the renewable energy fleet. These are endlessly debatable and only presented here to calibrate the implied challenge and cost of offsetting, and hence the political and technical attention that must be given to this upfront, in particular to address mitigation proactively and sufficiently.

An offset framework must be built on realistic opportunities and constraints. Institutional, budgetary and capacity limitations are likely to restrict offset development to within pragmatic distances of existing protected areas and operational management centres. All candidate receiving areas are thus a trade-off between biodiversity representation imperatives and the likelihood of effective establishment. The areas proposed have been guided by current reserve management inputs, but I acknowledge that greater ambition of offset-driven conservation action is also possible. An assumption is that sufficient resources and

[1] Offsets aim to stop or reverse the decline in biodiversity and ecosystem function. Their deployment is best located where this outcome achieves on-balance optimal outcomes and likely long-term persistence.

incentives exist for proponents to co-opt private and communal landowners to be active stewards of some offset receiving areas, and that conservation agencies have the staff and approach to service these areas in the long term.

An acknowledged gap in this framework is any treatment of the social implications of offset establishment at the scale required. Setting aside massive areas of land currently used for grazing, farming or other resource use in a manner that limits this use requires deep engagement, negotiation and compensation for those whose rights are curtailed. This is not covered here, as no engagement with indigenous people, local communities or landowners has occurred, and they need to establish the parameters of any compensation payable.

The eligibility criteria for green hydrogen are evolving. This study takes the view that hydrogen production with unacceptable impacts on threatened ecosystems or species (or land-owning communities) or which is insufficiently mitigated and offset, is unlikely to be tolerated by investors or the market. Hence, socially equitable, progressive and proactive offset approaches are required, coupled with a fastidious and transparent adherence to the mitigation hierarchy.

Executive Summary

The terrestrial biodiversity impacts associated with a big or even modest GH_2 scenario[2] will be significant but are difficult to circumscribe accurately given current uncertainties. All Scenarios would include some of the significant, negative biodiversity impacts and offset liabilities set out in previous work on the Boegoebergbaai Port and adjacent Special Economic Zone (i.e., Work Package 1 SEA). This study investigates prospective regional-scale direct impacts from related renewable energy (RE) development on sensitive biodiversity features. It identifies potential areas of low ecological importance that could accommodate developments with little offset implications, and proposes candidate offset sites ("offset receiving areas") catering for most priority biodiversity features that are likely to be impacted. At this scale of resolution (the area of interest is >5 million ha), definitive guidance is elusive, but mechanisms for streamlining site/project-level EIA offset studies are proposed and a biodiversity offset framework presented.

The big GH_2 scenario would result in a localised footprint of electrolysers, storage, transport and regional footprint of energy generation of >144 000 ha, while a small GH_2 scenario would still impact >21 000 ha. Associated linear infrastructure of multiple High Voltage transmission lines, a >500 km railway, and gas pipelines to Saldanha and Prieska would have extensive impacts in many different vegetation types and on specific vulnerable species.

While the optimal areas for locating GH_2 infrastructure to avoid impacts and, thus, offset implications, are constrained by logistics and product transport/handling considerations within the SEZ (Botha 2026), the regional location of renewable energy facilities is constrained by grid access and resource availability. Additionally, while there are large inland areas of the region potentially available for Photovoltaic (PV) development, Wind Energy Facilities (WEF) are constrained to the higher resource locales along the coast and escarpment. Even a modest or small GH_2 scenario demands extensive additional grid expansion.

The regional terrestrial sensitivity assessment for the SEA (Desmet 2026) sets out the global significance and uniqueness of this species rich area, and presents Critical Biodiversity Areas (CBAs), Key Biodiversity Areas (KBAs), Protected Area (PA) Expansion Priority Focus Areas, and expert mapped concentrations of species of conservation concern. Given the density of important biodiversity features and statutory planning designations in these areas (71% of the 5 million ha planning domain is sensitive), complete offset avoidance is unlikely, even with rigorous planning. The sheer scale of most impacts implies that few are likely to be rated of low negative significance, regardless of the status of underlying biodiversity features. Large impacts on some under-protected vegetation types where national targets are still attainable will likely be assessed as being of moderate or high negative significance – and can be offset in line with national guidance and using precautionary ratios.

In other cases, it is more likely that national targets for biodiversity features may be compromised (e.g., loss of ecosystem extent below thresholds required for continued functioning or persistence, contrary to constitutional and other legal imperatives), which demands 'Ecological Compensation[3]', IF the impact is allowed to proceed at all (DFFE 2023). Proposals for suitable ecological compensation for non-offsetable impacts are given in Section 3.4, but this does not suggest that the impacts should be authorised or would be acceptable to investors or be eligible under green hydrogen market rules.

A critical aspect of decision making (and offsetting) in an area of such rich species diversity is to ensure upfront planning of infrastructure on a regional scale. The density and distribution of plant and species of

[2] Scenarios include Sc0 = dynamic baseline business as usual, No GH2; Sc1 = "small H2"(0,05mtpa); and Sc2 = "big H2" (4 mtpa). See spatial data in Annexure B.

[3] In the South African context, ecological compensation is only allowed under very specific circumstances, including the overwhelming public interest, and requires extraordinary justification. The modality of compensation is often aligned with that of offsets, but involve dissimilar biodiversity features

conservation concern across much of the region may otherwise present fatal flaws to individual project EIAs unless extensive effort at avoidance in upfront planning of regional infrastructure is pursued.

Linear disturbance and permanent infrastructure may also compromise landscape-scale ecological corridors and impede some ecosystem processes. Offset plans should therefore include ecological corridors and processes at a sufficient scale to allow for effective ecological functioning. Another essential regional scale consideration is large bird movement – some of the biggest and most challenging regional terrestrial impacts to mitigate may be on large birds (especially Bustards and some raptors). Many impacts on habitat-generalist bird species would likely be adequately catered for by vegetation type/ecosystem offsets (Kellerman et al 2026).

Adherence to the mitigation hierarchy would require that all options are pursued to use damaged land for infrastructure development (especially WEF) where available. Over 26700 ha of damaged and mined land exists along the coast from Kleinsee to Alexander Bay (Botha & Desmet 2022). If used efficiently, this is potentially sufficient to meet half the WEF footprint requirement for even a Big GH_2 scenario (given that wake effects and layout constraints must affect optimal usage of these mine scars). Increased powerlines along the coast (while more vulnerable to corrosion) would likely pose a smaller risk to avifauna than inland ones. Resolving rehabilitation liabilities on these mine scars and sterilising mineral and petroleum rights to accommodate the new energy economy will take nimble regulators and effective administration.

Due to fog prevalence, space and grid access constraints, PV facilities will need to be constructed inland where there are far fewer already impacted areas. The dry environment and lack of fire indicate that much construction could be done on poles above intact natural vegetation without needing to clear large areas. This approach would substantially reduce costs and offset liabilities – and should be required for any PV site supplying a green hydrogen plant. Notwithstanding minimisation measures, at this scale or PV construction, offsets will still likely be needed. Several precincts (ranging from 40 000 ha to >1 000 000 ha) able to receive this development are identified with likely low sensitivity and low offset implications. Focusing substation development and grid alignment with these areas would significantly reduce the most significant footprint biodiversity impacts.

Assumptions[4] were made as to the percentage fixed and flexible infrastructure likely to trigger offsets. Using these assumptions and the proposed basic offset ratios (average of 2:1 for the areas impacted by PV and WEF (128 000 ha) and 10:1 for the impacts of fixed infrastructure (16 000 ha), unavoidably impacting on priority features), as interpreted from South Africa's National Biodiversity Offset Guideline, a combined Big GH_2 offset requirement of over **183 000 ha** of land would need to be secured. This is equivalent to creating new offset protected areas the size of Richtersveld and Namaqua National Parks combined. Even a Small GH_2 scenario could still require an offset of up to 40 000ha. Suitable areas exist for offsetting such impacts on most inland vegetation types, especially if done proactively and in collaboration with landowners and conservation agencies.

[4] Also refer to further assumptions in the preface and the Annexure B on footprint projections.

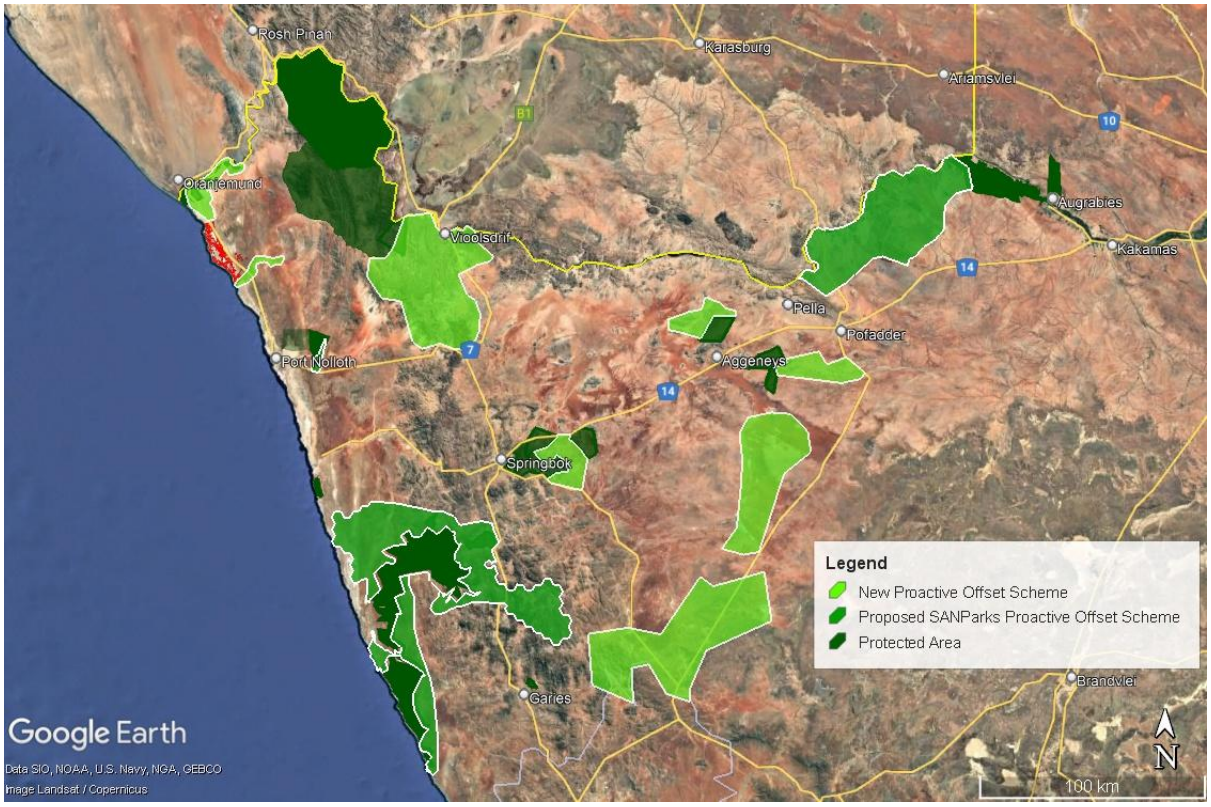

Figure S.2. Proposed Offset Receiving Areas for the broader WP2 study area. These are a combination of statutory Park Expansion Zones, NPAES priority focus areas for expansion, specialist mapped areas for threatened taxa and ecosystems, and project specific proposals from WP1. Note the receiving areas expand existing PAs where possible but don't necessarily create the landscape-scale ecological corridors required for long-term biodiversity persistence.

Biodiversity Offset Guidelines suggest that any regional CBAs or PA expansion priority focus areas may be suitable candidate offset sites provided exchange rules are adhered to (similar vegetation type or habitat). However, there is value in aggregating offsets for institutional and cost efficiency, as well as for reducing land use conflicts or competition where possible. Several areas are proposed for proactive offset schemes – a modality of upfront "banking" of offset areas and outcomes for subsequent use by development proponents in that region (UNDP 2025). These proactive scheme areas range from 3500 ha (Vyftienmylseberg) to 200 000ha (Namaqua and Augrabies National Park Expansion Zones). These would be best managed as declared Protected Areas to prevent loss to mineral exploitation and with improved access control to counter succulent poaching and other threats to species of conservation concern. Communal land and grazing systems could possibly be incorporated into some proactive offset schemes IF compatibility with biodiversity maintenance could be demonstrated and compensation arrangements agreed to. However, Desmet (2026), through analysis of grazing impacts on the regional flora over several decades, notes that this is unlikely to be the case.

Where offsets are technically not possible, Ecological Compensation would be required to mitigate impacts, including for some CBAs, range restricted ecosystems, species of conservation concern (SCC) and highly mobile species (especially avifauna) that are very difficult to effectively offset (see Section 3.4 below). Examples given include retrofitting existing infrastructure with impact mitigation devices (Kellerman *et al* 2026) or permanently reducing grazing pressure in sensitive areas by protecting larger areas. Calibrating the required ecological compensation accurately (and acceptably to regulators and I&APs) is fraught with challenges. Implementing the compensation without displacing existing state expenditures on biodiversity management in the region is unlikely – and would violate the key 'additionality' principle of offsets and ecological compensation.

Given the lack of resolution and clarity on the location and implications, the cumulative, indirect or induced impacts are unclear and hard to estimate for offsetting quantification. To what extent any indirect or induced impact could be linked to any particular project is also often very hard to determine. This complicates assigning offset liability and is a key reason why SEZ proponents should proactively mitigate impacts on behalf of tenants, and avoid contentious or mis-aligned project-level offset investigations or proposals. SEZ support for an investment in proactive offset schemes would be imperative to streamline implementation, avoid land use conflicts and manage the threat from illicit and poorly regulated mining on offset sites, ecological corridors and other unique features.

Successful accommodation of many of the planned developments and the persistence of nature in the region will rely on more detailed planning and negotiated trade-offs between key economic sectors. This is only likely to deliver ecological sustainability if biodiversity is catered for upfront, and not reactively after developments have been approved.

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Figure S.1. A previous regional conservation development framework (SANParks 2019) overlain with the initial three large "low conflict" zones able to accommodate especially PV production (1-3) and two modest zones for Wind energy (4,5) on coastal mining scars for initial GH2 planning (NCEDA 2021). This study refines these areas to guide green hydrogen development away from areas demanding substantial offsets. 3-1

Figure S.2. Proposed Offset Receiving Areas for the broader WP2 study area. These are a combination of statutory Park Expansion Zones, NPAES priority focus areas for expansion, specialist mapped areas for threatened taxa and ecosystems, and project specific proposals from WP1. Note the receiving areas expand existing PAs where possible but don't necessarily create the landscape-scale ecological corridors required for long-term biodiversity persistence. 3-7

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CHAPTER 3. BIODIVERSITY OFFSET FRAMEWORK

3.1 DEVELOPMENT IMPACTS, BIODIVERSITY FEATURES TO BE OFFSET & RATIOS

3.1.1 Understanding the potential GH2 development scenarios

The small GH_2 scenario would impact >21 000 ha with a localised footprint of electrolysers, and storage, while a big GH_2 scenario would also result in a transport and regional footprint of energy generation of >144 000 ha, (Annexure B). The terrestrial biodiversity impacts associated with a big or even modest GH_2 scenario will be significant but are difficult to circumscribe accurately given current uncertainties. Associated linear infrastructure of multiple High Voltage transmission lines, a >500km railway, inevitable access roads, and gas pipelines to Saldanha and Prieska would have extensive impacts in many different vegetation types, ecological corridors, and on specific vulnerable species.

While the optimal areas for locating GH_2 infrastructure to avoid impacts and, thus, offset implications, are constrained by logistics and product transport/handling considerations within the SEZ (Botha 2026), regional location of renewable energy facilities is constrained by grid access and resource availability. Wind Energy Facilities (WEF) are constrained to the higher resource locales along the coast and escarpment.

Due to fog prevalence, space and grid access constraints, PV facilities will need to be constructed inland where there are far fewer transformed areas. The dry environment and lack of fire indicate that much construction could be done on poles above intact natural vegetation without needing to clear large areas. This approach would substantially reduce costs and offset liabilities – and should be required for any PV site supplying a "green hydrogen" plant. If this kind of construction, coupled with tight geographic limitations (i.e. not the current Springbok REDZ but rather the less sensitive zones outlined in the SEA[5]) and SEZ-stipulated offset parameters, could be included in a standardised Environmental Management Program, it would reduce the time, cost and possibly contestation around PV Environmental Authorisations and mitigation requirements.

Notwithstanding standard EMPrs or required minimisation measures, at the envisaged scale of infrastructure and PV construction, offsets will almost certainly be needed.

Sufficient renewable energy generation has already been approved in the District (13 GW) and Province (78 GW) to cover the needs of small and big GH_2 scenarios, respectively (DFFE REEA data analysed by CSIR February 2025). However, many of these projects were approved > 10 years ago and/or prior to the Biodiversity Offset guideline being in place (and might not be thus effectively mitigated) or would need to be re-authorised prior to construction (due to lapsed authorisations).

Even a modest or small GH_2 scenario demands extensive additional grid expansion. To power the GH2 fleet of any scenario using the widely dispersed RE projects elsewhere in the province would entail significantly more high Voltage power lines spanning the landscape to Boegoebergbaai than are currently set-out in the footprint projection assumptions (see Annex 2) or the national Transmission Development Plan (NTCSA 2024). Additional regional powerlines (>1300 km) would increase impacts on avifauna which are difficult to mitigate. National transmission development plans only refer to a 400 KV line to the Gromis Main Transmission Substation near Kleinsee – which is insufficient to cater for even the small GH_2 scenario.

While there is insufficient available, low-biodiversity conflict area within 100 km of Boegoebergbaai port for RE for Sc2, large areas of relatively low biodiversity sensitivity have been identified (by this and other studies) for regional power production which may not require substantial biodiversity offsets. Several precincts (ranging from 40 000 ha to >1 000 000 ha) able to receive this development are proposed for regulatory consideration and/or potential further refinement and adoption (see Botha & Desmet 2022 for initial work, and Figure 3.5). Focusing substation development and grid alignment in these areas would significantly reduce most biodiversity impacts. In practice, however, the nature of the developments and linear

[5] This study does not ignore the REDZ, but rather aims to refine the less sensitive areas within and around it.

infrastructure and the ancillary industries' impacts are almost certain to be of a scale and nature as to still result in significant widespread biodiversity loss.

3.1.2 Impacted areas suitable for development

An offset framework should ideally identify precincts suitable for development where biodiversity is already effectively lost and has little chance of recovery. Apart from the coastal zone, no definitive map of damaged areas with no remaining natural habitat is available to inform a regional opportunities analysis. Botha (2026) and Botha & Desmet (2022) noted that large areas are available along the coast to host WEF with little or no impact, and these should be pursued before any green fields WEF are developed. This would create a double dividend in reducing rehabilitation liabilities (including those of the state) and would assist in arresting the sand movement smothering large sections of the coastal plain.

3.1.3 Biodiversity Features: CBAs & ESAs and PA expansion Priority focus areas

Desmet (2026) sets out the various biodiversity features informing decision-making in the region see (Figure 3.1 and Figure 3.2).

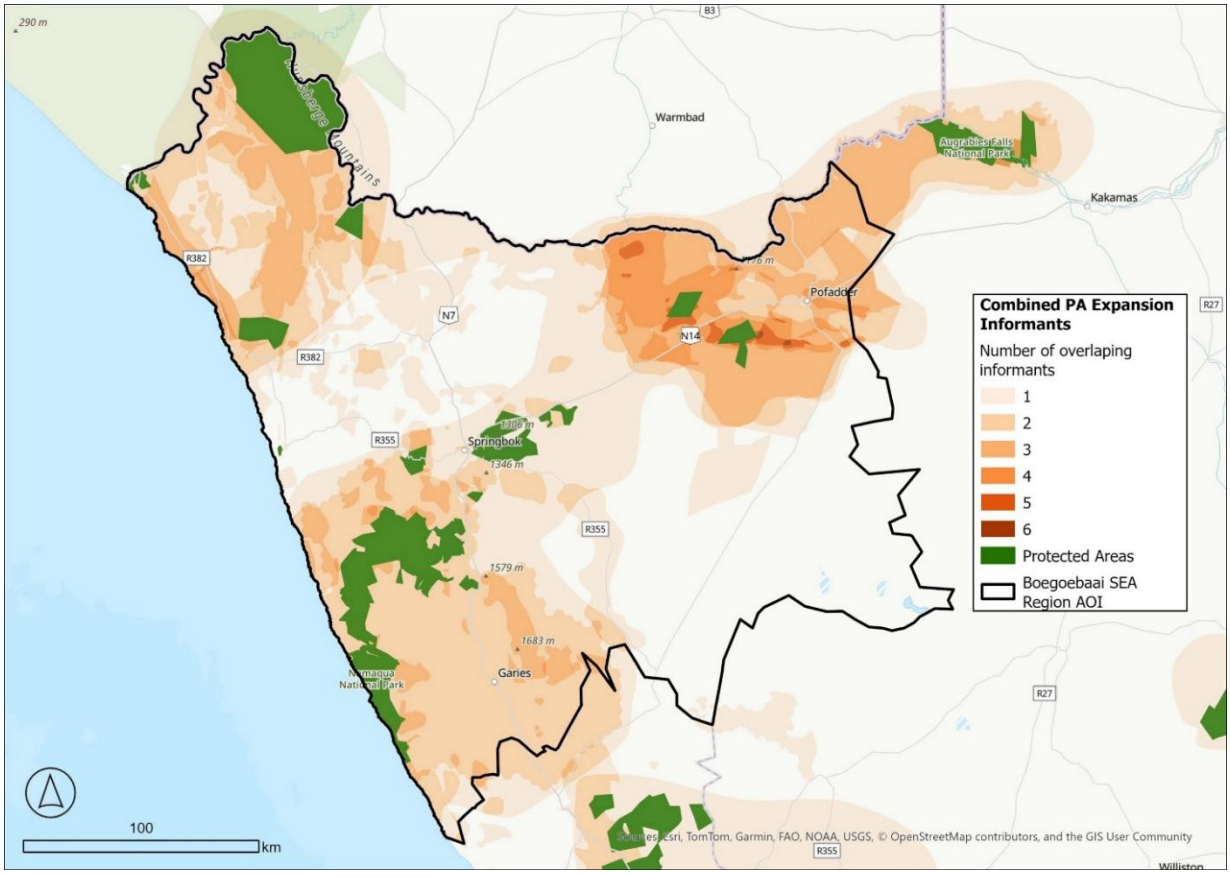

Figure 3.1: Major biodiversity informants, including CBAs, National Park Expansion Zones, prior PA expansion priority focus areas, listed ecosystems, expert mapped important biodiversity areas, and statutory protected areas. Darker shading indicates greater number of biodiversity priority planning informants. Some features not shown at this scale. (Desmet 2026).

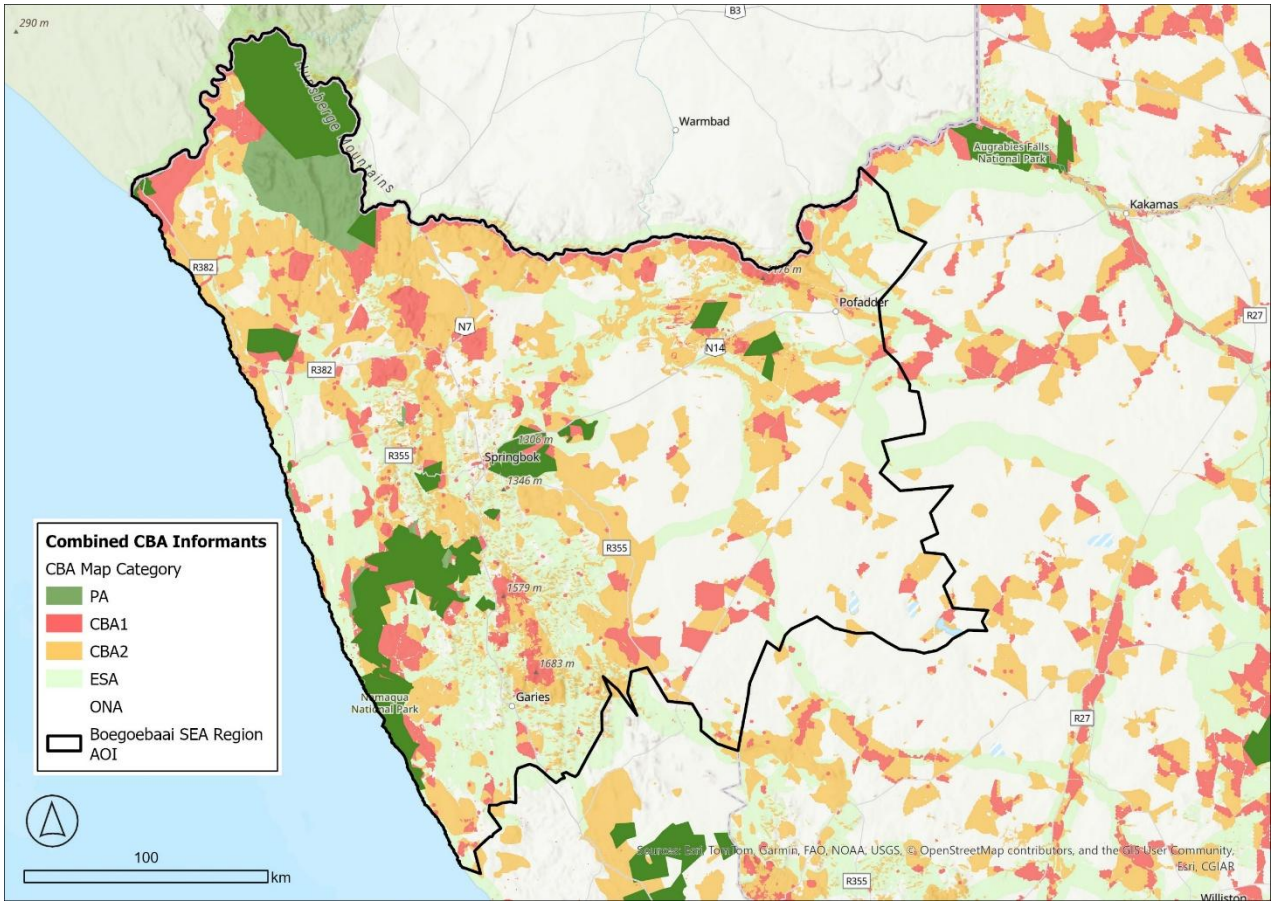

Figure 3.2: A Regional Sensitivity Map augmenting the current Biodiversity Spatial Plan (Oosthuysen. & Geldenhuys 2024) with expert identified areas and PA expansion priorities (Desmet 2026). A departure point is that impacts are best located in the least sensitive areas and offset candidate sites are secured in the most sensitive areas, especially adjacent to existing PAs. Note: this approach is agnostic of land ownership and the assumes mutually beneficial agreements can be negotiated by SEZ proponents.

3.1.4 Biodiversity Features: Vegetation types

Although many of the impacted vegetation types are designated Least Concern (LC) in terms of their national Ecosystem Threat Status (SANBI 2025a), they are also amongst the least protected in the country. Recognising the likelihood of these ecosystems supporting Species of Conservation Concern (SCC[6]), a precautionary approach would suggest that even if a site is classified as Other Natural Area (ONA) it should still attract a basic offset ratio, unless: i) no SCC can be demonstrated to occur; ii) and the site does not play an important ecological function role; and iii) the site would not be considered 'Natural Habitat' in terms of Performance Standard 6 of the IFC. Below is a table of all the potentially impacted vegetation types (South Africa's proxy for ecosystems), with statistics relevant to determining a suitable or required offset ratio, and the final ratio proposed for use in this framework (Table 3-1). The Red Listing of Ecosystems (RLE) process used for ecosystem endangerment ratings under NEMBA has several criteria. One of these criteria (D1) is the measure of recent disruption of biotic processes in that ecosystem. These are important contributors to accurately assessing Ecosystem Threat Status (see Desmet 2026).

[6] Species of Conservation Concern include legislated threatened species, as well as other red listed species with narrow distribution ranges or otherwise conservation worthy (in a specialist assessor's opinion). This has implications for IFC Performance Standard 6, which demands Net Positive outcomes from offset for Critical Habitat of Threatened Species and Ecosystems. This is a higher bar than No Net Loss for other Natural Habitat.

Table 3-1: Vegetation Types (ecosystems) found in the WP2 planning domain, their extent degraded (Desmet 2026), Ecosystem Threat Status and Protection Levels (SANBI 2025a). Inferred Offset ratios align with the National Guideline (DFFE 2023). Note that CBA and other biodiversity feature status would override these baseline vegetation type-derived ratios (see Table 3-2).

Vegetation Type	Percent Degraded	RLE (D1)	ETS (NBA 2025)	EPL (NBA 2025)	Starting Offset Ratio	Final Offset Ratio
Alexander Bay Coastal Duneveld	86,96	CR	CR	NP	30	30
Namaqualand Seashore Vegetation	57,41	EN	CR	PP	30	30
Namib Seashore Vegetation	77,78	EN	CR	NP	30	30
Richtersveld Coastal Duneveld	77,23	EN	CR	NP	30	30
Southern Richtersveld Scorpionstailveld	62,43	EN	CR	NP	30	30
Namib Lichen Fields	14,17	LC	CR	WP	30	30
Upper Annisvlakte Succulent Shrubland	6,53	LC	CR	MP	30	30
Western Gariep Lowland Desert	34,55	VU	CR	NP	30	30
Northern Richtersveld Scorpionstailveld	58,5	EN	EN	WP	10	10
Bushmanland Inselberg Shrubland	82,43	CR	LC	PP	30	30
Lekkersing Succulent Shrubland	80,17	CR	LC	MP	30	30
Richtersveld Sandy Coastal Scorpionstailveld	81,64	CR	LC	NP	30	30
Vyftienmyl se Berge Succulent Shrubland	86,03	CR	LC	WP	30	30
Aggeneys Gravel Vygieveld	55,06	EN	LC	WP	10	10
Bushmanland Vloere	50,07	EN	LC	PP	10	10
Central Richtersveld Mountain Shrubland	56,09	EN	LC	WP	10	10
Kosiesberg Succulent Shrubland	65,18	EN	LC	NP	10	10
Namaqualand Shale Shrubland	65,54	EN	LC	NP	10	10
Noms Mountain Desert	52,05	EN	LC	WP	10	10
Northern Richtersveld Yellow Duneveld	53,32	EN	LC	NP	10	10
Oograbies Plains Sandy Grassland	51,19	EN	LC	NP	10	10
Platbakkies Succulent Shrubland	51,7	EN	LC	NP	10	10
Richtersveld Red Duneveld	49,66	EN	LC	NP	10	10
Rooiberg Quartz Vygieveld	73,14	EN	LC	WP	10	10
Rosyntjieberg Succulent Shrubland	59,49	EN	LC	WP	10	10
Southern Nababiepsberge Mountain Desert	59,8	EN	LC	NP	10	10
Southern Richtersveld Inselberg Shrubland	58,29	EN	LC	NP	10	10
Southern Richtersveld Yellow Duneveld	67,65	EN	LC	NP	10	10
Stinkfonteinberge Eastern Apron Shrubland	60,88	EN	LC	WP	10	10
Stinkfonteinberge Quartzite Fynbos	54,29	EN	LC	WP	10	10
Western Gariep Hills Desert	66,99	EN	LC	PP	10	10
Anenous Plateau Shrubland	32,34	VU	LC	NP	5	5
Bushmanland Basin Shrubland	45,47	VU	LC	PP	5	5
Eastern Gariep Plains Desert	44,25	VU	LC	PP	5	5
Eastern Gariep Rocky Desert	36,76	VU	LC	NP	5	5
Eenriet Plains Succulent Shrubland	46,95	VU	LC	NP	5	5
Goariep Mountain Succulent Shrubland	41,46	VU	LC	WP	5	5
Kahams Mountain Desert	43,16	VU	LC	WP	5	5
Kwaggarug Mountain Desert	45,66	VU	LC	WP	5	5
Namaqualand Heuweltjieveld	42,69	VU	LC	PP	5	5
Namaqualand Strandveld	30,74	VU	LC	PP	5	5
Northern Nababiepsberge Mountain Desert	43,26	VU	LC	NP	5	5
Richtersberg Mountain Desert	30,16	VU	LC	WP	5	5
Richtersveld Sheet Wash Desert	38,94	VU	LC	WP	5	5
Southern Namaqualand Quartzite Klipkoppe Shrubland	34,78	VU	LC	PP	5	5

Vegetation Type	Percent Degraded	RLE (D1)	ETS (NBA 2025)	EPL (NBA 2025)	Starting Offset Ratio	Final Offset Ratio
Umdaus Mountains Succulent Shrubland	42,3	VU	LC	NP	5	5
Bushmanland Arid Grassland East	0,83	LC	LC	PP	2	3
Bushmanland Arid Grassland West	3,82	LC	LC	PP	2	3
Bushmanland Sandy Grassland	0,91	LC	LC	NP	2	3
Die Plate Succulent Shrubland	13,44	LC	LC	NP	2	3
Hantam Karoo	14,85	LC	LC	NP	2	3
Kamiesberg Granite Fynbos	5,17	LC	LC	NP	2	3
Kamiesberg Mountains Shrubland	8	LC	LC	NP	2	3
Lower Gariep Alluvial Vegetation	9,54	LC	LC	PP	2	3
Lower Gariep Broken Veld	4,19	LC	LC	PP	2	3
Namaqualand Blomveld	21,51	LC	LC	PP	2	3
Namaqualand Granite Renosterveld	18,21	LC	LC	NP	2	3
Namaqualand Heuweltjie Strandveld	23,6	LC	LC	PP	2	3
Namaqualand Inland Duneveld	22,35	LC	LC	PP	2	3
Namaqualand Klipkoppe Shrubland	22,48	LC	LC	PP	2	3
Namaqualand Riviere	17,76	LC	LC	PP	2	3
Namaqualand Sand Fynbos	20,8	LC	LC	PP	2	3
Western Bushmanland Klipveld	22,9	LC	LC	NP	2	3
Western Gariep Plains Desert	5,25	LC	LC	PP	2	3
Helskloof Canyon Desert	25,15	LC	LC	WP	2	2
Namaqualand Coastal Duneveld	9,88	LC	LC	MP	2	2
Northern Knersvlakte Vygieveld	1,78	LC	LC	MP	2	2
Riethuis-Wallekraal Quartz Vygieveld	10,87	LC	LC	WP	2	2
Tatasberg Mountain Succulent Shrubland	20,25	LC	LC	WP	2	2
Blouputs Karroid Thornveld	0,71	LC	LC	WP	2	0
Namaqualand Arid Grassland	2,08	LC	LC	WP	2	0

Only two ecosystems are LC on both RLE assessments, are well protected, and have >95% of their original extent intact (Blouputs Karroid Thornveld, Namaqualand Arid Grassland), suggesting that no offsets should be required for impacts in them.

3.1.5 Species

Species impacts are so fine-grained and localized, that, given the uncertainty of exact development footprints (i.e., not being site-specific), species-specific impacts can't be forecast or provide any defensible framework for effective offset type mitigation. SANBI has data and mapping for a large range of Not Protected or Poorly Protected species that could be used to site developments to avoid impacts (or to locate some offset candidate sites). A key assumption is that the CBA map (Oosthuysen & Geldenhuys 2024) and Sensitivity Mapping (Desmet 2026) identify most of these areas and habitats of SCC – this should be confirmed in project EIA level studies. A further assumption is that the applicable offset ratios and receiving areas would effectively and pragmatically cater for most impacted species, especially habitat generalists. Local expertise and taxon specialist experts continually identify new species or highly range-restricted species in the region[7]. Although the National Guideline suggests that Least Concern ecosystems may not require offsets, in this landscape most are "Not Protected" and would still need to be conserved to the national ecosystem targets (SANBI 2025a) to theoretically safeguard even 75% of their species complement. Avoidance is still the primary mitigation measure to address potential impacts on SCC, and it is highly unlikely that any offset framework could be judged adequate to conserve the full species complement of a site, without further diligent sampling at EIA stage, and augmentation of the proposals contained here.

[7] Pieter van Wyk *pers comm* October 2025.

3.1.6 Cumulative impacts

This is perhaps the most unclear impact that would result from the SEZ and RE roll out. There have been few previous developments anywhere in the country at this scale or cumulative impact studies I'm aware of that may give insight into what impacts might emerge. For these and other reasons a risk averse and proactive offsetting approach should be adopted, where:

- the ratios applied would be larger than just for an isolated, small scale development;
- greater attention is given to upfront offset design and location in the landscape;
- offset objectives and outcomes are put in place prior to impacts materialising; and
- performance and financial guarantees are provided by SEZ and/or project proponents to ensure long term attainment of offset outcomes.

3.1.7 Applicable ratios

A key issue in offset studies is often contestation between proponents, specialists and regulators around the offset calculus, especially what footprint requires offsetting (e.g., only moderately significant impacts and higher versus the full development), and what ratios should apply. This has only partially been resolved by the National Guideline (DFFE 2023), although this does not adequately cater for extensive or broad-range ecosystems that need large areas in which to function effectively to maintain species complements, or for which cryptic species or functional loss is not well captured in standard tools (such as Ecosystem Threat Status). Further the Guideline assumes a rigorous vetting of all CBA1 designated areas (Oosthuysen & Geldenhuys 2024) – which is not currently feasible to do in a province the size and with the data gaps of the Northern Cape – and assigns an explicitly punitive ratio (i.e., 30:1) to any impacts in them. This might not be defensible in this region unless more diligent and ground-truthed verification of CBAs is undertaken. Similar arguments apply to CBA2 areas. Nevertheless, until assessed otherwise by specialists with conservation agencies' concurrence, it is required that CBA1 areas are offset at this ratio (see Table 3-2).

Proposed here are defensible offset (and Ecological Compensation) ratios, developed from the National Guideline, that could be prescribed for all developments within or supplying the SEZ and GH_2 fleet regardless of the scenario finally approved for construction. Prior stipulation of these ratios avoids contestation and drawn-out EIA processes, and is a key mechanism to streamline offset assessment and quantification (see Section 3.5).

If investors or tenants in the SEZ need to align with IFC standards on Biodiversity Conservation[8] (PS 6), the SEA would do well to identify areas that would be considered 'Natural Habitat' or 'Critical Habitat' to clarify expected mitigation. This is beyond the scope of this chapter, but the implications require elaboration. Critical Habitat requires impacts to be offset to result in Net Gain (as opposed to No Net Loss for Natural Habitat). Although interpretations differ, Net Gain is difficult to conceive with many South African ecosystems or the explicit Target Based Compensation Framework for Offsets that has been adopted here. There is little opportunity or value in restoration of ecosystem structure, diversity or function in most ecosystems in ecologically and socially meaningful timelines. One way Net Gain could be interpreted is in achieving additional offset outcomes over and above what would be required in terms of the guideline – at least for those ecosystems that are still above their targets. This informs the ratios proposed in Table 3-1.

[8] Others, such as PS 7 on Indigenous Peoples, are also relevant for offset implementation but a detailed discussion is out of scope here.

Table 3-2: Biodiversity features and proposed applicable ratios for the SEZ and related RE facilities. Prior adoption of clear mitigation metrics applicable to all projects would avoid case-specific contestation and divergent approaches by different specialists and/or for different competent authorities.

Feature	Description	Proposed Ratio	Modifiers
Listed CR ecosystem	Currently natural or near-natural remaining ecosystem listed as CR under NEMBA	1:30	In this region, 'condition' is not a useful modifier except in extreme circumstances
Listed EN ecosystem	Currently natural or near-natural remaining ecosystem listed as EN under NEMBA	1:10	
Listed VU ecosystem	Currently natural or near-natural remaining ecosystem listed as VU under NEMBA	1:5	
CBA1[9]	Currently natural or near-natural remaining ecosystem identified as CBA in the N Cape CBA Map	1:15 to 1:30	The higher ratio applies unless defensible rationale for re-designation exists
CBA2	Currently natural or near-natural remaining ecosystem identified as CBA2 in the N Cape CBA Map	1:5 to 1:10	The lower ratio applies unless defensible rationale for CBA2 designation exists
ESA	Currently natural or near-natural remaining ecosystem identified as ESA in the N Cape CBA Map	1:3	Offset design/ location more NB than extent
Expert identified sensitive areas[10]	Fine scale delineation of local priority sites housing significant SCC, in good condition. Overrides VU and ESA designation and should be used as an overlay zone	1:10	Can increase if likely to be designated CBA in future
Natural vegetation ONA[11]	Remaining Natural Areas of a vegetation type regardless of protection level in the NBA	1:2	If 'poorly protected' or 'not protected' this ratio increases by 50%
Degraded	Natural area overgrazed, trampled or otherwise impacted for > 10yrs but still capable of natural rehabilitation	1:1	Required only if the site is surrounded by CBA or ESA or is a Listed Ecosystem
Mining scar/ No Natural Remaining		None required	

[9] This designation is complicated in the N Cape as areas in the province, especially in Namaqualand District, inadequately reflect local conditions and state of biodiversity. It is thus risky to require the maximum offset ratio for any impact on an area designated as CBA in the 2024 version, unless ground-truthed by experts and verified by DAERL..

[10] See Desmet 2026. Refinement of the areas, or explicit uptake in the CBA map revision, is advised.

[11] See Table 3-1for specific ratios applicable to the vegetation type impacted

3.2 REGIONAL CONSTRAINTS AND ENVIRONMENTAL OPPORTUNITIES FOR CANDIDATE OFFSET RECEIVING AREAS

Further to any required offset quantum is the question of where prospective, preferred and optimum candidate sites may be found. Given biodiversity patterns and processes in this region, it would be worth durably conserving relatively small high-value, species-rich and/or high-endemicity areas over larger species-poor, low-priority areas in the same ecosystems. Locating candidate offset sites must be informed by what biodiversity features occur where, in combinations with the push and pull of regional constraints (e.g., approved, biodiversity-incompatible land uses and rights) and opportunities (e.g., where conservation agencies are keen to expand the protected area estate); these are outlined below.

3.2.1 Constraint: Impacted areas

There are substantial mine-impacted areas along the coast, which is also threatened by new, illegal mining and large mobilised sand plumes. Further, apart from the far North (Orange River Mouth Nature Reserve) and extreme South (Namaqua National Park south of Hondeklipbaai), there are no PAs or active conservation authorities who may be able to establish, expand or manage offsets. This constrains identification of suitable coastal areas for candidate offset sites.

3.2.2 Constraint: Existing Mineral & Exploration Rights

Unfortunately, the long-awaited mining cadastre[12] has still not been implemented, and it is impossible to get accurate spatial data on the extent of real Mining, Prospecting and Petroleum Exploration Rights. A layer was created by SAHRA (circulated by CSIR) of all known development rights, applications and current studies which is the only data to help avoid unnecessary land use conflicts between offset area establishment and existing rights (Figure 3.3). Many rights are purely speculative. Where possible all Offset receiving areas proposed avoid these rights.

3.2.3 Constraint: RE Developments Approved or Applied For.

Unlike mining and petroleum, an accessible, relatively up to date spatial database of renewable energy applications and approved projects is maintained by the DFFE. Although there are errors, and the authorised footprints are not captured (which is something to be addressed for future planning), it does provide some intelligence around which to build spatial design into an offset framework. However, complicating issues are the fact that: (1) too few of these RE projects were approved with sufficient offset mitigation, (2) where mitigation requirements were incurred the context has changed, and (3) it is unclear which of these projects can or will still be built. This can play out in a manner that further constrains this framework or provides a strategic opportunity, depending on the regulator's and SEZ proponent's appetite to proactively address the likely offsets imperative. An ad hoc and opportunistic RE build is likely to result in ongoing biodiversity loss in this region. Little spatial information is available for other large scale regional infrastructure developments (e.g., a proposed dam at Vioolsdrif, grid infrastructure expansion). The locations of known rights or applications are shown in Figure 3.3 (courtesy SAHRA and CSIR).

[12] An easily and publicly accessible, spatially explicit database of mining and related rights and applications

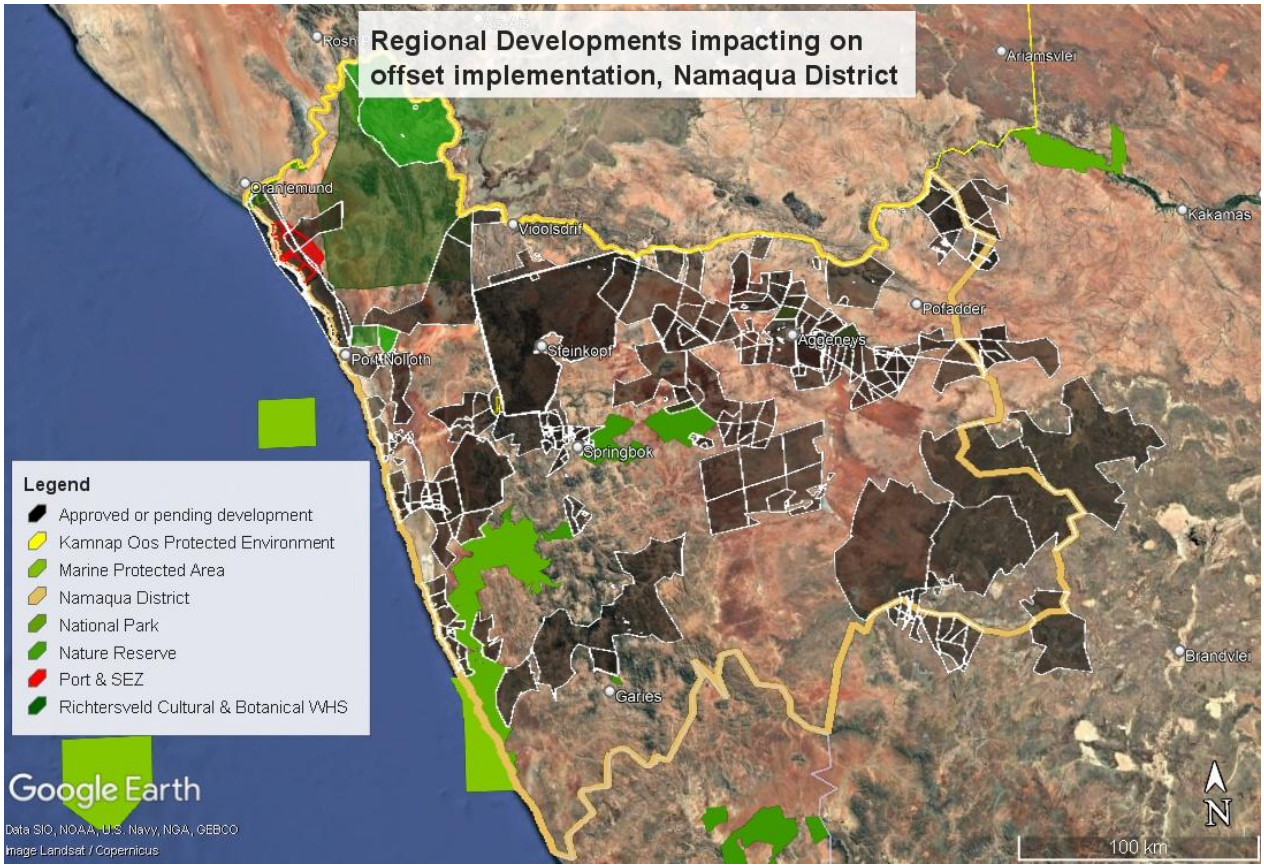

Figure 3.3: Approved, pending or exploratory studies for enhanced development rights in the WP2 study area. Note that the rights attach to or are coded by entire cadastres, which inaccurately portrays the scale of proposed development in this region with massive farm portions. A recommendation for future databases is to more accurately capture approved footprints to aid planning, compliance monitoring and enforcement and assess offset sufficiency.

3.2.4 Opportunity: Priority areas for biodiversity and PA expansion

The National PA Expansion Strategy[13] was approved by Cabinet in 2020 for implementation. Building on this is Vision 2040 (SANParks 2024), an approach to conserving living landscapes. It seems imperative to avoid unnecessary developments in these areas and set aside parts of the landscapes as cornerstones of this vision. In this region, the priority focus areas are land hungry (see Desmet 2026 for an explanation) and would stretch even an ambitious and exceedingly well-funded suite of conservation agencies to implement. The NPAES priority focus areas and Vision 2040 are key design informants of the offset receiving areas and the proposed proactive offset schemes.

It is difficult to compare offset implications from any GH2 scenario with the No-Go option of Business-as-Usual. The current offset liabilities required by all three competent authorities in the region are poorly known. The National Offsets Register (SANBI 2025b) lists only two from the district although many more are known. There is no mechanism for offset planning, and no means of aligning Competent Authorities' Offset approvals or guidance without an EMF or SEMP that a SEA would bring. To my knowledge, no other regulatory tool or decision support structure exists to achieve this.

[13] The PA expansion priority focus areas identified in the NPAES represent the best locales in which to pursue PA expansion generally, and should not be viewed as some form of proto-PA.

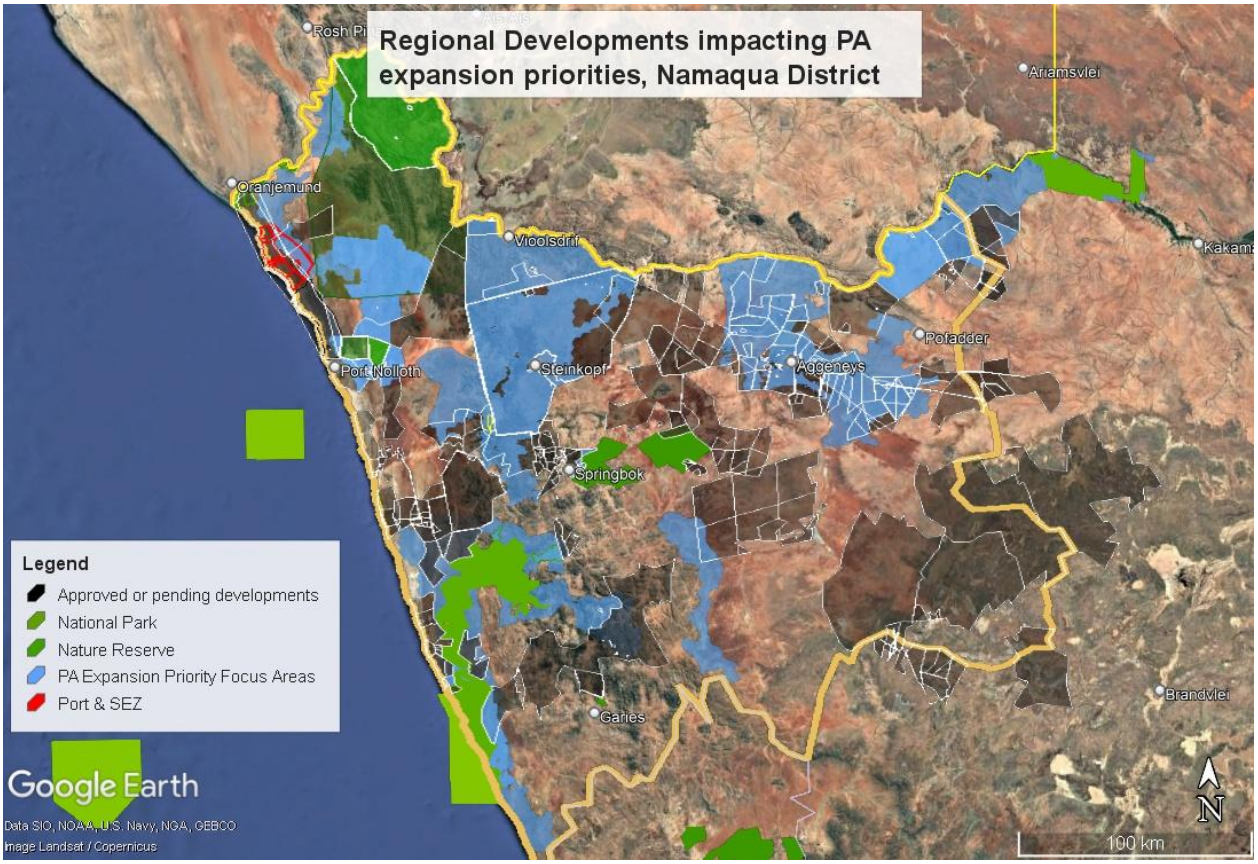

Figure 3.4: The protected areas and PA expansion priority focus areas (2018) in Namaqualand overlaid with approved or pending development applications. White outlines over the blue PA Expansion Priority Focus Areas indicate overlap or potential conflicting landuses.

3.3 OFFSET IMPLEMENTATION OPTIONS AND CRITERIA

3.3.1 Indicative Offset Size

To deliberate on whether sufficient offset candidate area exists (and make the likely total offset liability explicit for the Sc2 Big Green Hydrogen scenario), assumptions were made as to the percentage fixed[14] (80%) and flexible[15] infrastructure (20%) likely to trigger offsets. This is hard to predict with any precision, but is useful as a heuristic exercise, and essential to arriving at indicative offset sizes.

Using these assumptions and the proposed basic ratios (average of 2:1 for the areas impacted by PV and WEF (i.e. 20% of 128 000 ha) and 10:1 for the impacts of fixed infrastructure (i.e. 80% of 16 000 ha) unavoidably impacting on priority features) yields a combined Sc2 offset requirement of ~**180 000 ha** of land that needs to be secured. This is equivalent to creating new offset protected areas the size of Richtersveld and Namaqua National Parks combined. No offset on this scale has been attempted in South Africa.

[14] The SEZ, Electrolyser, storage, road, substations and related infrastructure occupy 16000 ha (Annexure B.)

[15] The WEF, PV and Grid connections cover 128 000 ha for the Big GH_2 Scenario. (Annexure B)

3.3.2 Offset receiving areas

A previous study (Botha & Desmet 2022) identified the optimum places to locate terrestrial offsets as being in the two already published and approved National Park Expansion Zones. It also proposed a new protected area expansion corridor from Richtersveld National Park (Klein Duin section) to Harras mountains along the R382 towards Steinkopf. Further areas in which to locate offset receiving sites for the SEZ are elaborated on in WP1 (Botha 2026), summarised in Table 3-3.

Guidance from the SEZ site-based framework (WP1) noted that to offset the Port and Sc1 impacts in the SEZ to achieve requisite outcomes for Listed Ecosystems requires that both restoration and protection efforts are needed as ecological compensation to satisfy offset principles and to reach biodiversity targets. It is unclear if this approach would be needed for regional impacts, but there appears to be enough low-sensitivity land available to avoid impacting ecosystems classified as CR, EN or VU in the first place.

For WP1 and the SEZ, fine scale delineation of offset receiving areas acknowledged local community priority sites combined with expert mapping. This has not been possible at the scale of WP2.

For WP1 (see Figures 4-6 and 4-8 in Botha 2026), the protection and restoration efforts are best focused on:

1- expanding the existing Orange River Mouth Nature Reserve to join the disparate sections along the lower Orange River around Grootderm and to create and rehabilitate buffers around the most sensitive features (such as the Namib Lichen Fields). Arresting the mobilised sand is of primary importance. (this could reach **19 000 ha**)

2- Establishing a new PA along the Holgat river from Daberas to the coast, potentially as a contractual extension of the Richtersveld National Park (up to **7 400 ha**). In theory, this could be linked up to the existing Oograbies Wes/Klein Duin section through the inland portion of Farm 1 as per the existing SANParks Land Inclusion Plan (although it creates an unwieldy PA with low tourism potential and high management costs)

3- Securing and managing future impacts on the larger expert identified priority areas of Visagiesfontein, Swartbank, Rooibank, and the unique Whistling Rat colony. Alignment between experts and conservation authorities is required to agree on the rationale and specifics of this priority, but at least **20 000 ha** could be available for offsets.

4- Around 560 ha of expert identified priority areas found around Namakwakop, Boegoeberge, and the other smaller priority sensitive areas around the Port should be set aside[16].

For WP2, offset receiving zones (i.e. where most suitable offset candidates are likely to be found) were delineated based on i) where existing Parks or Reserves are expanding or could feasibly be expanded; ii) where priority sites (CBA1 in Desmet 2026) persist; and iii) representing those vegetation types likely to receive the bulk of the RE roll out. These are also set out in Table 3-3 and Figure 3.5, and could also form the foundations of creating large landscapes aligned to Vision 2040 (see Desmet 2026).

Large offset receiving areas are proposed in the Koa Valley – Stofbakkies – Kliprand corridor (area 1, Figure 3.5). This large corridor would secure several CBA1 patches while anchoring a future landscape corridor to the W Cape border and Kamiesberg Park Expansion Zone. This would cater for impacts across most of the Bushmanland Basin vegetation types and several of the most species rich Namaqualand types. Whether these areas need to be so large or could ever be managed as formal PAs is questionable, even with offset funding in place. Some other effective conservation measure, effective at a landscape scale at reducing biodiversity loss and catering for ecosystem processes and species movement, may be required. This receiving area could also cater for the intended expansion of the Vaalputs Radioactive Waste Storage Facility 15 km away.

[16] These could effectively count as set asides towards offset liabilities if they are actively protected and the surrounding buffers restored (van Wyk 2024) but are not viewed as offset sites *sensu strictu.*

Where prudent and supported by the SANParks Regional Manager and environmental management staff, several Park Expansion Zones are identified as offset receiving areas: Augrabies – Pella (area 2), Kleinduin section-Richtersveld (area 3); and Namaqua Park (area 4 in Figure 3.5). A subset of the Vioolsdrif-Steinkopf NPAES Focus Area is also proposed as an offset receiving site (area 5), although the ability of SANParks to take on its management was queried[17].

A large-scale consolidation of priority areas between Goegap and Kangnas Nature Reserves (area 6) would also seem prudent and offers flexibility in management authority options. Expanding the Gamsberg Nature Reserve (itself an offset site) to encompass the priority inselberg habitats surrounding the two sections (area 7) would also safeguard most of the priority sites in that bioregion.

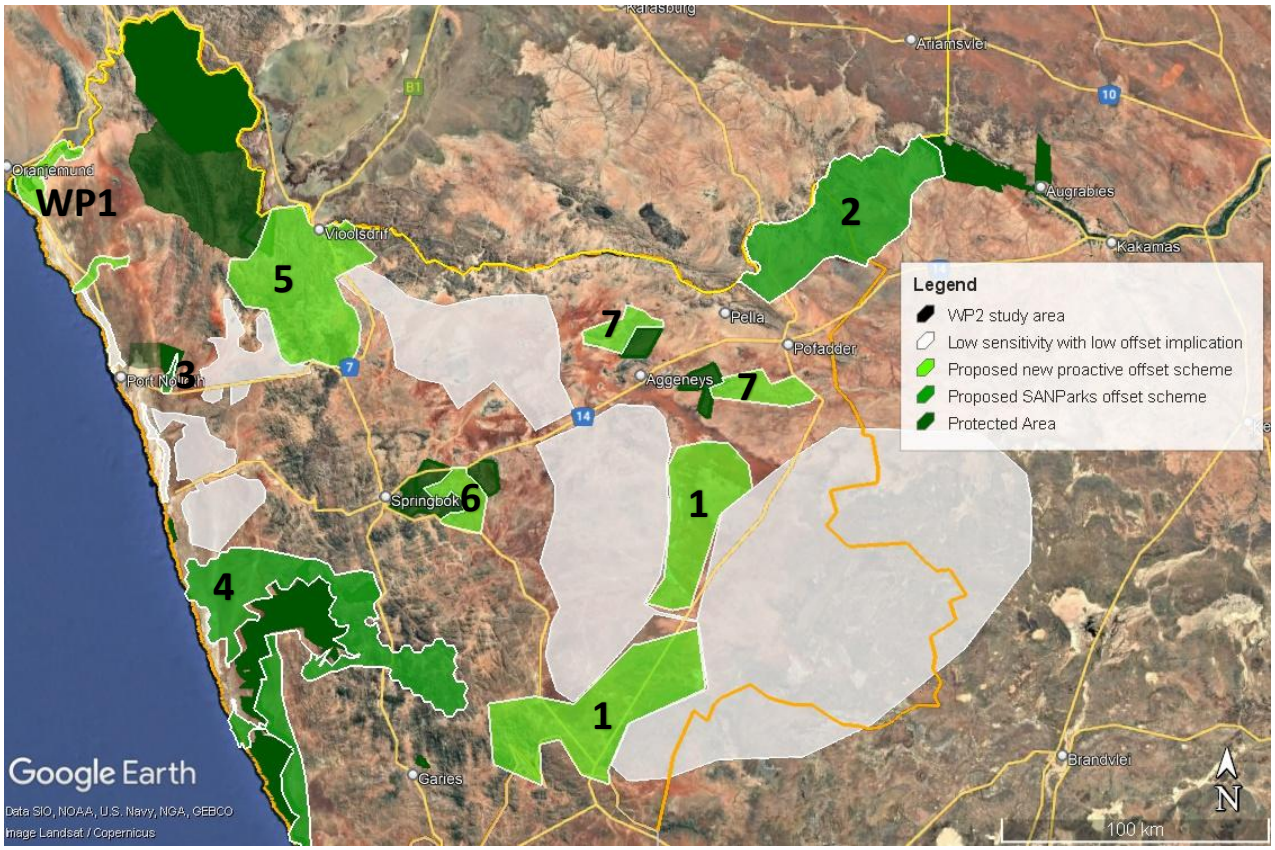

Figure 3.5: Proposed Proactive Offset Scheme receiving areas around existing PAs. Constraints imposed by already approved developments will complicate offset implementation. Areas of low sensitivity and therefor low offset implication are shown in white. The need to avoid land use conflict wherever possible indicates joint planning for and adherence to a regional plan. Note boundaries are approximate, not resolved in the East, and need fine scale delineation. Mine damaged coastal land suitable for wind energy not visible at this scale.

Although some receiving areas have some form of legal status (the Park Expansion Zones), others need to be confirmed and refined by broader specialist consultation, community engagement, and conservation authority input[18]. The initial identification in this report is necessarily broad and illustrative and avoids identifying specific property parcels prematurely, which could unnecessarily hinder implementation. A subsequent planning process or EMF (or provincial Spatial Plan for implementing the GH_2 pathway) could deepen the engagement around these proposed offset zones, codify them, and build implementation

[17] Discussions are underway to transfer the Richtersveld WHS core area and potentially Nababiep Nature Reserve to SANParks for management, but it's unclear if this would extend further East in Farm 22.

[18] Although input was solicited from SEA specialists, time constraints prevented thorough consultation. Only preliminary input was obtained from DAERL and SANParks. Detailed consultation, landowner engagement and agreements are required prior to formalising these areas in a policy document.

modalities (through landowner agreements etc.) that is beyond the scope of the SEA. It should, however, accompany any SEZ implementation plan developed.

There are unfortunately still certain vegetation types that would not be well covered by these proposed receiving areas. Namaqualand Strandveld (VU *sensu* Desmet 2026) and Richtersveld Duneveld (CR sensu SANBI 2025a) types are poorly represented. This may not be an issue if the coastal WEF are predominantly located on mine scars and the proposed WP1 Offset and Namaqua National Park northern receiving areas are effectively protected and rehabilitation initiated prior to SEZ build out. Using the basic assumptions in Section 3.3.1, offsetting the small GH_2 scenario still might entail as much as **40 000 ha** of offsets. This would require two thirds of all the local offset receiving areas identified in WP1 to be secured.

Table 3-3: Potential offset receiving areas for developments at Boegoebergbaai, the SEZ and associated regional renewable energy projects. *Note that only local features are likely to be suitable for Port & SEZ linked offsets. **Regional features could provide offsets for SC2 big GH2 impacts. Although sufficient area might seem available, not all the impacted ecosystems are protected by these receiving areas..

WP1 Local Feature/Priority*	Area (ha)		WP2 Regional Feature**	Area (ha)
Pagvlei-Grootderm-Brandkaros	19 600		1. Kliprand - Stofbakkies – Koa Valley	200 000
Rooibank heuweltjies	14 000		2. NPAES focus area Augrabies - Pella	195 000
Swartbank heuweltjies	3 500		3. NPAES focus area Vyftienmylseberg Kleinduin/ Richtersveld NP	3 600
Farm 1 (natural portion) NW of Kleinduin Section Richtersveld NP	10 000		4. NPAES surrounding Namaqua NP	300 000
Visagiefontein & Kop	3 300		5. NPAES Vioolsdrif-Steinkopf-	200 000
Holgat river & catchment	7 400		6. Goegap Reserve - Kangnas consolidation	28 000
			7. Gamsberg Reserve extension	54 000
Total	**≈ 60 000**		**Total**	**≈ 990 000**

Mitigation trade-offs between biodiversity features are an unfortunate reality. Some development sites with low ecosystem offset liabilities will impact avifauna more than plants (see for example Figure 3.6), and others will impact invertebrates or reptiles more than birds. Similarly, some offset receiving areas are likely to serve some biodiversity features better than others. This is unavoidable and can only be addressed by comprehensive offset and protected area expansion in the region, covering diverse landscapes and biophysical features, key gradients, and known hotspots.

It is risky at this scale of analysis to provide detailed guidance on trade-offs. DFFE has previously indicated to the South African Wind Energy Association that decisions on approving impacts and mitigation measures on irreplaceable features (e.g. CBA 1) that would involve trade-offs are made on a case-by-case basis. Trade-offs demand careful, systematic and transparent evaluation of the potential consequences in undermining the country's biodiversity targets as well as the resilience of sensitive features or ecosystems services to further loss. The purpose of trade-off rules is to safeguard nature, not facilitate loss or impact leakage. The burden of justification always falls on proponents of trade-offs, and should attract independent review and public scrutiny.

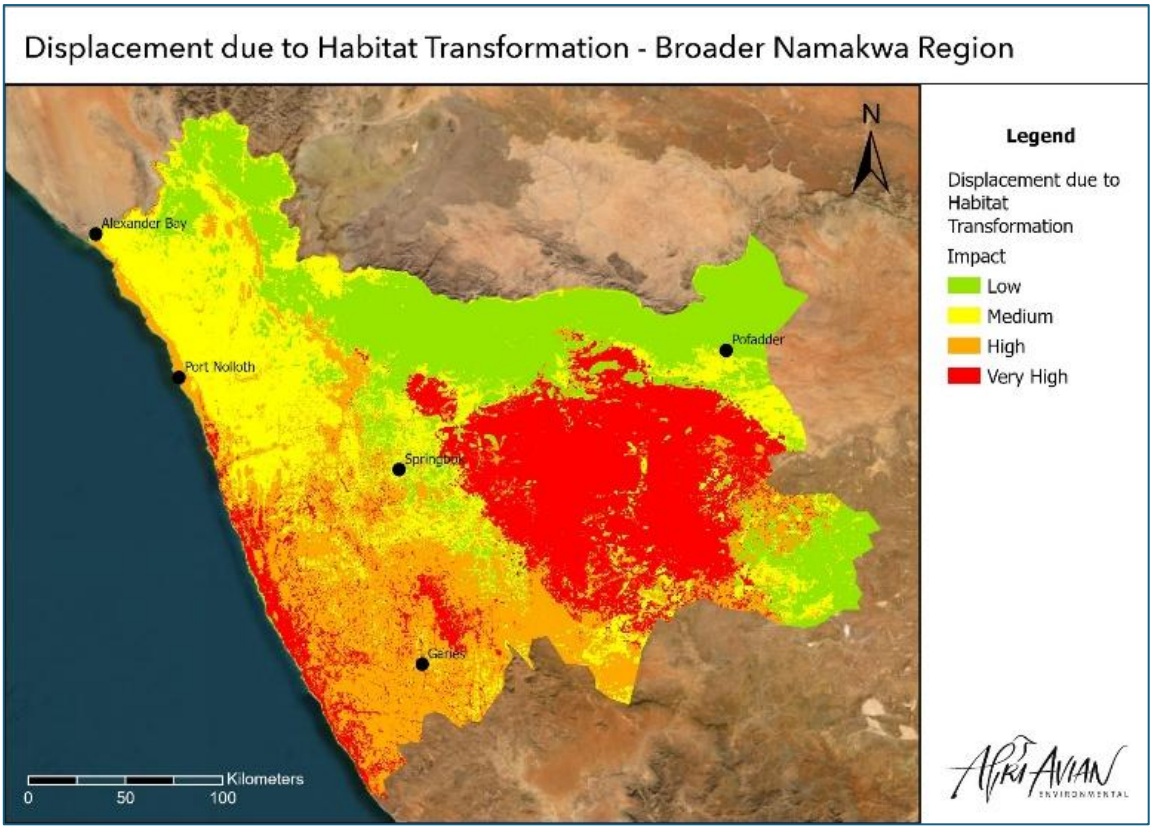

Figure 3.6: Map of bird species displacement due to habitat loss. An example of a mitigation trade-off between biodiversity features. Areas of greatest sensitivity for bird impact through habitat loss (Bushmanland basin shrubland) are those of low importance for plant species and other taxa. Siting PV facilities here would incur little offset liability but could cause significant bird habitat loss. Figure from Kellerman et al (AfriAvian) 2026 – this volume.

3.3.3 Proactive offset scheme options

The SANParks' pilot proactive offset scheme (UNDP 2025) around their Parks is a useful model on which to build. This model allows clarity on offset outcomes for regulators, I&APs and investors, and provides clear cost implications for budgeting, planning and compliance by proponents. While the basic mechanics of the pilot proactive scheme have been resolved, it would need additional capacity (in terms of scheme administration and on-ground park management and restoration) in SANParks for effective scaling. Long term implementation/collaboration agreements between SANParks and the SEZ proponents would be needed to ensure the suitable staff are recruited (especially for landowner engagement, financial administration, and conservation operations management). This would allow additional properties to be contracted in or purchased, effective rehabilitation and park management, administration of the capital and management fees, and auditing of and reporting on the scheme.

While proactive schemes may seem expensive and cumbersome upfront, experience indicates that they are a way to guarantee outcomes for biodiversity, landowners and the public. Piecemeal offset development and implementation have proven expensive, complex, and time-consuming in Northern Cape landscapes, even where land transactions are relatively straightforward (WFA 2018, M Botha *pers obs*). In the WP2 region the likelihood of competition for offset land, conflicts with other land uses, and possible rent-seeking behaviour due to information asymmetry and power dynamics is high.

3.4 ECOLOGICAL COMPENSATION FOR NON-OFFSETABLE IMPACTS

Some impacts, especially on SCC or range-restricted habitats and vegetation types are not readily offsetable. A key assumption is that, at least for WP2, there are sufficient low-sensitivity areas to not trigger highly significant vegetation or CBA impacts that would demand Ecological Compensation under the Guideline. However, **IF** any such impacts were approved based on overwhelming national economic importance[19], then Ecological Compensation mitigation is required. This would likely be for those biodiversity features that are not catered for by large scale ecosystem offsets, being very localised, habitat-specific fauna and flora that for some unknown reason can't be avoided, or avifauna specifically impacted by renewable energy and associated infrastructure of a GH_2 roll out.

The Avifauna report (Kellerman et al 2026) recommended region-wide implementation of various conservation actions, including retrofitting of existing infrastructure to reduce bird mortality[20]. Establishing or capitalising existing Conservation Trust Funds to support effective ecological compensation for some avifauna impacts could be considered appropriate, provided the interventions met the following criteria. A sound, high-integrity ecological compensation activity is one:

- Built on explicit (usually species-specific) interventions to reach targets that contribute to enhanced survival and population recovery,
- Coupled with a clear implementation plan with responsibilities and compliance monitoring incorporated,
- That is clearly additional and doesn't displace existing budgets or activities, and
- With contingency planning, alternative strategies, adaptive management, and performance guarantees in case planned interventions don't work.

International reviews have also set out general criteria for robust offset-type mitigation measures that would apply to ecological compensation in the SA context (Pope *et al* 2021; Penca 2024).

In summary, specific proposals from this SEA for ecological compensation for unavoidable but technically unoffsettable include:

1- additional proactive expansion of regional protected areas to achieve other biodiversity targets especially for threatened ecosystems (and their nearest analogues) and aggregations of species of conservation concern (including in the Proactive Offset Schemes),

2- endowing sustainable funding mechanisms to secure long term (>99 years) conservation management of the offset areas (and potentially also the expanded PAs) – provided these come with commitments to maintain existing budgets from statutory conservation authorities that may be managing the schemes,

3- upgrading/retrofitting existing RE facilities and powerlines to reduce bird species impact by:

   a. reconductoring the existing grid and bunching new lines for visibility;

   b. staggering adjacent transmission line pylons across the spans to improve bird collision avoidance;

[19] This would be a difficult argument to make due to other, overwhelmingly more suitable, less damaging, and more readily mitigated GH2 sites exist elsewhere or are already under-development.

[20] Measures addressing direct species mortality could be viewed as offsets, as is done elsewhere in the world. In this instance, Ecological Compensation may be a more accurate term, as the measures are broadly targeted and indirect (numerous species benefit, and it's not certain that CR species will be saved) and the fact that some of the impacted spp. are listed as EN and CR, and that the additional grid and WEF may well drive their populations down further, implying offsets are not appropriate

c. retrospective installation of line flappers and other avoidance technologies, especially on sections of line with known high mortalities;

d. blade painting/patterning of existing WEF or those that have just reached financial close and were approved without such mitigation; and

e. installing at least single axis tracking for existing PVs to reduce "mirage and lake effects" (as well as dust deposition).

However, ecological compensation is difficult to quantify and administer and creates serious challenges around assigning liability, moral hazard, performance auditing, and compliance monitoring and enforcement. The region is one of the centres of RE development due to the solar and wind resources, even without the SEZ. Approved facilities (≈ 13GW in the district, 76GW in the N Cape province as of February 2025 DFFE) are likely a fraction of what is currently being investigated for development by proponents. All new facilities should be required to install the mitigation noted in the Avifauna Chapter. Approved RE facilities may well have permits lapse prior to commencement and re-permitting may trigger additional mitigation due to the updated regulatory regime and evolving standards. These factors complicate judgements of what infrastructure could be retrofitted and indicate that the ecological compensation opportunities for the SEZ-linked RE facilities are relatively low and/or are very complex.

3.5 RECOMMENDED STREAMLINING OF BIODIVERSITY OFFSETS

Compliance with the mitigation hierarchy is imperative, which demands "Avoidance" (alternative sites are exhaustively explored), "Minimisation"[21] (alternative technologies and other mitigation measures) and even "Rehabilitation" be attempted before offsetting can be considered. How to ensure any "streamlined offsets" process in any regulatory tool is not used to short cut the mitigation hierarchy, and then to incorporate this imperative in the SEA guidance framework, is not clear. Specific guidance is provided below (see Section 3.5.2) to ensure that regional developments cater for biodiversity as far as possible, and don't rely on offsets alone for mitigation. These build on the guidance from Desmet (2026).

3.5.1 Clarify offset requirements and metrics/exchange rules upfront

The SEA should inform the broader planning framework for the Green Hydrogen pathway through an established environmental management instrument like an EMF. From an offset perspective, an EMF could avoid typical project level challenges (assessment disagreements, difficulty securing candidate sites in tight timeframes, and concluding funding and implementation agreements prior to issuance of an environmental authorisation). Clear rules, exchange metrics and implementation modalities (such as required participation in a dedicated proactive offset scheme) would clarify for investors and proponents upfront the imperative and realistic costs of biodiversity mitigation. An overarching offsets instrument would also ensure equity (all applications/projects would be treated similarly), ensure avoidance of highly significant impacts, and reduce land use conflict. It would also give conservation agencies clarity on impending impacts and where to best invest their capacity and resources – including to plan and execute any proactive schemes.

Perhaps most importantly, upfront clarification of what impacts are unacceptable and thus not offsetable and, for the rest, where offset implementation would emerge would allow a unitary negotiation process with the different landowning communities. This would provide all members with insight into what long term land use constraints and opportunities would apply, what compensation would be available for this, and what role they could play in offset scheme (and the broader biodiversity economy) implementation in the region. A piecemeal approach to this engagement by multiple different actors of project-level EIAs is likely to cause confusion, unmet expectations, and competition. This is almost certain to have poor outcomes for biodiversity.

[21] The are very limited opportunities for rehabilitation of impacts in this environment that would deliver substantial biodiversity returns.

3.5.2 Focus on securing large landscape conservation outcomes

All told, the priority for candidate offset receiving areas may meet the spatial targets but may not quite capture all the SCC and the local ecological processes that need to be maintained for long term biodiversity persistence. Additional smaller sites for SCC or important features may need to be secured and managed as isolated PAs to ensure no unacceptable loss and meet performance standards for "critical habitat". Planning for large landscape scale outcomes (and the wider contribution of the biodiversity economy) may also require focusing on a "sense of place" and "wilderness" that are not adequately covered by blunt offset metrics.

Specific opportunities exist to demand that any infrastructure element of either a small or big GH_2 scenario conform to design parameters to support nature's persistence. For instance, all PV structures should be pole mounted and not built on cleared ground. This allows continued species movement, seed dispersal, grazing, and ecological functioning. Linear infrastructure (roads and railways, gas pipelines) must include multiple and regular areas of overpass or underpass at a scale that would ensure animals can move relatively freely (and reduce collision mortality or migration disruption).

Although it is not possible to be exhaustive at an SEA level, to reduce the main impacts and risks to biodiversity, it could be stipulated that any PV facility wishing to conclude a power purchase agreement with the SEZ and green hydrogen fleet must be constructed without clearing ground. And all engineering and design specifications for linear infrastructure include stipulations for minimising biodiversity impact in the earliest stages.

3.5.3 Proactive schemes around National Parks (and provincial reserves)

To what extent the cumulative, indirect or induced impacts from the entire GH_2 fleet and SEZ could be linked to any particular project is unclear. This complicates assigning offset liability and reinforces the suggestion that the SEZ proponents should proactively mitigate impacts on behalf of future tenants. SEZ support for an investment in proactive offset schemes would be imperative to streamline implementation, avoid land use conflicts and manage the threat from illicit and poorly regulated mining to offset sites, ecological corridors and the persistence of unique features. The SANParks' pilot proactive offset scheme (UNDP 2025) around their Parks would appear to be a useful model on which to build. This allows clarity on offset outcomes and cost implications for budgeting, planning and compliance purposes.

3.5.4 Recommendations for project-level offset studies

- Focus on demonstrating adherence to the mitigation hierarchy (and avoidance of non-offsetable impacts as a priority),

- Require a precautionary approach, that even if a site contains ONA, it should still attract a basic offset ratio unless: i) there is demonstrable evidence that no SCC occur on the site; ii) the site does not play an important ecological function role; and iii) the site would not be considered as 'Natural Habitat' in terms of Performance Standard 6 of the IFC [i.e. despite some degradation, it still largely contains the principal characteristics and functions of a native ecosystem].

- Explicit reference to SANBI data and mapping for Not Protected or Poorly Protected species must be made, and DAERL (2024) mapping AND the SEA Sensitivity Mapping (Desmet 2026) should be used as a departure point for updating in all cases and checked by specialists in the EIA process, together with diligent baseline surveys.

- Proactive engagement at pre-application stage with conservation authorities, landowners, and communities potentially depending on candidate offset sites is imperative. This cannot wait until late in Scoping or start of Assessment phase.

- Use the proactive offset focus areas as a departure point for all candidate offset site selection and assessment.

- Use of the set of standard offset ratios presented here for any SEZ aligned development, with any deviation requiring a substantial burden of proof and broad consultation

- Performance and financial guarantees should be required as standard to ensure achievement of objectives and outcomes specified upfront in the EIA process.

- Require no clearing of land for PV structures, unless a well-argued case, that has been independently reviewed by experts, can be made.

- Require provision of regular, sufficiently wide wildlife crossing structures on linear infrastructure (new fenced, tarred roads, railway lines), as a standard mitigation measure.

- SEZ proponents investigate establishment of proactive offset schemes to streamline implementation, avoid land use conflicts and manage several threats, and EIA studies confirm the participation liability of each project.

3.6 CONCLUSION

The likely scale and significance of impacts by the Boegoebergbaai port, GH_2 infrastructure and regional RE fleet on several threatened, rare or otherwise conservation-worthy biodiversity features on land, some of which are likely to be strictly "not offsetable", imply that substantial regulatory and political attention is required to safeguard biodiversity. Sufficient low sensitivity areas are available in the region, and a pragmatic offset framework with proposed ratios for various features is provided. Several proposed offset schemes adjoining existing protected areas that do not significantly impact existing rights holders could be established in consultation with landowners. However, this implementation would best be done proactively by SEZ proponents on behalf of tenants and prior to the complex and unpredictable outcomes of project-level EIAs. A clear commitment from development proponents and upfront resourcing and land access agreements are needed. Such schemes could also put in place the foundations for larger nature-based visions for sustainable development in the region.

Several features (Listed CR vegetation types and Species of Conservation Concern) may be impacted beyond acceptable thresholds where offsets are not suitable. Appropriate mitigation is better framed as Ecological Compensation and although initial suggestions are given, this approach is always undesirable compared to more rigorous avoidance and minimisation in the first place. Proactively addressing offset and compensation commitments clarifies upfront to investors, clients and product markets that the biodiversity imperatives are being safeguarded and are not collateral damage in the pursuit of an energy transition.

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3.8 ANNEXURES

A. BRIEF

"*Work Package 2:*

Scope summary:

… The primary objective of the Biodiversity Offsets Framework chapter for the regional-scale development scope is to outline the required offsets, where required, for mitigating the biodiversity impacts of development proposals linked to the Northern Cape green hydrogen economy and identify opportunities for proactive biodiversity offset planning in the region. The chapter will also provide recommendations or guidelines to streamline the process in offset assessment, design, and approval at the subsequent project level.

Role:

- *Liaison with Work Package 2 Author on "Regional Ecology, Biodiversity and Conservation Planning", with possible specific or high-level input as required.*
- *Review of the Work Package 2 report chapter on "Regional Ecology, Biodiversity and Conservation Planning".*

Specific tasks:

1. *Plan of Study*
    - *Outline the approach, data requirements, assumptions, limitations and timeframe of tasks.*
    - *Provide report / chapter framework.*
2. *Description of the receiving environment:*
    - *Describe the land use dynamics and change trends of the receiving environment and broader region as it relates to your topic. This will feed into the dynamic baseline scenario (Sc0) – "how is the social-ecological system changing even if a GH2 economy does not realise?".*
    - *Describe the key characteristics of the receiving environment as it pertains to your area of expertise – "what, where, why is it important?"*
    - *Spatially explicit as far as possible.*
3. *Sensitivity analysis:*
    - *Outline the spatial extent of biodiversity features that would trigger offsets*
        i. *Spatial layers distinguishing relative sensitivity or offset categories of the receiving environment (Low = Biodiversity offsetting not required, Medium/High = Biodiversity offset required, Very High = Biodiversity offset not possible).*
4. *Aspects and impacts register*
    - *Potential impacts (negative and positive) on biodiversity that may arise from the planned activities and infrastructure, based on a project description provided by CSIR.*
    - *Identify key biodiversity features at risk, where applicable, and prioritise them for offset planning.*
    - *Consider cumulative impacts in the region, across three scenarios using a risk framework methodology that will be provided by CSIR.*
        i. *Scenarios will include Sc0 = dynamic baseline considering inevitable dynamics and trends (e.g. climate, land use, societal); Sc1 = "small H2"(1mtpa); Sc2 = "big H2" (7 mtpa). Sc1 and Sc2 will be elaborated and provided by CSIR based on the project description.*

5. *Offset requirements definition and selection of offset receiving areas*
    - *Define the specific biodiversity offset requirements necessary to mitigate identified impacts.*
    - *Develop criteria or mechanisms for determining and implementing appropriate offsets.*
    - *Identify potential offset receiving areas within the regional study area that can compensate for biodiversity losses.*
6. *Recommended strategic management actions*
    - *Develop practical recommendations or guidelines for future EIA studies, design and approval of biodiversity offsets at the project level.*
    - *Practical recommendations to inform and align with national policy and regional planning.*
    - *Recommend strategies for integrating offsets into broader land-use planning and conservation initiatives. "*

B. FOOTPRINT PROJECTIONS FOR SMALL AND BIG GREEN HYDROGEN SCENARIOS

Table 3-4: Impact quantifications for small and big Green Hydrogen scenarios. (as at Sept 2024). Note, this is probably a minimum footprint and excludes indirect and induced impacts. For instance, a 600km pipeline to Saldanha with a 20m servitude would impact at least 1200 ha (not 600). Prieska is another 600km.

	Aspect	Unit	Sc1: Small GH_2	Sc2: Big GH_2	*Assumptions*
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	15 ha per 1 GW
	GH2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mpta GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mpta)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	57	454	1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28	227	0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mpta)
	Desalination output volume	Ml/day	36	286	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 operational.
	Desalination footprint	ha	7	57	5 Ml/day output needs 1 ha
	Desalination discharge	Ml/day	48	387	Ratio of desalinated water to brine discharge water to be 42.5:57.5. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine).
	Pipeline intake volume	Ml/day	84	672	Output + discharge
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	*GW*	*6*	*48*	60 % solar : 40 % wind
	RE footprint - solar	*ha*	*12 000*	*96 000*	0,5MW/ha
	RE extent - solar		*12 000*	*96 000*	Footprint = extent
	RE facilities - solar	*no of facilities*	*6*	*48*	Clusters of 1 GW facilities
	RE capacity - wind	*GW*	*4*	*32*	60 % solar : 40 % wind
	RE footprint - wind	*ha*	*4 000*	*32 000*	1 MW/ha
	RE extent - wind	*ha*	*40 000*	*320 000*	0,1 MW/ha
	RE facilities - wind	*no of facilities*	*3*	*21*	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 600	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	600	20 m servitude
	Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.
	Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)
	Main infrastructure components footprint	**ha**	**21 082**	**142 240**	

Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; Ml/day = million litres per day; km = kilometre

C. ACRONYMS

a.m.s.l	Above mean sea level
CBA	Critical Biodiversity Area
CPA	Community Property Association
CR	Critically Endangered – a Red List category for ecosystems or species
DAERL	Department of Agriculture, Environment, Rural Development & Land Reform – N Cape.
DEDAT	Department of Economic Development and Tourism – parent department of NCEDA
DFFE	Department Forestry, Fisheries and the Environment. (Previously DEA)
DMRE	Department of Mineral Resources and Energy
DTSL	Department Transport, Safety and Liaison – N Cape
EGI	Electricity Grid Infrastructure
EIA	Environmental Impact Assessment
EN	Endangered - a Red List category for ecosystems or species
ESA	Ecological Support Area
ESBA	Ecological or Biologically Significant Area (in the ocean or coastal region)
GH2	Green Hydrogen – being H_2 produced and transported with renewable energy
LUMS	Land Use Management System
NBA	National Biodiversity Assessment (produced by SANBI every 5 yrs. Next due end 2025)
NCEDA	Northern Cape Economic Development and Investment Promotion Agency
NPAES	National Protected Area Expansion Strategy
NEMA	National Environmental Management Act (Act 101 of 1998) as amended
NEMBA	National Environmental Management Biodiversity Act (Act 10 of 2004)
NEMPA	National Environmental Management Protected Areas Act (Act 57 of 2003)
PA	Protected Area
PBO	Public Benefit Organisation
PFA	Priority Focus Area (of the National Protected Area Expansion Strategy)
PV	Photovoltaic
RE	Renewable Energy
REDZ	Renewable Energy Development Zone
REIPPP	Renewable Energy Independent Power Producer Programme
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SDF	Spatial Development Framework
SEZ	Special Economic Zone
VVVT	Vrywillige Voor Verligte Toestemming (Afrikaans for Free Prior Informed Consent)
WEF	Wind Energy Facility

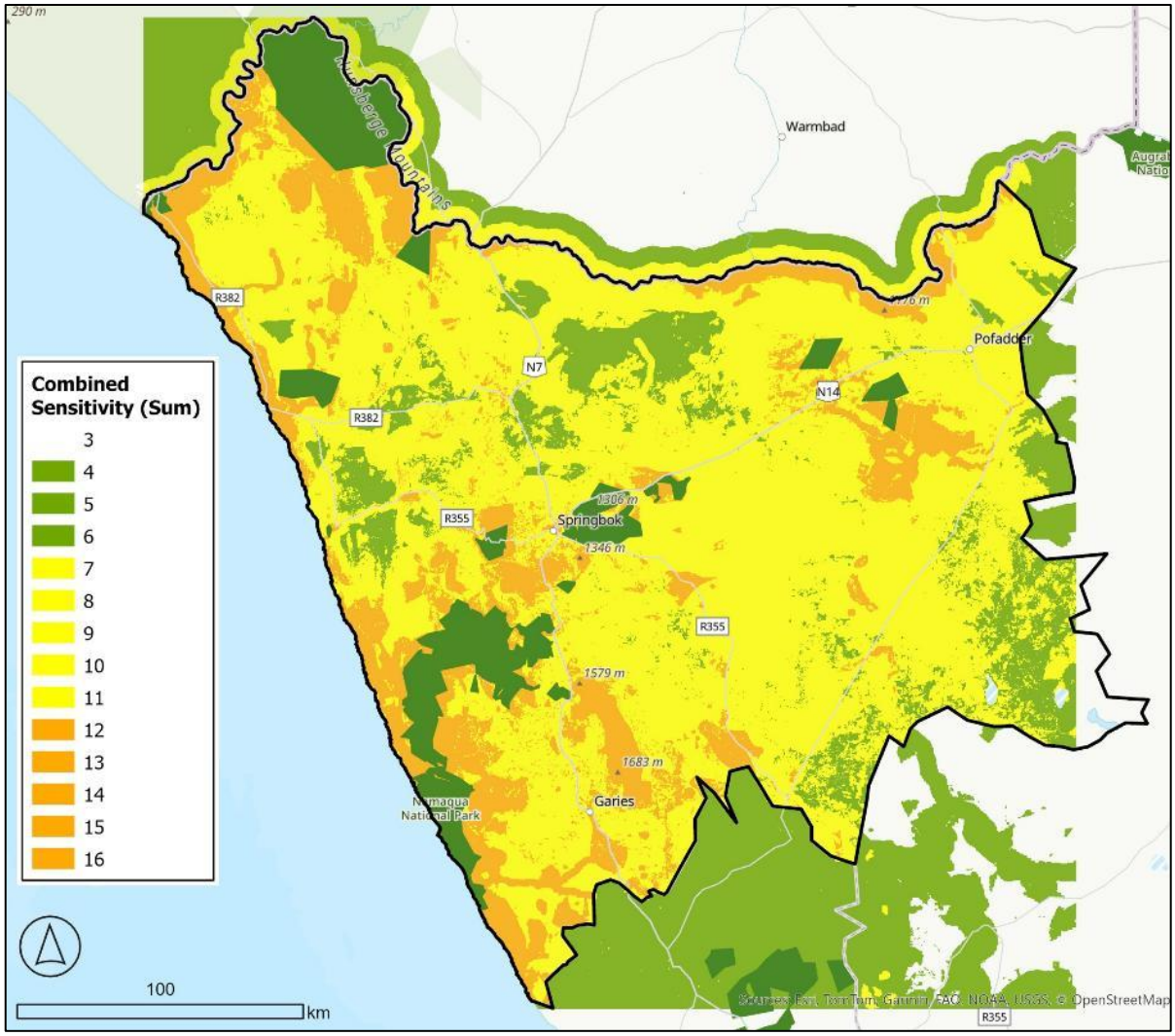

Figure 3.7: The combined biodiversity sensitivity rank with an alternative legend grouping summed ranks in 3 combined sensitivity categories: Low-Medium, Medium-High and High-Very-High.

CHAPTER 4

Water Resources and Aquatic Ecology

CHAPTER 4: Water Resources and Aquatic Ecology

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Executive Summary

E1 OVERVIEW

The Namakwa Region lies in the Northern Cape of South Africa in a region mostly characterised by very low rainfall, high evaporation rates and high levels of dependency on groundwater (Van Gend et al. 2021), with the entire study area being classified as either Hyper-Arid or Arid. Surface water resources are very limited, comprising mainly ephemeral streams and sporadic runoff events, mostly lasting for only a few days, with long dry periods in between events.

The region is however one of high biodiversity, with some areas supporting endemic flora and/or fauna of very high conservation importance. The only perennial river that flows through the area is the Orange River, the estuary of which enters the sea on the northwestern corner of the study area. Other rivers are seasonal to ephemeral, and although the area includes extensive pans and wetlands in places, surface water is generally sparse, both spatially and temporally.

In the context of the proposed Green Hydrogen Development ("GH_2") with its required expansion of renewable energy generation and transmission infrastructure in the Namakwa Region ("the GH_2 supporting infrastructure"), the availability and quality of water for further development is likely to play a critical role in defining some of the opportunities for renewable energy expansion, and the direct and indirect impacts of such development on water demand.

At the same time, some of the proposed SEZ development interventions might increase the availability of fresh water in some areas, through desalination projects, changing current development constraints. Any new development in the region, particularly development at scale, including extensive linear infrastructure developments as well as impacts on flow regime and hydroperiod, could however impact on water resources from a biodiversity perspective, and need to be considered both locally and at a catchment level, when weighing up development opportunities and threats.

This Chapter considers the implications of regional expansion of renewable energy generation and transmission infrastructure on surface and groundwater resources, in terms of water quantity, quality and availability, both spatially and temporally, and the links between these systems. The ecological implications of such development on aquatic ecosystems are also considered, with a focus on inland aquatic ecosystems (e.g. rivers, wetlands, dams and pans) and estuaries. Three scenarios are considered – a baseline scenario (Sc0) with climate change and existing slowly increasing developments and populations; Green Hydrogen Development (GH_2) Scenario 1 (Sc1) (relatively small-scale renewable energy for GH_2 till 2035); and GH_2 Scenario 2 (Sc2) (upscaled renewable energy development, by 2050).

E2 GROUNDWATER SYSTEMS

E2.1 General

- Groundwater occurs in three different aquifer systems in the region namely:
    - Sandy/alluvial aquifers with direct recharge;
    - Fractured crystalline bedrock with indirect recharge from the primary aquifer;
    - Weathered zones or regolith (the layer of loose, weathered material overlying bedrock) and essential for the discharge from the alluvial aquifers and recharge to the fractured aquifers.
- Groundwater recharge is generally low (in the region 0.1 – 10 mm/a) and water quality as measured by electrical conductivity which is a function of the dissolved salts in the water, is relatively poor (70 – >1 000 mS/m).

E2.2 Current Trajectory and Anticipated Scenario 1 and Scenario 2 Impacts

- Climate change projections indicate that the Namakwa District will become hotter and drier; Mean Annual Precipitation (MAP) will decrease, and Mean Annual Potential Evapotranspiration (MAPE) will increase. A reduction in MAP is likely to decrease recharge to the alluvial aquifers, which consequently will impact recharge of basement aquifers. Shifting climate patterns are also likely to result in increased reliance on an already strained groundwater system.

- In a baseline scenario where no significant developments are anticipated to occur, population growth trends will result in increased strain on water supplies.

- Compounding the baseline scenario with further development (as per development of GH_2 and GH_2 supporting infrastructure) may result in a scenario where neither supply nor infrastructure is able to meet increasing demand.

E2.3 Main Sensitivities

- Given the high reliance of communities on groundwater, a number of Groundwater Resource Units have been identified as intermediate and high priority. Additionally, three Strategic Water Source Areas (SWSAs) have been delineated as of Very High Sensitivity in the study area: Port Nolloth, Kommagas and Kamiesberg SWSAs.
- Current Wastewater Treatment Works (WWTWs) and water treatment and distribution infrastructure are failing and require upgrades.
- The Department of Water and Sanitation (DWS) project lists indicate that the District Municipality (DM) is already struggling to meet current water demand and added pressure may have severe consequences.

E2.4 Key Recommendations

- High-risk activities (e.g. chemical storage and pipelines, treatment and processing facilities) should not take place in areas delineated as high and very high sensitivity from a groundwater perspective.
- Further GH_2 development planning would need to be informed by feasibility studies on costly mitigation measures, including investment into municipal infrastructure and management, and groundwater desalination.
- Consideration should be given to the fact that although provision of desalinised water may alleviate regional water scarcity, the operational requirements and potential mismanagement are accompanied by environmental and ecological risks, especially to marine ecosystems. This may ultimately result in a spatial transference of risk and impacts from the proposed development. The ecological, practical and financial feasibility of this mitigation measure, however, would need to be investigated.

E3 SURFACE HYDROLOGY

E3.1 Key Systems

Surface water resources in the interior are limited. Most drainage features drain westwards, with a few eastward draining channels in the east of the area. However, large areas in the central region are endoreic. Runoff in the drainage network is very scarce, with discharge events only occurring during infrequent heavy rains, and lasting only a few days. Runoff is limited to less than 10% of the time with long dry periods between events. The Orange River bounds the study area in the north, flowing westwards to discharge at Alexander Bay. Abstractions from the Orange River sustain much of the communities and industry in the north of the region.

E3.2 Current Trajectory and Anticipated Scenario 1 and 2 Impacts

The region is predicted to become warmer and drier in the near future, with some 18% of the area likely to change from Arid to Hyper-Arid, offering fewer development opportunities outside the Orange River supply network. Planned augmentation of the Orange River abstraction infrastructure and reticulation is aimed at supplying *inter alia* the anticipated needs for GH_2 Scenario 1. However, with the current system consistently yielding less than the design demand, future schemes will require improved operation and maintenance, with adequate funding and capacity.

E3.3 Main Sensitivities

The current abstractions from the Orange River and reticulation into the interior of the region are ageing and often do not yield their design demand, which continues to increase. Proposed new and augmented abstraction works and reticulated networks are considered extremely sensitive to poor management and maintenance, since they have been assessed as being the only viable source for sustaining water supply to the region. These systems may be supplemented by coastal desalination works, but there is some concern over the capacity of local operators to cope with the more sophisticated technology.

From a different perspective, with the very low occurrence of runoff events and long periods without runoff, all rivers and floodplains are also considered fragile to disturbance and river networks would be unable to reconfigure from disturbance (e.g. erosion) within periods of several decades.

E3.4 Key Recommendations

- Estimate the actual future water needs for Sc1 and Sc2 development and the extent to which, if any, these can be met through design and implementation of new and augmented water supply schemes from the Orange River, while providing for the ecological reserve for the lower Orange River and its estuary;
- Implement and adequately fund effective desalination plants for saline groundwater and seawater use to augment highly limited surface water supplies;
- Provide for adequate operation and maintenance of the abstraction, treatment, reticulation and storage works for water from the Orange River;
- Provide for expertise to operate desalination plants at proposed coastal locations;
- Prevent disturbance to river systems and floodplains, particularly at infrastructure crossings;
- Prevent encroachment of structures or dwellings into floodplains;
- It is in addition noted that the required dependence of new development and expanded populations on desalination infrastructure does mean that these would be highly vulnerable to energy disruption caused by infrastructure failure, mismanagement or power outages.

E4 INLAND AND ESTUARINE AQUATIC ECOSYSTEMS

E4.1 Key Systems

Aquatic ecosystems considered in this chapter include inland and estuarine ecosystems as well as micro-outlets. Wetlands are limited, due to the aridity of most of the study area. Inland aquatic ecosystems thus largely comprise ephemeral rivers and pans, although there are some areas (e.g. the Kamiesberg mountains) where there are seasonal and perennial wetlands that play important roles in the supply of livestock grazing areas and in erosion control and groundwater recharge. The Orange River is the only permanent river in the study area, and it receives most of its flows (outside of periodic local floods) from its upstream catchment. Endoreic areas in the study area support ephemeral pans. Pans are the most common aquatic ecosystem type in the study area, and many of these are classified as Critically Endangered or Endangered, depending on their Bioregion.

The Orange River Estuary is the largest and most ecologically important estuary in the study area. In addition to this, the study area includes four smaller Cool Temperate Arid Predominantly Closed (CTAPC) estuaries (the Buffels, Swartlintjies, Spoeg and Groen River Estuaries) and a few micro-outlets, where flows are too ephemeral to support estuarine habitat. Apart from the Orange River, eight mainstem ephemeral rivers flow into the Atlantic Ocean within the study area, while others dissipate inland and never reach the sea. Most rivers are in good ecological condition (PES Categories B/C), with notable exceptions including the Kwaganap, Bitter, and parts of the Groen River system. Pressures on these systems include road infrastructure, mining, invasive species, overgrazing, and groundwater abstraction.

E4.2 Current Trajectory and Anticipated Scenario 1 and 2 Impacts

In the Baseline Scenario, potential drivers of inland aquatic ecosystem degradation mainly comprise possible changes in pan ecosystem diversity; water quality deterioration (increasing salinity and nutrients); reduced riparian resilience as a result of reduced frequency of flows and extended no flow periods; increased vulnerability of ephemeral systems to erosion, grazing and trampling; and an increased likelihood of invasion of watercourses by alien plants, thus compounding surface and groundwater impacts.

Decreases in groundwater flows and increases in groundwater salinity would also be of concern for water quality in all four CTAPC estuaries in the study area. A reduction in the frequency and magnitude of floods in the lower reaches of ephemeral rivers with estuarine outlets would also potentially further impact on estuarine connectivity, by reducing breaching episodes and thus limiting fish recruitment into these systems.

Without active intervention, existing impacts on the Orange River Estuary would continue, and additional flood reduction impacts including changes in sediment regime, alien plant invasion and a general deterioration in river function and processes would be anticipated, if the proposed large dam upstream of the study area (Vioolsdrift Dam) is constructed.

In the context of large-scale expansion of linear, hardened infrastructure such as roads and pylons across the Namakwa Region, impacts such as concentrated flows into watercourses, erosion, changes in sediment regimes and ecosystem fragmentation are all likely, along with indirect impacts such as nutrient enrichment from variously treated or untreated effluent discharges and potentially expanding urban formal and informal settlement footprints.

Many of the inland aquatic ecosystems within the study area are Critically Endangered or Endangered ecosystems and any impacts to such systems would be significant. The Orange River Estuary and the four CTAPC estuaries in the study area are all rated as Endangered systems, of high conservation priority.

E4.3 Main Sensitivities

Inland and estuarine ecosystems in the study area are sensitive to the following key issues:

- Changes in water quality (increased or decreased salinities; nutrient enrichment);
- Changes in hydrology (increased water flows (e.g. from WWTW effluent discharges) as well as decreases in flow frequency and/or the magnitude of flood flows;
- Physical disturbance;
- Habitat fragmentation;
- Alien plant invasion.

E4.4 Key Recommendations

i. Measures to **avoid** impacts include the following:

a. No new development should be located in areas mapped as Very High Sensitivity;

b. Limited Low Risk activities (e.g. essential road crossings) might be considered in High Sensitivity areas, provided there is adequate mitigation;

c. Only Low Risk activities should be located in buffer areas (Medium Sensitivity);

d. High Risk activities should be located only in areas of Low Sensitivity;

e. If Medium Risk activities are mitigated to low Risk, they could take place in areas of Low Sensitivity and some Medium sensitivity areas (excluding buffer areas);

ii. Measures to **mitigate against** impacts include design and implementation of appropriate stormwater management systems, appropriate management of buffer areas, attention to the design of existing and new road crossings over watercourses to minimise watercourse impacts, attention to construction disturbance and avoiding the passage of vehicles through pans, ephemeral watercourses and estuaries;

iii. Measures to **manage** impacts include pre-development implementation of the non-flow-related requirements for the Orange River Estuary to meet its REC; pre-development upgrading of WWTWs in areas likely to expand their urban populations; and upgrading of WWTWs that discharge treated or untreated effluent or enable irrigation within 500 m of any estuary so as to fall within the mesotrophic range for aquatic ecosystems, with regard to phosphorus and nitrogen nutrients.

E5 RESULTS OF SENSITIVITY ASSESSMENTS

Groundwater, surface water and aquatic ecosystem sensitivity layers are shown in **Figures E1-E3**. The layers have not been consolidated, since different activities / landuses may impact differently on groundwater versus surface water and associated aquatic ecosystems.

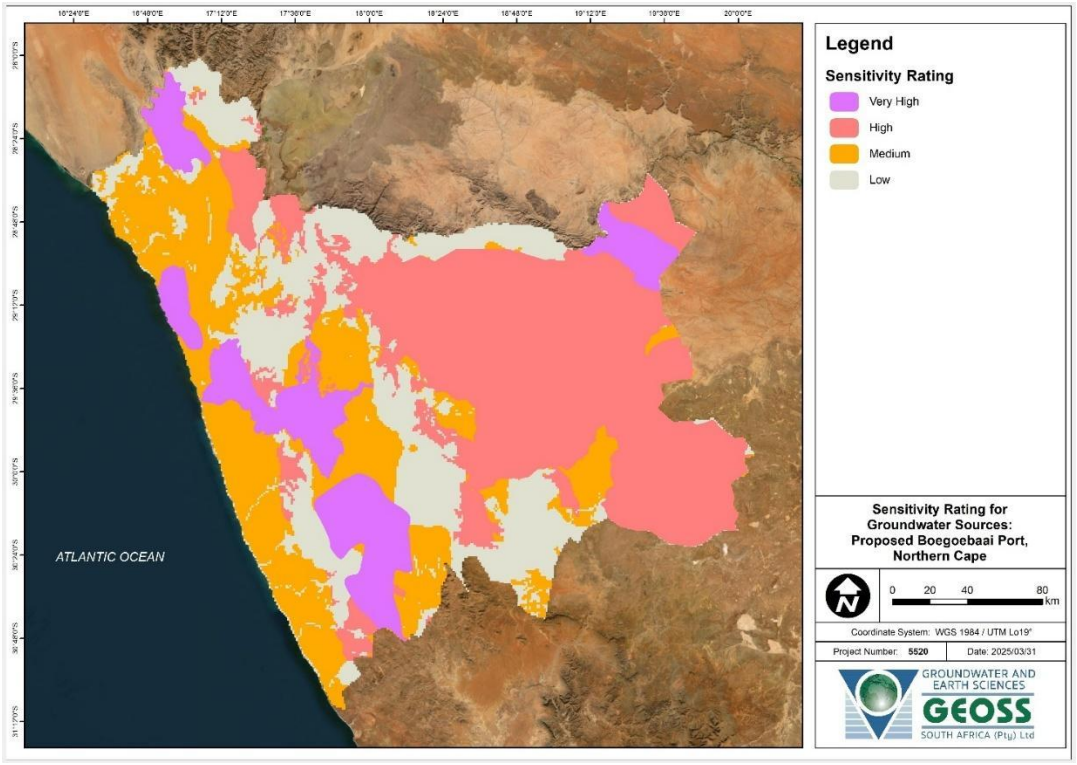

Figure E1
Results of application of the groundwater sensitivity classification

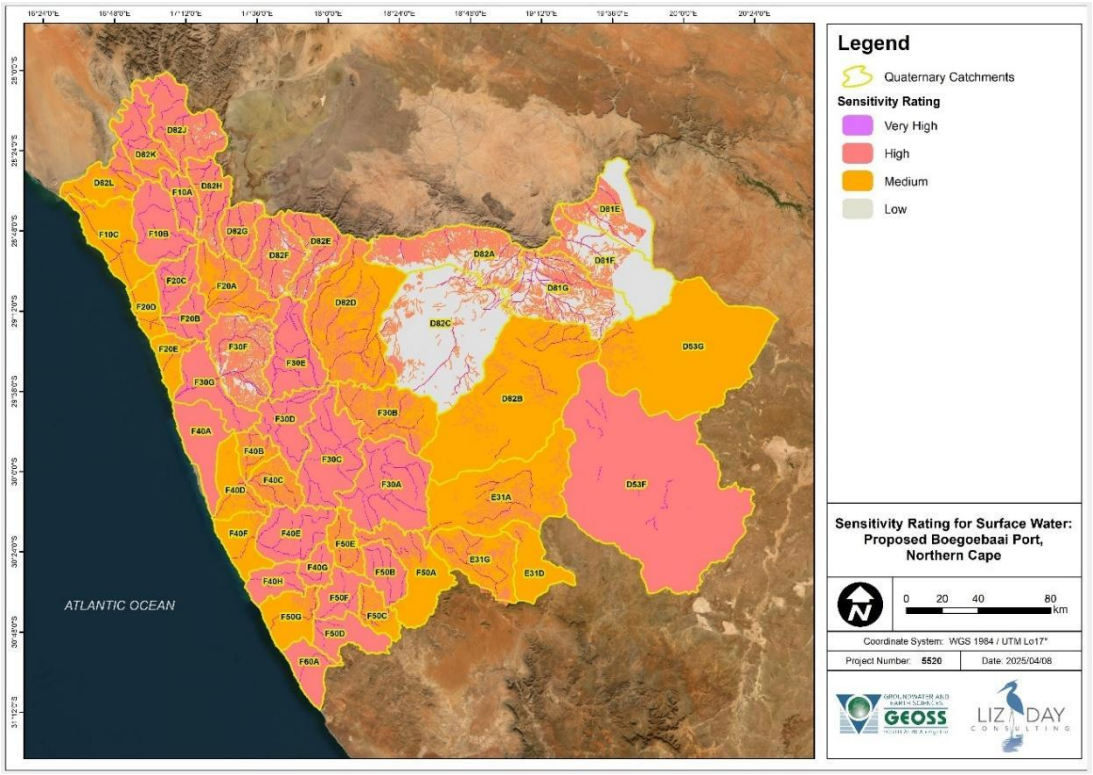

Figure E2
Results of application of the surface hydrology sensitivity classification

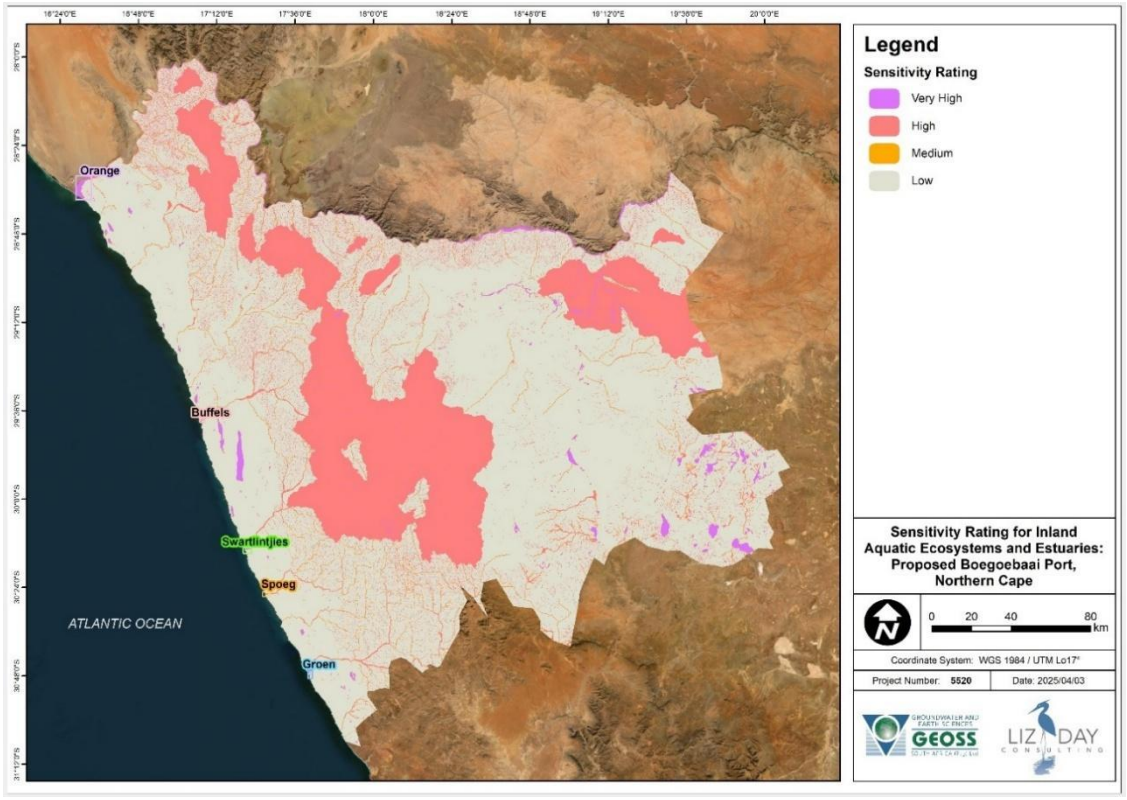

Figure E3
Results of application of the inland and estuarine aquatic ecosystem sensitivity classification

E6 POTENTIAL OPPORTUNITIES

The report acknowledges that, in addition to risks posed by the proposed development of GH_2 and its supporting infrastructure, such development could also bring with it opportunities for development in some areas, if the availability of fresh water increased as a result of affordable desalination projects, thus changing current development constraints. Such opportunities would however themselves be associated with increased risks from a biodiversity perspective, and their realisation would be contingent on meeting the challenges already highlighted around effective upgrading, expansion and maintenance of WWTW and water treatment infrastructure, and water reticulation.

E7 RECOMMENDED STRATEGIC MANAGEMENT ACTIONS

In addition to the recommendations already outlined, a number of strategic actions are also recommended if this project is to be taken forward. These comprise:

- Generally:
    - Ensuring that the additional water volume (and water quality) that would be required by the proposed development would in fact be available – this would require consideration by the DWS Water Resource Classification team, currently engaged in this assessment;
    - Adding to this is a requirement for the immediate implementation (or re-constitution) of effective long-term monitoring of surface and groundwater quantity and quality across the Namakwa region. This is critical to inform the detailed accounting of water supply and demand across the region, and to identify areas where over-abstraction or excess waste

water discharges are affecting the sustainability of the resource and its dependent human communities and natural ecosystems

- From a groundwater perspective:
    - Investment in improvement in infrastructure and management of groundwater resources in the study area, including a focused investment in supplying treated, desalinised water to serve projected increased demand from domestic and industrial users in a GH_2 scenario;
    - Protection of groundwater quality from high-risk activities by implementing stricter regulations and requiring adherence thereto;
    - Investment in training schemes to enhance borehole management, in particular regarding mitigation of issues such as iron biofouling;
    - Investment in managed aquifer recharge schemes, including appropriate investment in training, human resources and infrastructure, to mitigate against possible natural increasing salinisation of groundwater;
- From a surface hydrology perspective:
    - Provision for (allowed-for) abstraction from the Orange River and reticulation to the level of Scenario 1 demand;
    - Provision for adequate operation and maintenance of (authorised) abstraction, treatment, reticulation and storage works;
    - Investment in the urgent development / out-sourcing of expertise to operate desalination plants at proposed coastal locations;
    - Ensuring that the water demand (volume and quality) for Scenarios 1 and 2 can be met, based on sustainable use of available surface and groundwater resources, including supplementation with groundwater and desalinated seawater sources as well as with treated WWTW effluent;
- From an inland and estuarine ecosystem perspective:
    - Avoidance of inland and estuarine aquatic ecosystems in any development context, given that these ecosystems are regionally rare, sensitive and of (generally) high ecological importance, as well as the fact that their degradation could result in multiple other impacts, including impacts on road infrastructure;
    - Implementation of the non-flow related rehabilitation requirements for the Orange River Estuary, as outlined in DWS (2017b and 2024b);
    - Consideration of the need for pro-active watercourse and terrestrial offset banking to ensure holistic biodiversity conservation across all habitat types;
    - Upfront investment in maintenance / improvement in road design, to ensure that flood flows into estuaries are not artificially attenuated, while also ensuring that flows under roads do not result in concentrated flows, channel narrowing and resultant erosion of river channels;
    - Ensuring that the recommended EWR for the lower Orange River and the Orange River Estuary can still be met, and is in no way jeopardised by the proposed development – this would require investment in desalination of both seawater and groundwater.

E8 CONCLUSIONS

This chapter considers water resources in the study area from both the perspective of the limitations this resource places on future development and the sensitivity of these systems themselves to some aspects of the proposed development. The greatest risks are posed by activities resulting in changes in water quality;

reductions in water availability or predictability; and physical disturbance that reduces natural downstream flushing (e.g. estuaries) or increases channel erosion, especially in the vicinity of road crossings. Surface and groundwater flows and quality are interlinked, and changes in one can have impacts on the other. These resources are moreover already under threat as a result of climate change and existing demand.

Given the arid to hyper-arid character of the study area, water and its sustainable management are critical factors in any future development planning in the area. In this regard, it seems evident that the development of GH_2 and GH_2 supporting infrastructure should only be considered in a context where allowance is also made for large-scale desalination of seawater and/or groundwater to provide for the increase in direct and indirect water demand likely to be associated with such development. Such an approach would come at great potential ecological risk due to the inherent risks associated with brine generation and disposal as well as their energy requirements. Further, the naturally ephemeral watercourses and pans in the area have high biodiversity value and would be vulnerable to changes in hydroperiod, including receipt of additional (potentially nutrient enriched) water from ancillary developments such as expanded WWTWs and effluent outflows. Attention to creating a circular water economy that did not change aquatic ecosystem function would be important if the proposed development were to proceed.

Risk assessments presented in this chapter show that a high degree of avoidance of aquatic ecosystems and groundwater recharge areas is required, to reduce the high likelihood of major consequence for water resources including inland and estuarine aquatic ecosystems.

Overall, it must be stressed that while solar and wind energy sources in the study area may be amply available, the limited availability of water resources and the high sensitivity of aquatic ecosystems in this particular region is a major constraint for such development at the outset, taking into account current and future demands; projected climate change impacts; and the existing capacity constraints of water, sanitation and other services in the region.

It must also be stressed that multiple regulatory authorisations including water use licenses, Environmental Authorisations and others would be needed if the proposed GH_2 Development were to proceed further. These would all require in-depth assessments, and would need to be supported by biodiversity, hydrological and geohydrological data relevant to the study area as a whole, as well as to discrete developmental units.

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Abbreviations

CTAPC	Cool Temperate Arid Predominantly Closed (estuary)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	electrical conductivity
ETS	Ecological Threat Status
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Area
GA	General Authorisation
GRU	Groundwater Resource Unit
ha	hectares
LM	Local Municipality
L/s	litres per second
m	metres
m^3	cubic metres
mamsl	metres above mean sea level
MAP	mean annual precipitation
MAPE	mean annual potential evapotranspiration
mbgl	metres below ground level
mm/a	millimetres per annum
mS/m	milli-Siemens per meter
NGA	National Groundwater Archive
NFEPA	National Freshwater Ecosystem Priority Area
NMP	Namaqua Metamorphic Province
NNMP	Namaqua-Natal Metamorphic Province
PES	Present Ecological State
PV	Photo-voltaic
EIS	Ecological Importance and Sensitivity
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
SEZ	Strategic Economic Zone
SWSA	Strategic Water Source Area
WARMS	Water Authorisation Registration Management System
WMA	Water Management Area

CHAPTER 4. WATER RESOURCES AND AQUATIC ECOLOGY

4.1 INTRODUCTION AND SCOPE

4.1.1 Background

Green hydrogen (GH_2), and its derivative products (e.g. green ammonia and green methanol) potentially provide an opportunity to decarbonise the South African energy economy, generate new revenues, create jobs and skills and facilitate a Just Energy Transition (Schreiner *et al.* 2024). As part of South Africa's ambition to become a player in the globally emerging green hydrogen (GH_2) market, a substantial programme of greenfield infrastructure has been proposed in the Northern Cape, consisting of three main components:

- A new deepwater port at Boegoebaai, with dry and liquid bulk berths as well as multi-purpose terminals;
- A mixed-use Special Economic Zone (SEZ), located in the region adjacent to the proposed Boegoebaai Port; and
- Expansive regional renewable energy (wind and solar PV) generation and transmission infrastructure.

The production of GH_2 at the scale envisaged could have multiple direct and indirect impacts, including on local economies, infrastructure, communities and natural ecosystems and resources. In order to consider these potential impacts, the Council for Scientific and Industrial Research (CSIR) has been appointed to undertake an independent Strategic Environmental Assessment (SEA). The overarching purpose of the SEA is to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai Port, Special Economic Zone, and wider Namakwa Region renewable energy development in a sustainable manner (Schreiner *et al.* 2024) (see **Figure 4-1.1**).

The SEA has two outputs:

- Boegoebaai Port and Special Economic Zone (SEZ) (Work Package 1): Local-scale SEA report, concerned with assessing the sensitivities of the receiving environment around the proposed port and SEZ;
- Namakwa Region SEA (Work Package 2): Regional-scale SEA report covering the main sustainability issues associated with expansion of renewable energy (wind and solar PV) generation and transmission infrastructure across parts of the Namakwa District, in response to the proposed development of the Boegoebaai Port and SEZ.

The present report falls under Work Package 2. It considers the implications and associated risks and opportunities of potential expansion of renewable energy generation and transmission infrastructure for surface and ground water resources, as well as for aquatic ecosystems and aquatic biodiversity.

4.1.2 Scope of work

The [1]Namakwa District lies in the Northern Cape of South Africa in a region mostly characterised by very low rainfall and high levels of dependency on groundwater (Van Gend *et al*. 2021). The region is also one of high biodiversity, with some areas supporting endemic flora and/or fauna of very high conservation importance. The only perennial river that flows through the area is the Orange River, the estuary of which enters the sea on the northwestern corner of the study area. Other rivers are seasonal to ephemeral, and although the study area includes extensive pans and some wetlands, surface water is generally sparse, both spatially and temporally. In addition to the Orange River

[1] Also referred to as Namaqualand

Estuary, the SEA area ("the study area") includes the Brak, Groen, Bitter, Spoeg, Swartlintjies, Buffels, Kwaganap and Holgat River outlets to the sea, classified variously as Cool Temperate Arid Predominantly Closed (CTAPC) estuaries and micro-outlets (Van Niekerk *et al.* 2024).

In the context of the proposed expansion of renewable energy generation and transmission infrastructure in the area, in support of the proposed Boegoebaai Port and SEZ development, the availability and quality of water for further development is likely to play a critical role in defining some of the opportunities for renewable energy expansion, and the direct and indirect impacts of such development on water demand.

At the same time, some of the proposed SEZ development interventions might increase the availability of fresh water in some areas, through desalination projects, thus changing current development constraints. Any new development in the region, particularly development at scale, and including extensive linear infrastructure developments, could also impact on water resources from a biodiversity perspective, and would need to be considered both locally and at a catchment level, when weighing up development opportunities and threats.

This is then the backdrop to the present chapter, produced as one of several inputs into Work Package 2. This chapter considers the implications of regional expansion of renewable energy generation and transmission infrastructure for surface and groundwater resources, in terms of water quantity, quality and availability, both spatially and temporally, as well as the links between these systems. The ecological implications of such development on aquatic ecosystems are also considered, with a focus on inland aquatic ecosystems (e.g. rivers, wetlands, dams and pans) and estuaries. Note that marine ecosystems are considered separately, in the Work Package 1 outputs of this project.

4.1.3 Project team

This input has been integrated from collaborative inputs provided by a multi-disciplinary team, including:

- Professor Simon Lorentz (hydrologist, SRK Consulting);
- Ms Zita Harilall (geohydrologist, GEOSS); and
- Dr Liz Day (aquatic (freshwater) ecologist, Liz Day Consulting).

Note that the original surface hydrology report has been appended to this report (Appendix F). Geohydrology and aquatic ecosystems reporting has been compiled directly into the present document.

4.1.4 Limitations and assumptions

- The findings of this chapter have been drawn from a focused desktop assessment, based on existing spatial and other data and available reports, the implications of which were required to be distilled into a concise document, for inclusion in final SEA reporting;
- This means that no new surface, groundwater or biophysical data were collected as part of this assessment, which was furthermore informed only by the existing knowledge of the specialist team of various parts of the SEA area ("the study area"). One of the implications of the limited, site-specific data that could be used to inform this study was thus that a conservative approach had to be taken to the assessment of the importance and sensitivity of aquatic ecosystems, particularly ephemeral pans
- With regard to groundwater impacts and their implications:
    - The regional groundwater maps in terms of yield, quality and vulnerability are of a regional scale and may not account for small-scale nuances and therefore only provide an indication of expected conditions;

- No site visit was undertaken to the study area, and groundwater information was compiled from available databases and literature;
- The WARMS 2025 database search only accounts for registered groundwater use. It is possible that there may be unregistered groundwater users, thus affecting the accuracy of current and projected groundwater use volumes;
- The results yielded by the above database search may not be accurate and may not account for either newly commissioned boreholes that have yet to be incorporated into the database, and boreholes that no longer exist, as borehole records date back as far as 1914;

- From an aquatic ecosystems perspective:
  - The assessment has relied on existing watercourse and estuary spatial data, included in the NFEPA and NWM (ver 5) datasets. These data are useful to inform broad conservation planning, but have not been ground-truthed sufficiently for high-confidence information of environmental impact assessments and for detailed development planning. This is a significant limitation in this assessment – the mapped extent of watercourses in the above datasets is not necessarily accurate;
  - An important assumption is that the Resource Quality Objectives (RQOs) and Recommended Ecological Categories (RECs) for the Orange River and the estuaries within the study area remain unchanged, and remain legislated targets for aquatic ecosystem management in the area, and in the upstream Orange River Catchment (e.g. DWS 2016 2017a 2017b and 2024);

- Another assumption, relevant to the assessment of opportunities, constraints and impacts in this report is that it is assumed that no new water pipelines will be created to convey fresh water for domestic use inland from the SEZ, and that these areas will remain reliant on existing water resources – this may in fact not be correct, if desalination allows water production at scale;
- Finally, this project assumes that the expansion of green energy projects that would be a requirement for green hydrogen production at the proposed Boegoebaai Port and SEZ would be confined to the Namakwa Region. This is not necessarily true, and expansion of these activities further afield might in fact take place, but the implications of this have not been considered here.

4.1.5 Definitions

All references to wetlands and watercourses in this document are based on the following definitions, taken from the National Water Act (NWA) (Act 36 of 1998):

"**Watercourse"** means -

(a) a river or spring;

(b) a natural channel in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be watercourse, and a reference to a watercourse includes, where relevant, its bed and banks;

"**Wetland**" means -

Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Government Notice (GN) 4167 of December 2023 furthermore defines:

"**Extent of a watercourse**" as:

> *(a) The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; and*
>
> *(b) Wetlands and pans: the delineated boundary (outer temporary zone) of any wetland or pan.*

The National Environmental Management: Integrated Coastal Management Act 2008 (as amended: 2015) defines an estuary as follows:

"**Estuary**" means a body of surface water—

> (a) that is permanently or periodically open to the sea;
>
> (b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or
>
> (c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water;

Aquatic ecosystems are defined in Ollis *et al.* (2013)'s National Classification System for wetlands and other aquatic ecosystems as including

- Inland systems (i.e. watercourses (as defined above) comprising rivers, wetlands, springs and pans
- Estuarine systems (as defined above); and
- Marine systems.

This report is concerned only with Inland and Estuarine aquatic ecosystems, but includes non-estuarine "micro-outlets" as described in van Niekerk *et al.* (2020). These are defined in the latter paper as follows:

> *These are very small waterbodies (<1 ha in area or <50 m in length) that are ephemeral in nature (i.e. they can dry out during periods of low flow) or are elevated above mean sea level, with a perched outflow channel that does not facilitate tidal mixing of salt- and freshwater. They can, however, act as a limited conduit between the land and the sea during periods of elevated stream outflow or exceptionally high storm sea events.*

4.1.6 Study area

The study area for this project encompasses an area of approximately 5.8 million hectares (ha), located in the Northern Cape Province of South Africa. It extends north and east from the coast, just north of the small town of Bitterfontein, including some 310 km of coastline and running inland up to about 260 km east. The South African boundary of the Orange River, from about 30 km east of Onseepkans to the coastal mining town of Alexander Bay, comprises the northern boundary. Within the study area are located both the Namakwa National Park in the south and the Richtersveld Transfrontier Park (extending over the Orange River into Namibia to the north).

4.1.7 Project approach

The findings of this Chapter have been driven by the Water Resources study team, with additional input from other specialists involved in different Chapters in the two SEA Workstreams, including input from the Socio-economics and Infrastructure and Planning Chapters.

Appendix A provides a listing of the datasets used in this Chapter, to generate the maps and overall findings.

4.2 MAJOR WATER RESOURCE DRIVERS

4.2.1 General

The major natural drivers of surface and groundwater resources, and the inland and estuarine ecosystems that depend on them, comprise climate, geology, soils and catchment geomorphology. These drivers determine the quantity and quality of water resources in the study area, as well as its spatial and temporal variation. Human interventions and activities are secondary drivers, also impacting on resource quality and quantity. This section provides a brief overview of these major drivers.

4.2.2 Climate

4.2.2.1 Rainfall

The rainfall in the study area is the lowest in the country, with Mean Annual Precipitation (MAP) varying from 60 mm to 215 mm as illustrated in **Figure 4-2.1**. MAP typically increases from west to east until the escarpment is reached, then decreases towards the interior. Higher lying areas within the study area receive much higher rainfall volumes than the surrounding lower lying areas and coastal plains.

The areas in the study area with the lowest rainfall include the north-western coastal region; the north -eastern section and along the Orange River. Rainfall increases towards the southern interior of the region, with highest values in the Kamiesberg mountains. Along the coastline, frequent fog occurs during winter, due to the cold Benguela current. These fogs contribute to moisture levels.

Mean annual values are, however, extremely deceptive, since the distribution of rainfall events is large, with some areas experiencing no rain for periods of years and rainfall often occurring in extreme events. This is reflected in the runoff analysis and particularly the number of dry days between runoff events.

Mean Annual Precipitation is predicted to decrease by 12% in the Near Future (2050). This result is derived from the average of six Global Climate Models (GCMs) applied to the study area. The maximum change GCM predicts a 24% decrease and the minimum a 5% increase.

The distribution of estimated Near Future changes in MAP is illustrated for the Average of 6 GCMs in Appendix C1 (**Figure C1.9**).

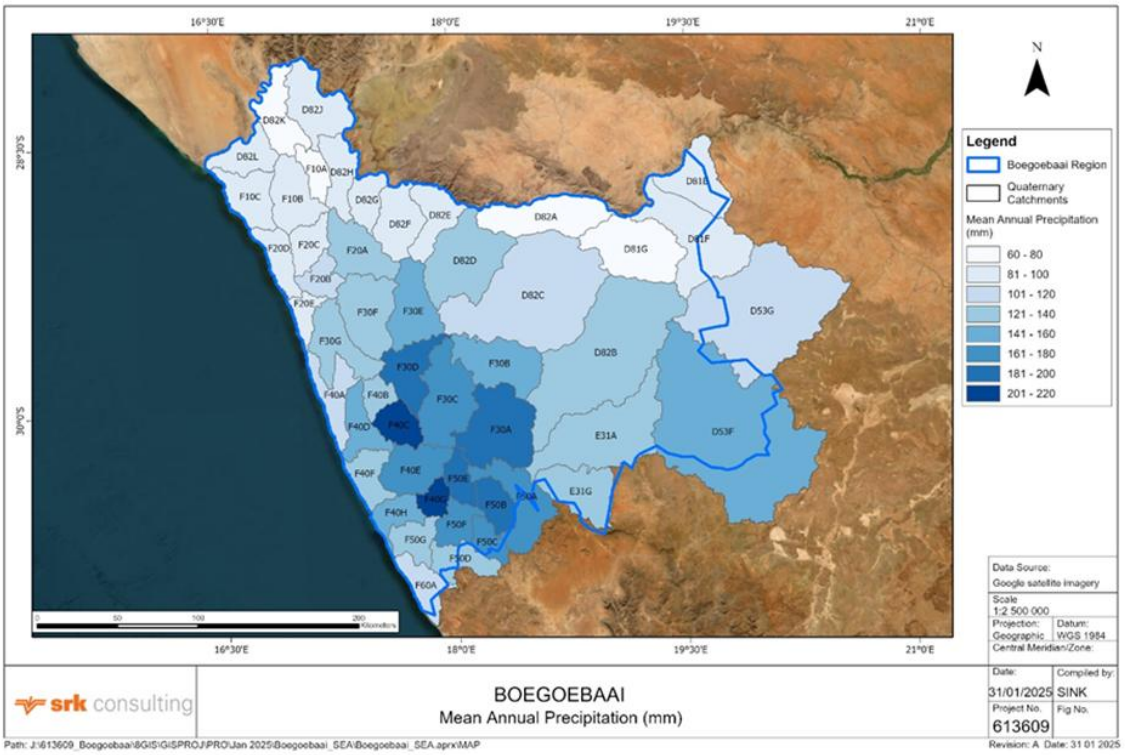

Figure 4-2.1: Distribution of the mean annual rainfall in the study area.

4.2.2.2 Temperature

The region has warm summers, with temperatures averaging around 30 °C and occasionally peaking at 40 °C, while winters are cooler, with daily averages ranging from 8 to 17 °C. Observed average daily temperatures for Springbok (within the study area) are shown in **Figure 4-2.2**.

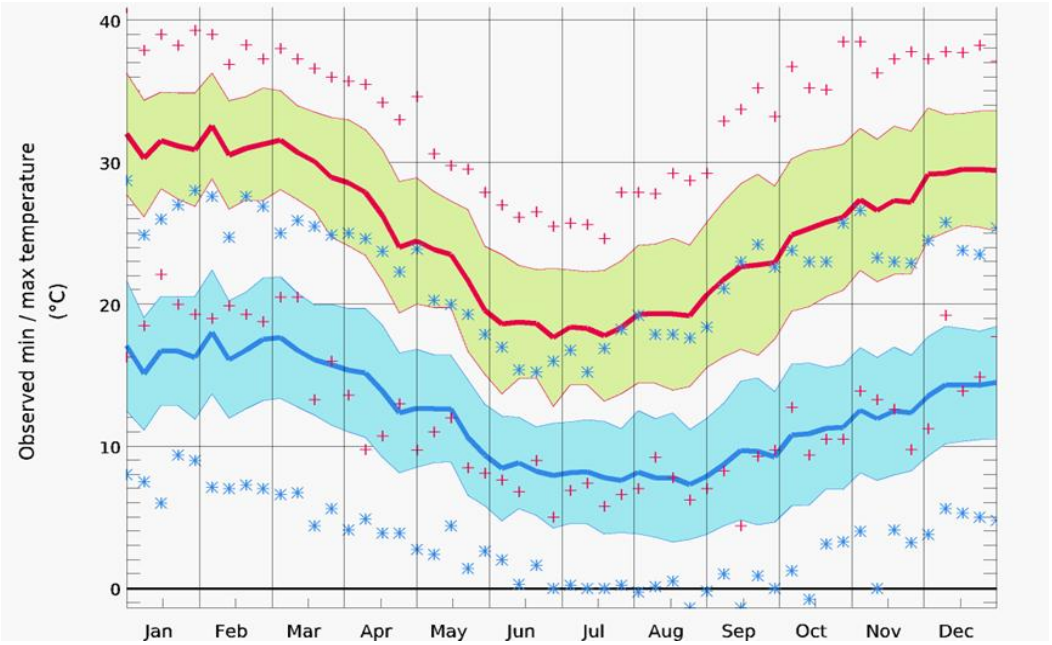

Figure 4-2.2: Mean daily maximum and minimum temperatures at Springbok.

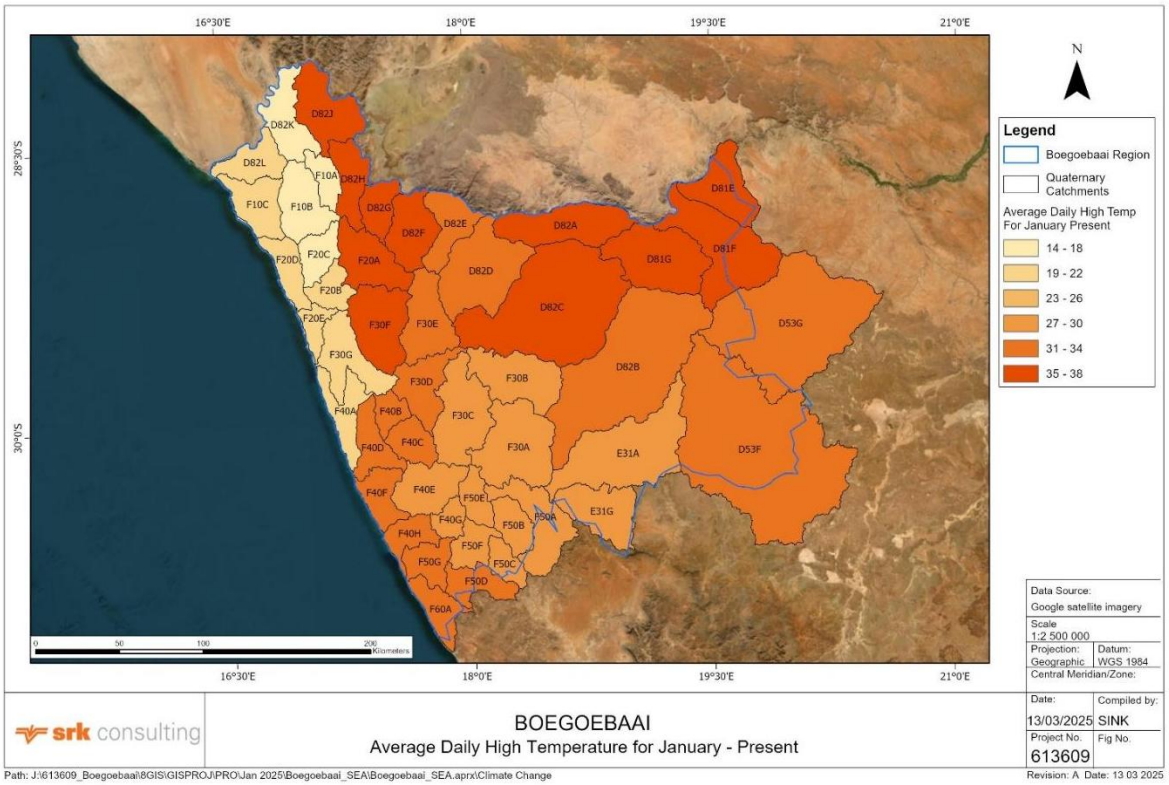

Figure 4-2.3: Distribution of average Temperatures for January.

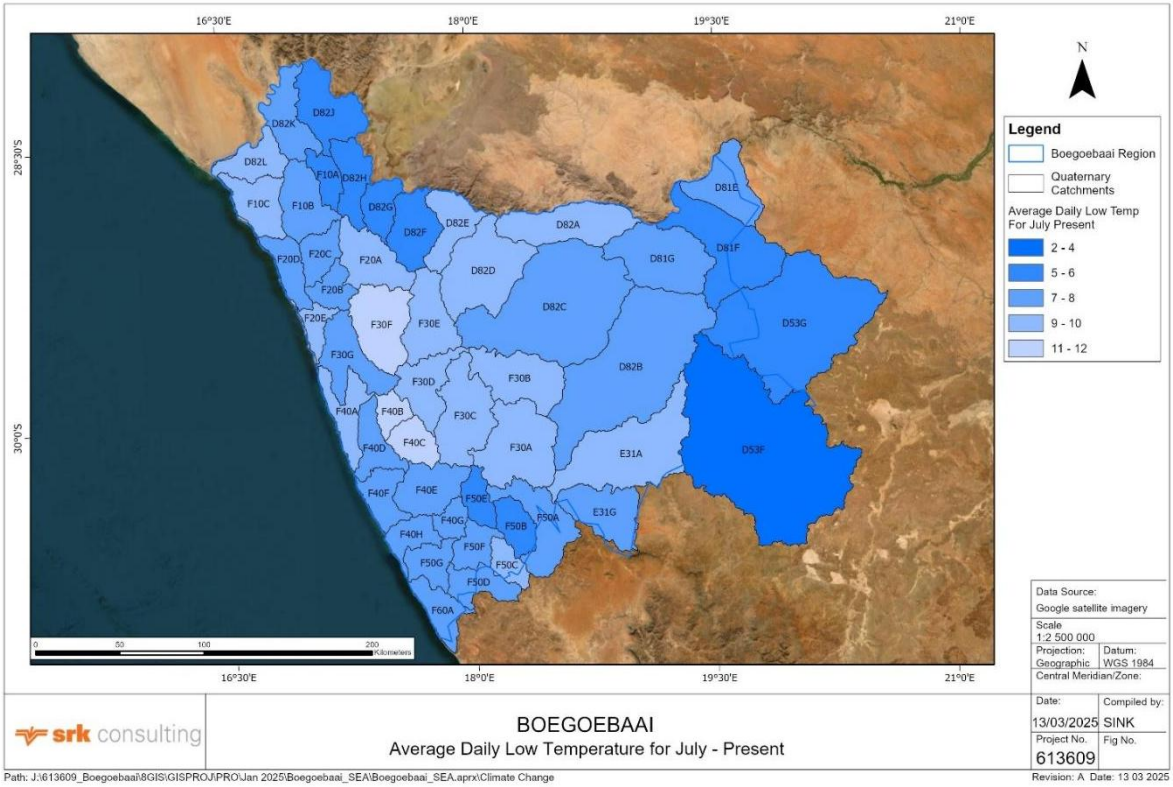

Figure 4-2.4: Distribution of Average Temperatures for July.

4.2.2.3 Mean Annual Potential Evaporation and Potential Evapotranspiration

Potential evaporation tends to increase from the west to the east (Adams et. al., 2004

Mean Annual Potential Evaporation (MAPE) ranges between 611 mm and 2 680 mm (**Figure 4-2.5**) and exceeds the MAP by between 8 to 44 times. Evaporation rates are lowest in the northwest coastal areas of the region and increase towards the east and south.

The Aridity Index, defined as the ratio $\frac{MAPE}{MAP}$, is greater than 20 over 24% of the quaternary catchments, classifying these as Hyper-Arid (Gunkel and Lange 2017). The remainder are all classified as Arid, being less than 20, while 12% of the quaternaries have an Aridity Index less than 10. However, none of the quaternary catchments have an Aridity Index less than 5, which might classify these as Semi-Arid.

Mean Annual Potential Evaporation is predicted to increase by 7% in the Near Future scenario (2050). This result is derived from the average of six GCMs applied to the study area (WRC 2023). With the predicted changes in MAP and MAPE in the Near Future scenario, some 18% of the quaternary catchments are likely to change from Arid to Hyper-Arid (estimated from Schütte et al., 2024; Gunkel and Lange, 2017),

The distribution of estimated Near Future changes in MAPE is illustrated for the Average of GCMs in Appendix C1 (**Figure C1.10**). The Present and Near-Future distributions of Aridity Index are also presented in Appendix C1 (**Figures C1.7** and **C1.8**).

Annual potential evapotranspiration (PET) ranges between 12 – 15 times the MAP. However, in certain quaternary catchments, this factor is as high as 22 (Adams et al., 2004). Studies found actual evapotranspiration is much higher in areas of dense vegetation and shallow water levels than in areas of sparse vegetation and deeper water levels (Van der Sommen and Geirnaert, 1988), Campbell et al., (1992) further reported that evaporation occurred to a depth of 91 cm in the subsurface of the alluvium cover.

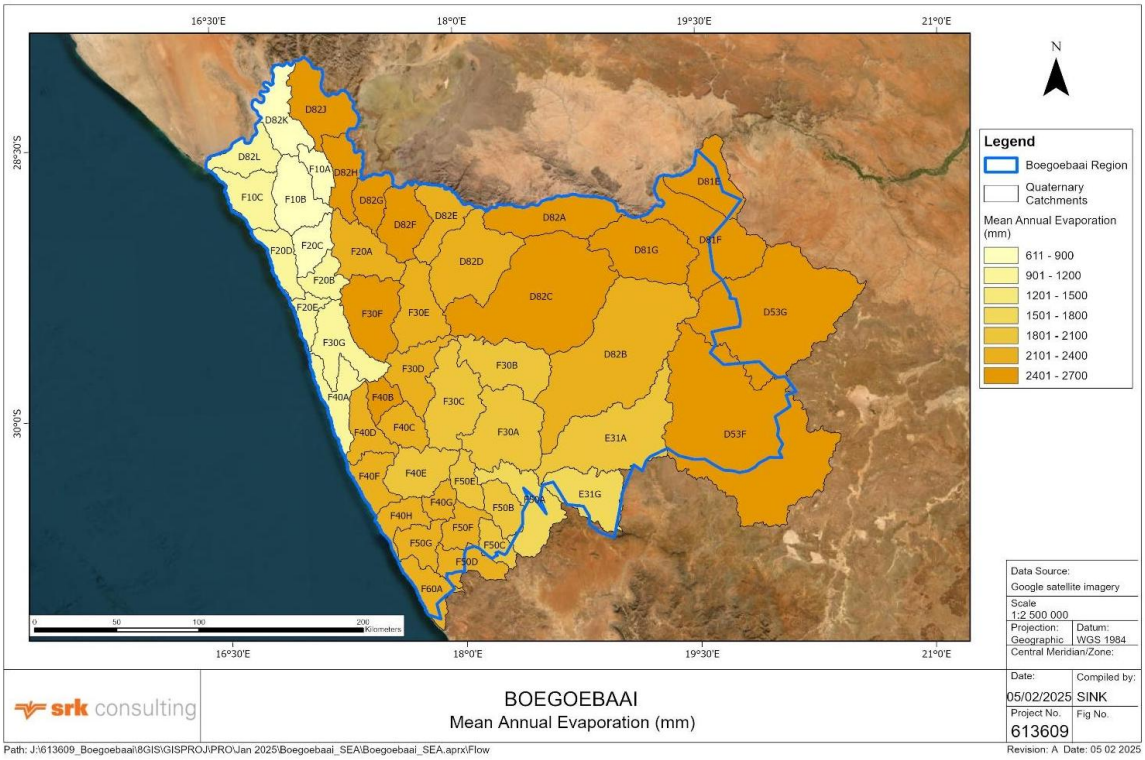

Figure 4-2.5: Distribution of Mean Annual Potential Evaporation

4.2.3 Geology

Namaqualand geology is subdivided into three geological provinces, the Namaqua Metamorphic Province (NMP), the Gariep Complex and the Phanerozoic Cratonic cover (Tankard et al., 1982; Visser, 1989). The NMP, composed of deformed and metamorphosed sedimentary and igneous rocks, forms part of the Namaqua-Natal Metamorphic Province (NNMP) of southern Africa. The NNMP is a high-grade metamorphosed orogenic belt that developed along the southern and southwestern margins of the Kaapvaal Craton (Nke et al., 2020). The NNMP is composed of meta-igneous and meta-sedimentary rocks formed or metamorphosed during the Namaqua Orogeny at ~1 200 to 1 000 Ma. It is understood to be one of several orogenic belts involved in the assembly of the supercontinent, Rodinia (Dalziel et al., 2000). These geological units crop out extensively in the Northern Cape (100 000 km^2) and KwaZulu-Natal (20 000 km^2) geographical provinces of South Africa and are referred to as the Namaqua and Natal Sectors of the Namaqua-Natal Province respectively (Cornell et al., 2006; Nakwafila, 2015) (see **Figure 4-2.6**).

The main lithological units of the NMP are meta-volcano-sedimentary units intruded by multiple granitoid intrusions (Blignault et al., 1983). The NMP rocks display evidence of four metamorphic events (Robb et al., 1999; Clifford et al., 2004). D1 deformation (greenschist-facies) occurred during the Orange River Orogeny, dated at 1 700 – 1 900 Ma (Blignault et al., 1983). D2 and D3 metamorphism occurred during the polyphase Namaquan Orogeny, dated at 1 020 – 1 220 Ma (Robb et al., 1999; Clifford et al., 2004). D2 deformation occurred during the main phase of the Namaquan Orogeny during which time, the Namaqua domains were intensely deformed and then juxtaposed along major thrust zones to form a regional-scale SW-vergent thrust stack, resulting in the present-day geological setting (Macey et al., 2022). D4 deformation occurred after the Namaquan Orogeny and is understood to be a result of tectonic relaxation (958 – 1 005 Ma) (Macey et al., 2022; Thomas et al., 1996; Colliston and Schoch, 2003).

The NMP is subdivided into several tectono-stratigraphic domains (or subprovinces) which are bounded by major shear zones. These subprovinces are the Richtersveld, Bushmanland, Gordonia and Kheis tectonic Subprovinces (Tankard et al., 1982; Hartnady et al., 1985). With the exception of the Richtersveld Subprovince, all of these subprovinces experienced polyphase deformation, metamorphism and plutonic activities during the Namaquan Cycle (~1 200 – 1 000 Ma) (Thomas et al., 1996). These subprovinces are further subdivided into terranes which are categorised according to changes in lithostratigraphy across structural discontinuities (Cornell et al 2009; Nakwafila 2015) (**Figure 4-2.7**).

The regional geology is of particular economic value and has given rise to the presence of many mines, particularly alluvial diamond and copper mining. The basement rocks are covered by Cenozoic alluvial cover, primarily shoreline terrace along the coast and surficial sandy and aeolian soils in the interior (CGS 2011).

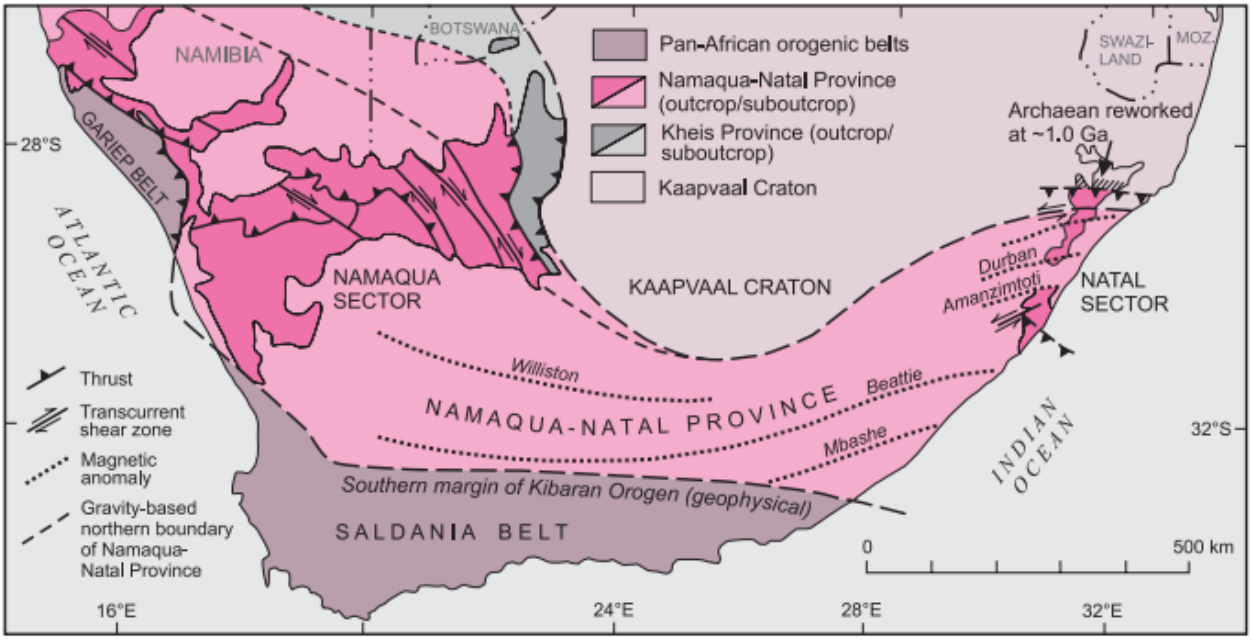

Figure 4-2.6: Geological setting of the Namaqua-Natal Province (Cornell et al. 2006).

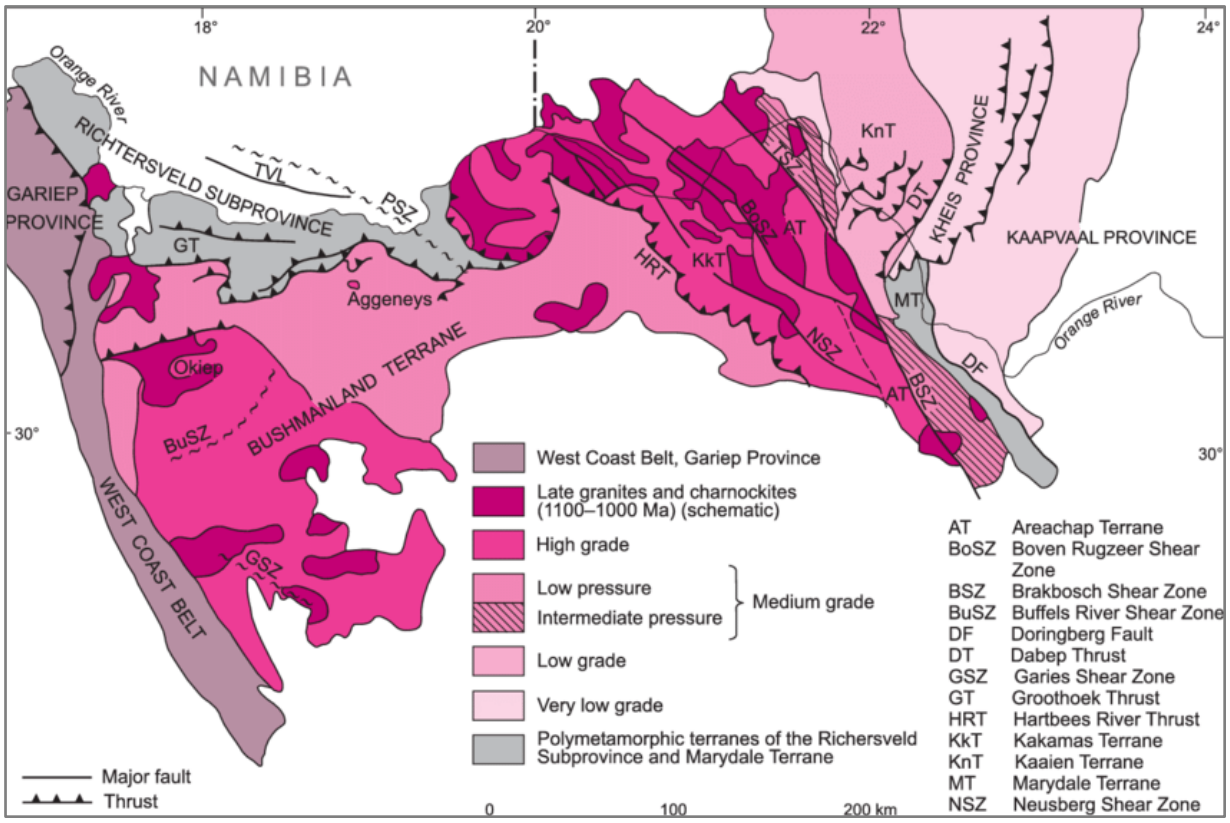

Figure 4-2.7: Geological terrains of the Namaqua Sector of the NMP (Cornell et al., 2006).

4.2.4 Geomorphology

Three geomorphological zones exist in Namaqualand: (1) the western coastal lowland or plain which is characterised by crystalline basement rocks overlain by younger sedimentary rocks and sands; (2) the escarpment zone of exposed granitic domes, interspersed with thick layers of weathered material cut by alluvial palaeochannels; and (3) the gently undulating Bushmanland Plateau consisting of erosional and aggradational phases (Adams et al., 2004; Titus et al., 2009; Van Gend et al., 2021).

The Orange River has preferentially eroded bedrock fractures, joints and foliations to form multiple channels which divide large (up to ~15 km long, ~2 km wide), numerous , stable islands formed of alluvium and/or bedrock. Notable changes in channel-bed gradient occur along the river which strongly controls anabranching - a river pattern which is characterised by multiple channels which divide and rejoin around semi-permanent ridges or islands (Tooth and McCarthy, 2004). Much of the groundwater abstracted from the alluvium near the river, is actually recharged from the river itself. The bedrock aquifer systems are mainly limited to fault-controlled valleys that occur throughout the study area and are traditionally targeted for the development of groundwater resources (Titus et al., 2009).

4.2.5 Land use and anthropogenic activities

The aridity of much of the study area means that large areas are rural with sparse settlements and little development, and includes large areas of natural vegetation, some of which overlie Strategic Groundwater Source Areas (see Section 4.7.2.5). Mining and agriculture are the main commercial activities in the study area, with the latter concentrated along the main stem of the Orange River. Mining occurs primarily along the West Coast and the lower reaches of the Orange River, and mining expansion is noted as a threat to the condition of some of the important estuaries along this coast (e.g. Groen and Spoeg estuaries – see Section 4.5.3.3). The larger towns in

the area (Springbok, Garies and Port Nolloth) service both the mining and agricultural industries. Most of the smaller towns / urban settlements occur along the Orange River or near to mines (DWS, 2024) (**Figure 4-2.8**).

The area has an exceptionally high biodiversity (Rundel and Cowling 2013) and is known for its annual production of indigenous (including highly endemic) spring flowers in particular, which support a growing tourism industry. While these extend over large parts of the Namakwa Region (Namaqualand) during spring flowering, the main nodes of tourism are the Namakwa National Park in the southwestern portion of the study area and the Richtersveld Transfrontier Park (extending over the Orange River into Namibia to the north).

Livestock grazing takes place in many areas, often at a subsistence level or supporting often impoverished small rural communities. Over-grazing is a problem in many areas, reflecting in changes in sediment type and load in many of the watercourses including the lower Orange River (DWS 2024). Grazing is often focused along ephemeral river beds, which provide more consistent water sources and foraging for livestock, but in places exacerbates erosion and degradation of these fragile systems (see Section 4.5.2.5).

With the very low rainfall over much of the area, surface water storage is limited and there are very few dams in the study area, and no big ones. **Figure 4-2.9** maps dam density, and shows that most of the study area has < 26 dams per quaternary catchment. Higher densities of dams occur in the wetter Kamiesberg Mountains of the Namaqua Highlands ecoregion, discussed in Section 4.5.2.1 and mapped in **Figure E1** (Appendix 1).

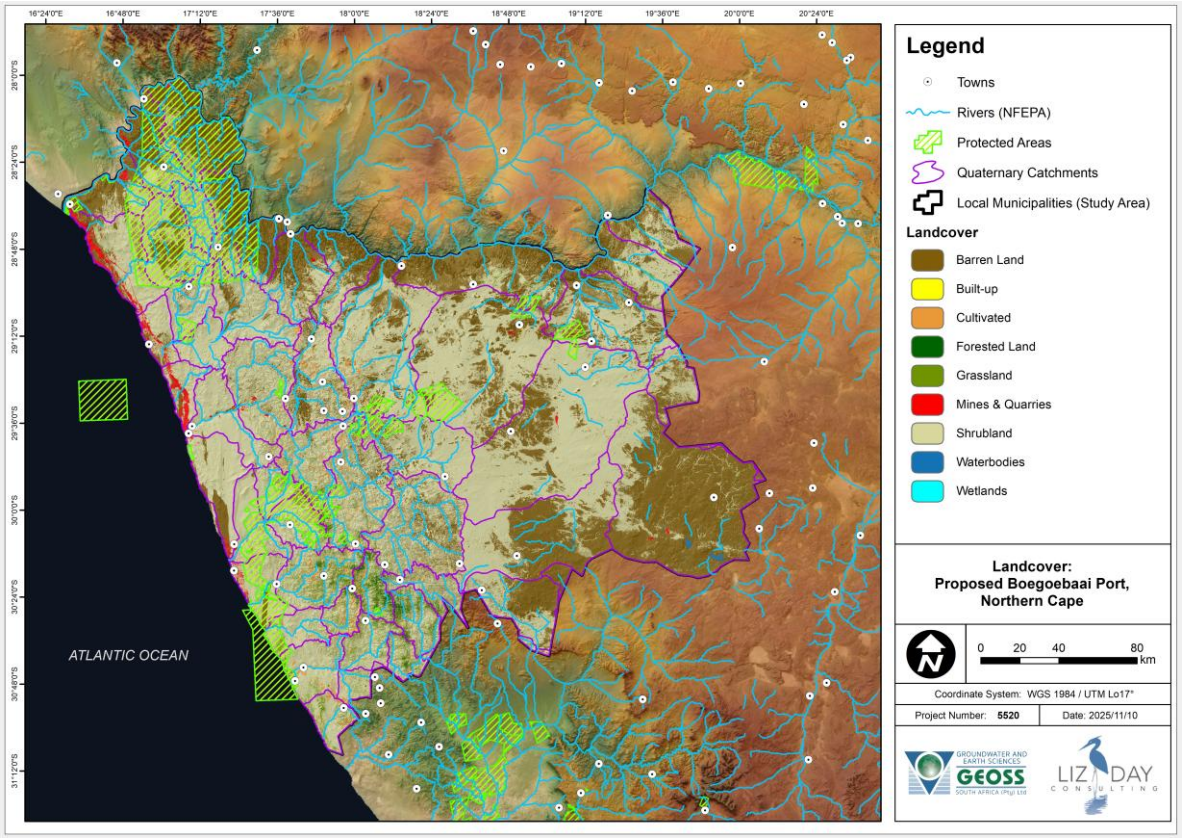

Figure 4-2.8: Distribution of Land-Use in the study area (SA Land-Use (2022))

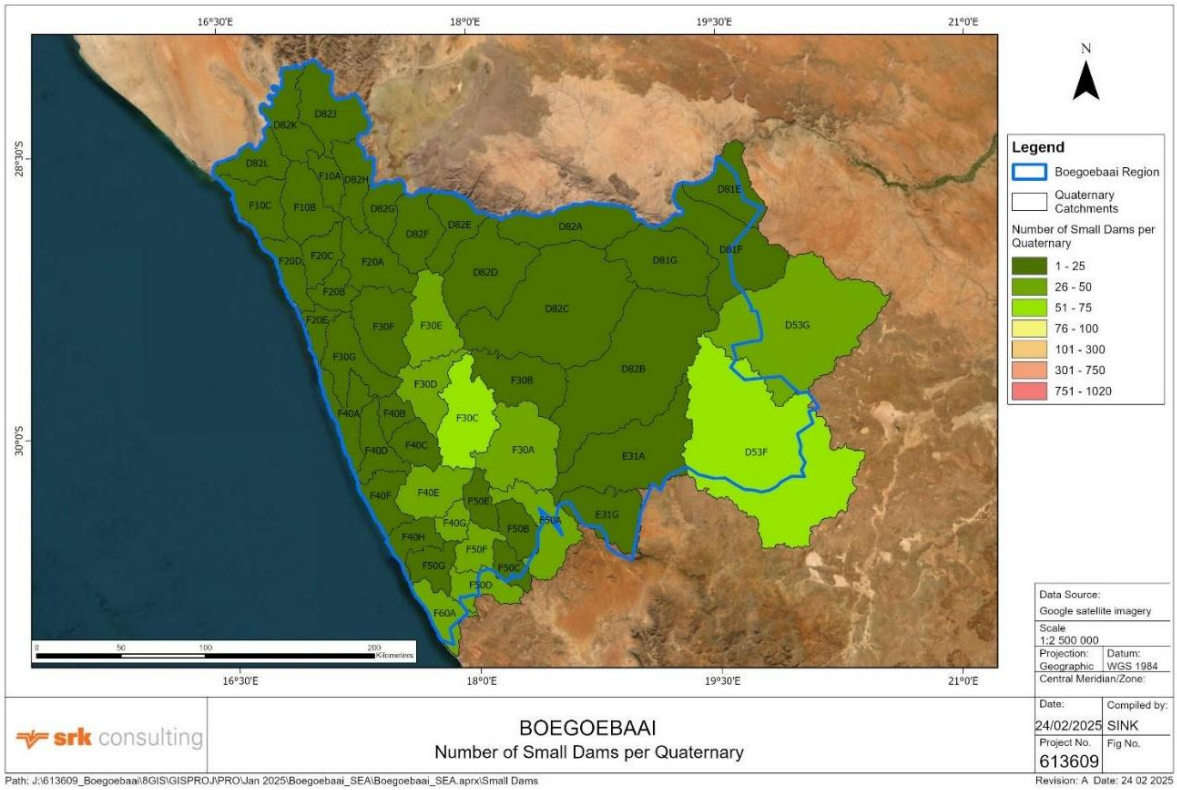

Figure 4-2.9: Distribution of the number of small dams per quaternary.

4.3 HYDROGEOLOGY

4.3.1 Groundwater occurrence

Groundwater occurs in three different aquifer systems in the region (Pietersen et. al. 2009), namely:

- Sandy/alluvial aquifers;
- Weathered zone or regolith;
- Fractured crystalline bedrock

Alluvial aquifers are closely interlinked with deeper fractured bedrock aquifer systems via weathered zones that serve as pathways for subsurface intergranular flow from the shallow alluvial aquifers to the deeper granitic, gneissic and bedrock aquifers (Benito et al., 2011; Marais et al., 2001a and 2001b; Van Gend et al., 2021). The granitic and gneissic host rocks, however, are associated with low primary porosity and groundwater is hosted in fractures and joint planes, though the effective porosity is variable as these fractures are not always interconnected. Consequently, the granitic and gneissic host rocks are associated with very low hydraulic conductivities in comparison to the alluvial aquifer systems (Watson et al., 2021).

4.3.2 Yield

Immediately beneath the proposed port zone, a fractured aquifer with an average borehole yield of 0.0 – 0.1 L/s is mapped (**Figure 4-3.1**). This fractured aquifer is mapped along the banks of the Lower Orange River between the towns of Sendelingsdrif and Alexander Bay, and extends along the coast from the South African-Namibian border before tapering out at Kleinsee. As one moves east and south from the aforementioned aquifer, intergranular aquifers are mapped to overlie fractured aquifers. From Kleinsee to the southern extent of the Greater Namakwa Region, both an intergranular and fractured aquifer are identified with similarly low yields, ranging between 0.0 – 0.1 L/s. Aquifer yields in the study area are generally poor along the borders of the larger study area, not exceeding an average yield of 0.5 L/s in the various aquifers. Towards the southeast, however, higher yields (0.5 – 2.0 L/s) are generally encountered in the intergranular and fractured aquifers spanning between Springbok, Garies and Kliprand (**Figure 4-3.1**).

4.3.3 Quality

Groundwater quality in the region is variable, but generally poor. The regional groundwater map indicates that the aquifers in the area have electrical conductivity values ranging between 70 mS/m to more than 1 000 mS/m (DWAF, 2001) (**Figure B6** in Appendix B). Groundwater in the area is often highly saline and unsafe to consume without treatment. The best quality water is observed in the higher-yielding aquifer located in the area spanning between Springbok, Garies and Kliprand. In this area, EC ranges between 70 – 300 mS/m which can be considered good to marginal quality in terms of domestic water standards (DWAF, 1998). Along the coast in the southern region of the greater study area (from Hondeklip Bay southwards), the poorest water quality is observed, mapped to exceed 1 000 mS/m. The groundwater quality observed in the rest of the greater study area ranges between 300 – 1 000 mS/m. It must be noted, however, that varying water quality can be encountered within a region due to stratification. Groundwater in different layers can exhibit distinctly different chemical compositions due to variations in composition of the host geology, mineral interactions, and the presence of contaminants.

The groundwater quality across the Namaqualand region is generally quite similar in composition, exhibiting a dominant Na-Cl signature throughout the various aquifers. The Na-Cl nature of the groundwater is either a result of the direct infiltration of Na-Cl-type precipitation, or the preferential dissolution and leaching of more soluble evaporitic salts during the infiltration process (Titus et al., 2009). Salt dissolution occurs as water infiltrates through the weathered overburden. Alternatively, the direct evaporation of precipitation results in the dry deposition of salts. Lower salinity water tends to be encountered in the alluvial aquifers and limited to the higher lying regions of the catchment, and higher salinity water in the basement aquifers as a consequence of mineral dissolution (Titus et al., 2009; Pietersen et al., 2009). Due to the stratification of better quality water in the alluvial aquifers overlying poorer

water quality in the basement aquifers, abstraction over time could result in a deterioration in the quality of fresher aquifers.

The poorer quality groundwater encountered in the region has often been attributed to high rates of evaporation. Analysis of stable hydrogen and oxygen data, however, suggests that evaporation does not play a major role in salinisation of the groundwater (Van Gend et al., 2021). Major ions and strontium ratios indicate that salts present in the groundwater are linked to dry deposition of marine aerosols and ion-exchange reactions in soils in the alluvial aquifer systems. The hydrochemical variability of the groundwater in the basement aquifer systems suggest that there are strong local controls linked to weathering processes in individual basement rock types (Van Gend et al., 2021). The region is also known for its high density of heuweltjies. Heuweltjies are large circular mounds associated with paleo and modern termite activity, and are generally up to 30 m in diameter, but may be as wide as 50 m, and up to 3 m in height. These structures are prominent throughout the region and have increased permeability due to biological activity of various endemic animal species (Lovegrove and Siegfried 1989). Heuweltjies occupy between 14 – 25% of the landscape (Lovegrove and Siegfried 1986; McAuliffe et al., 2019a; Picker et al. 2007) and contain elevated levels of micro and macro elements, including salts, in comparison to the surrounding soils (Kunz et al., 2012; McAuliffe et al., 2019a 2019b; Midgley and Musil, 1990; Midgley et al., 2012). Electromagnetic scanning and measurement of water-soluble soil EC values on and off heuweltjies show that the structures are saline, with salinity increasing with depth. Level of measured groundwater salinity correlates with level of heuweltjie salinity (Van Gend et al., 2021). Rainfall records from the last 150 years provide support for the hypothesis that accumulated salts, particularly heuweltjie salts, are flushed into the groundwater system during sporadic, large volume rainfall events. Heuweltjies could therefore, potentially represent a previously unrecognized contributor to groundwater salinisation across Namaqualand (Van Gend et al., 2021).

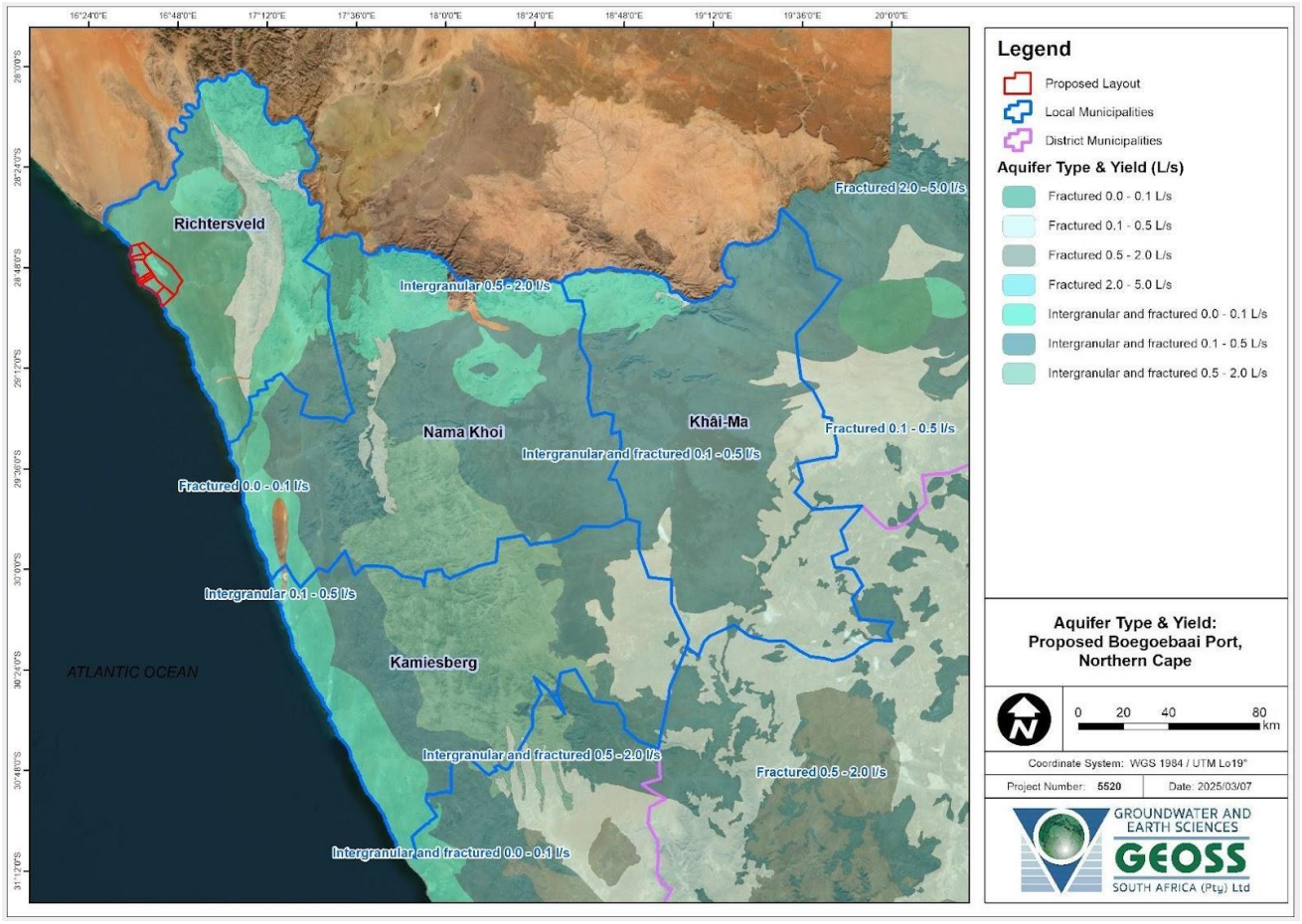

Figure 4-3.1: Regional aquifer yield (L/s) (DWAF 2001).

4.3.4 Recharge

Various estimation methods were undertaken by Adams et. al., (2004) in an attempt to estimate groundwater recharge across catchments F30, F40 and F50. Methods included: the chloride mass balance (CMB) method; cumulative rainfall departures (CRD) method; saturated volume fluctuation (SVF) method; statistical approaches and GIS analytical approaches. Results indicate that recharge rates to the basement and alluvial aquifers in the region are estimated to be within the range of 0.1 – 10 mm per annum, with higher values being associated with alluvial aquifers and high altitude sites, and the lower limits to the fractured rock aquifers (Adams et al., 2004; DWS, 2016). Groundwater recharge decreases from the escarpment zone to the coastal zone, i.e. from east to west (Adams et al.. 2004; DWS. 2016). Further, stable oxygen and hydrogen isotopes indicate that indirect recharge is dominant in the region, involving the infiltration of surface runoff as well as discharges from springs and adjacent aquifers. Direct recharge only dominates in the mountainous areas as a result of higher rainfall volumes over these areas due to the orographic effect (Adams et al., 2004). Alluvial aquifers are easily recharged on account of their hydraulic characteristics and position within the landscape. Flood events also produce significant recharge to these aquifers. The structural control on the ephemeral drainage systems is evident in their alignment along fracture systems that are associated with the underlying bedrock (Adams et al., 2004). Alluvial aquifer systems are important pathways for groundwater recharge to the weathered and bedrock zone aquifers (Adams et al., 2004). Isotope data for the groundwater indicates variable mean residence times, ranging from very young (<50 years) to very old (>30 000 years). Intermediate ages are an indication of active mixing of younger and older water (Adams et al., 2004)

4.4 SURFACE WATER RESOURCES

4.4.1 Catchment context

Most of the study area lies in the Vaal- Orange Water Management Area (WMA) – the largest WMA in South Africa, which includes the whole of the Orange River's catchment within the country. Parts of the southern boundary of the study area do however extend into the Breede-Olifants WMA – a large and complex WMA including the catchments of the Olifants, Berg, Breede and Gouritz Rivers, as well as numerous smaller river catchments that drain into the Atlantic and Indian Oceans via estuaries or other outlets.

Within the present study area, the above WMAs are in turn made up of four secondary catchments, comprising the Coastal Orange, Orange and Orange Tributaries sub-WMAs within the Vaal-Orange WMA, and the Knersvlakte sub-WMA, in the Breede-Olifants WMA.

Fifty-nine quaternary catchments have been mapped in these sub- WMAs, and form the basis for much of the surface and aquatic ecosystems catchment descriptions and assessments provided in this section. The quaternaries and the four sub-WMAs are shown in **Figure 4-4.1**. Of the watercourses shown in the figure, only rivers within the Orange sub-WMA flow into the Orange River itself, and in this region, many of these only flow occasionally and some never reach the river at all. The Orange River receives most of its runoff from upstream(Upper Orange WMA).

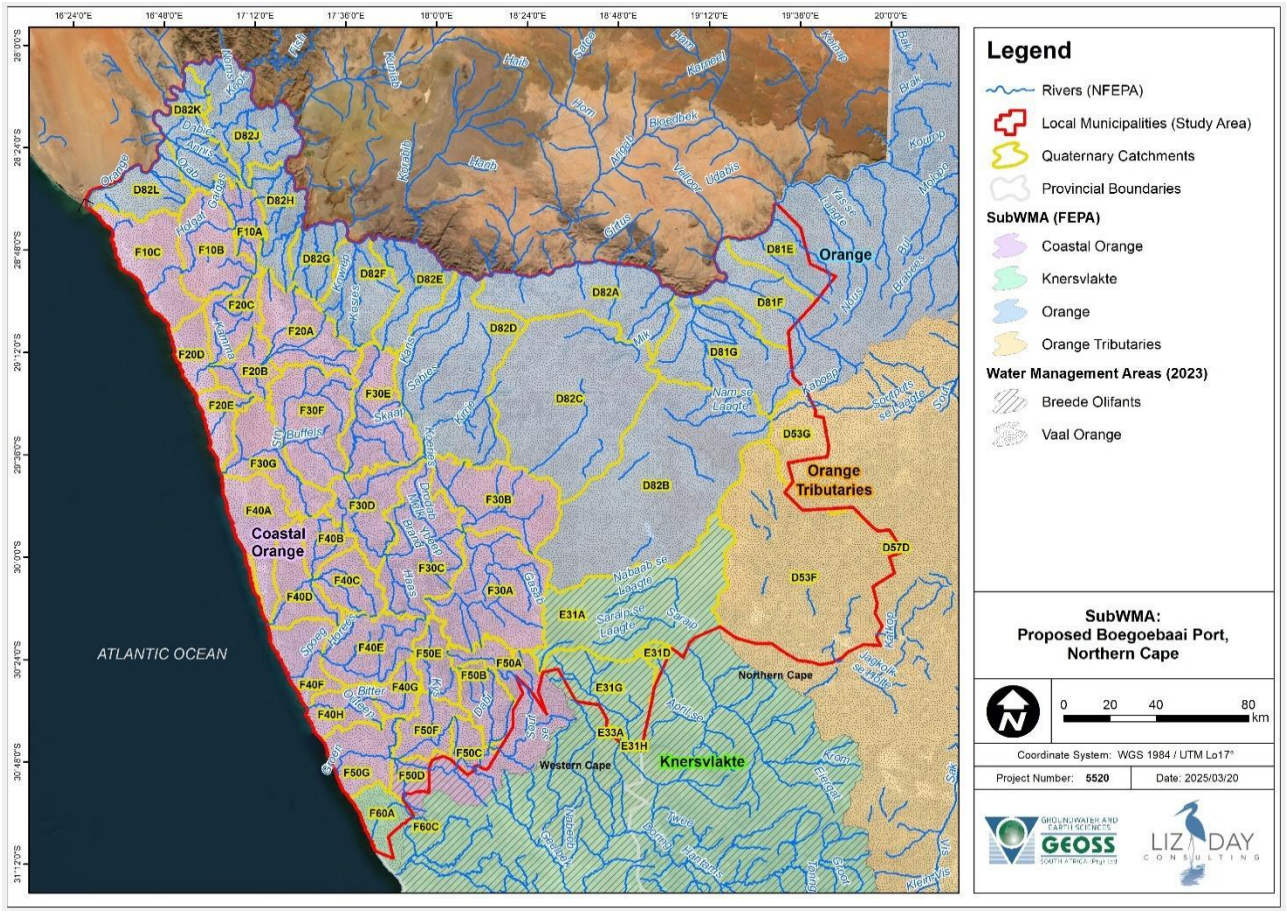

Figure 4-4.1: Study area in the context of DWS Water Management Areas and Sub Water Management Areas (SubWMA) from the NFEPA programme (Driver et al., 2011).

4.4.2 Surface water hydrology

The entire study area is classified as either Hyper-Arid or Arid, with no Semi-Arid catchments. The surface water resources are therefore very limited, with ephemeral streams and sporadic runoff events, mostly lasting for only a few days, with long dry periods in between events. The surface water runoff has been assessed on a Quaternary catchment basis.

4.4.2.1 Quaternary Runoff

4.4.2.1.1 Endoreic Areas

Two large Quaternary catchments (D82B and D82C) are completely endoreic as illustrated in **Figure 4-4.2**. This means that no surface runoff or stream discharge leaves these catchments, and all internal surface runoff terminates in internal pans or groundwater recharge zones. A few other Quaternaries have a portion of their area defined as endoreic, but otherwise most have drainage features that leave the Quaternary.

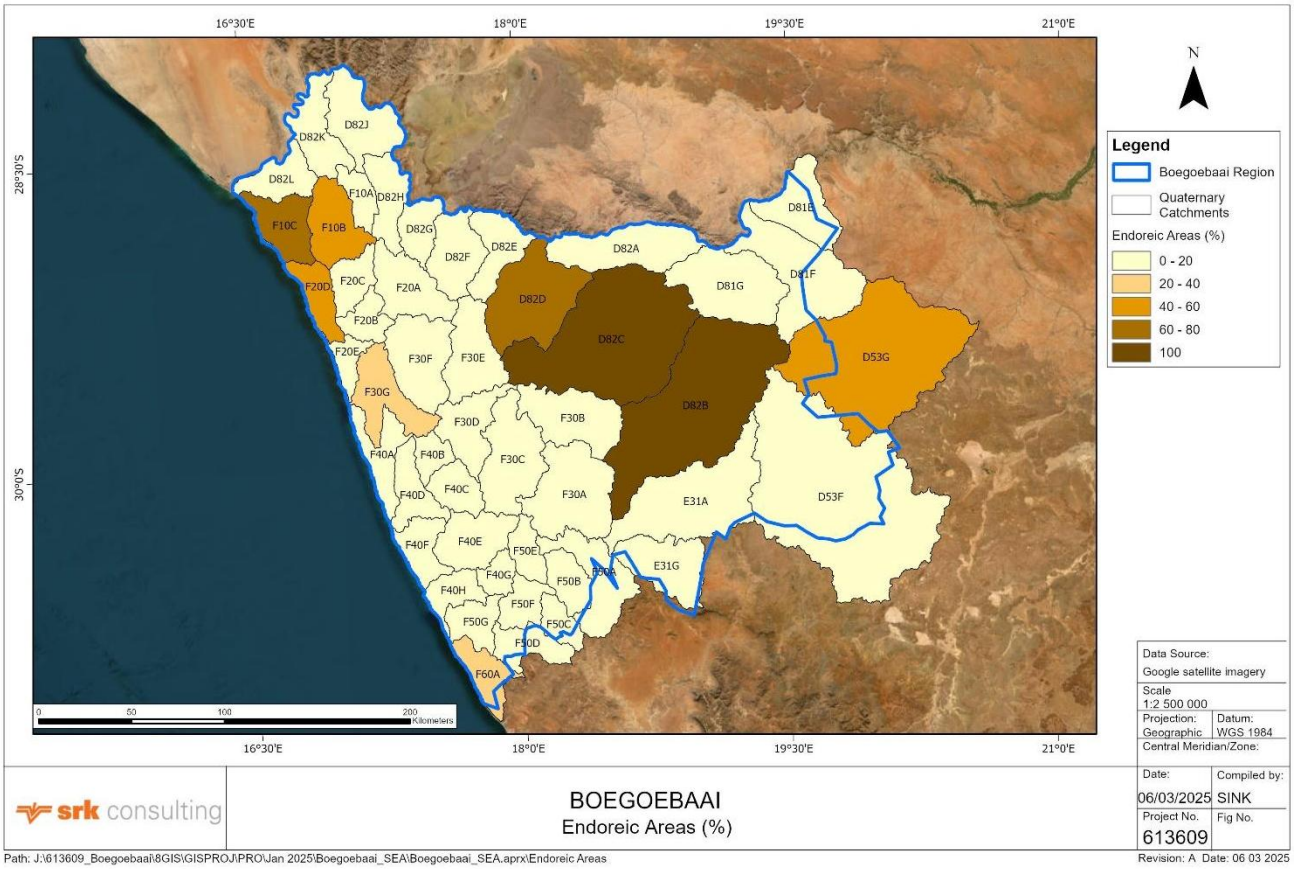

Figure 4-4.2: Distribution of endoreic areas (Mantel and Hughes 2023).

The Mean Annual Runoff (MAR) for the Quaternary catchments in the study area has been estimated in WR2012. These estimates reveal mean annual quaternary runoff varying from a minimum of 0 (completely endoreic) to a maximum of 1.24% of the average annual precipitation, with the average of all Quaternaries without endoreic areas reporting MAR of 0.57% of MAP. However, average annual estimates of runoff are misleading in areas with such sporadic runoff regimes. An effort was therefore made in this project to estimate the distribution and magnitude of runoff events and dry periods between these.

Simulations of the quinary catchments making up the quaternaries in the study area have been modelled using the ACRU agro-hydrological model, with daily meteorological inputs (Schütte *et al.* 2023). These simulations were calibrated using observed daily runoff data from two stations, F5H001 and F5H002 as well as a daily runoff record derived from a study on the Buffels river (Benito *et al*. 2011). The stations and contributing catchments are illustrated in **Figure C2.2** (Appendix C).

The simulated and observed flow regimes for the Buffels river catchment indicate the sporadic nature of runoff, with all discharge events occurring over less than 10% of the time (**Figure 4-4.3**).

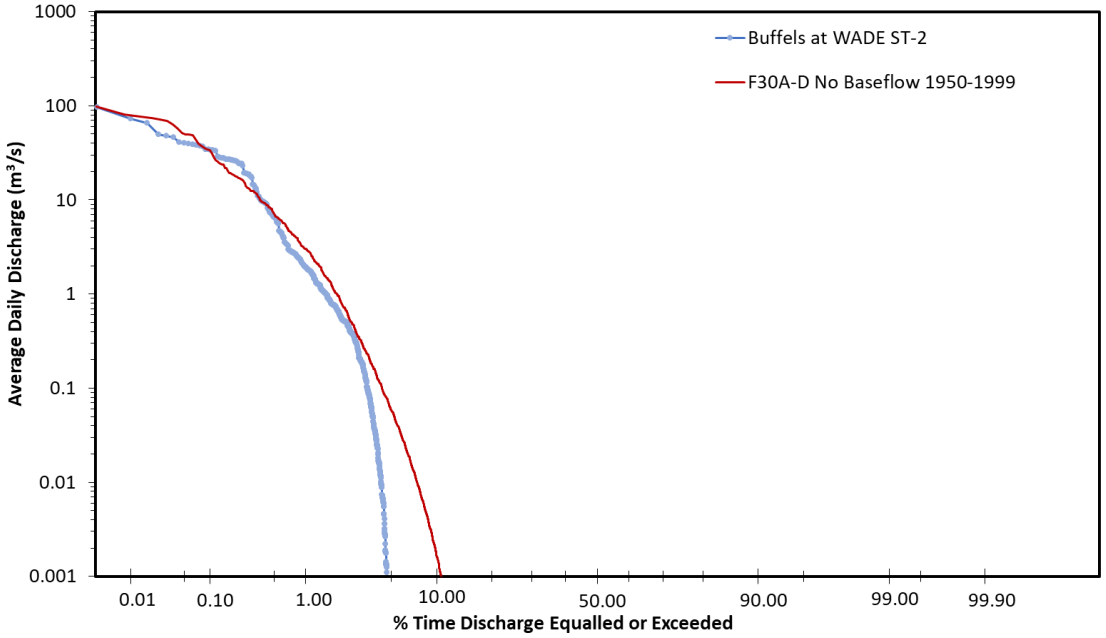

Figure 4-4.3: Comparison of simulated and observed flow regimes for the Buffels river (ZADE station 2 in Figure C2.2 (Appendix C)).

The simulated runoff for all quaternaries resulted in similar flow regimes and very low annual runoff. The MAR is predominantly less than 2 mm per annum, with the lowest MAR along the coast, increasing towards the east, particularly in the high lying interior, decreasing again, eastwards on the leeward side of the mountains and finally increasing again in the far east of the region and far north along the Orange River (**Figure C2.3** (Appendix C2)). The Quaternary MARs are generally less than 1% of the MAP, except in the far east and north, where the Quaternary MARs are some 2% of MAP (**Figure C2.4** (Appendix C2)).

Mean Annual Runoff is predicted to decrease by 20-40% over most of the region in the Near Future (2050). A few Quaternaries in the coastal north and in the far east of the region are predicted to increase (up to 20%) in the Near Future (**Figure C2.5** (Appendix C2)).

This result is derived from the average of six GCMs applied to the study area. (Schütte, *et al*. 2023). The highest of the GCMs predicts mostly increasing MAR, while the lowest GCM predicts decreasing MAR everywhere (**Figures C2.6** and **C2.7** (Appendix C2)).

Long periods without any flow occurring (No-Flow periods) are particularly prevalent throughout the region. The average duration of No-Flow periods ranges from 334 to 365 days (**Figure C2.8** (Appendix C2)), while the longest period of No-Flow in the 50-year simulated record, ranges from 3 to 7 years over most of the region, with maximum No-Flow durations reaching 16 years in the north coastal region (**Figure C2.9** (Appendix C2)).

No-Flow periods are predicted to decrease in number but increase in duration in the Near Future (2050) (**Figures C2.10** to **Figure C2.13** (Appendix C2)).

4.4.3 Water quality

4.4.3.1 General

The study area includes two very different kinds of surface aquatic systems, the one (the Orange River) driven by upstream flows and subject to high levels of water use for agriculture, industry and domestic use throughout its reaches in South Africa, and the other, comprising ephemeral to seasonal rivers and other watercourses, some of which feed into the Orange River while others flow into the Atlantic Ocean on the West Coast via estuaries (classified by Van Niekerk *et al.* 2020 as Cool Temperate Arid Predominantly Closed Estuaries) or micro-outlets, or simply dissipate into the surrounding landscape or the underlying aquifer.

4.4.3.2 Overview of water quality in the Lower Orange River (current study area)

The DWS monitors water quality in important mainstream rivers. The only DWS water quality monitoring sites in the present study area are located along the Orange River and comprise six sites, between Onseepkans in the east and Alexander Bay in the west. Summary water quality data for these sites, extracted from DWS (2024a) are presented in **Table D1** (Appendix D). These data, which cover variable time periods between 1965 and 2023, suggest that:

- River salinities (measured by electrical conductivity (EC) data) are variable, but increase with distance downstream, while also showing high inter seasonal variability;
- Median orthophosphate data suggest that the river lies within the mesotrophic range of DWAF (1996) and in a Present Ecological State (PES) Category C (as per DWAF (2008b) thresholds), although the range of data indicate at least periodic increases in enrichment of this nutrient to well over hypertrophic thresholds, at at least some of the sites in this dataset;
- Median nitrogen nutrient data also suggest that the river over the reflected monitoring period was generally in an oligotrophic condition (PES Category C to A/B in terms of DWAF (2008b)), although maximum concentrations per site indicate at least periods when nitrogen enrichment fell into a Category D for this variable (again, as per DWAF 2008b);
- Median total ammonia concentrations were low at all sites. However, maximum concentrations at times would have fallen within the range where concentrations of the un-ionised component of this variable (NH_3) would have exceeded thresholds of concern for acute or chronic ecosystem toxicity (as per DWAF 1996 at the cited pH levels and assumed temperatures of 20°C).

DWS (2016a) summarises water quality data for the two Ecological Water Requirement (EWR) sites located along the Orange River, indicating water quality in a PES Category C/D at EWR04 (Vioolsdrift) and PES C at EWR05 (Sendelingsdrift), and citing agricultural return flows, abstraction and mining activities as the main causes of concern along these reaches.

Coleman and van Niekerk (2007), drawing on the above datasets for the period up until 2004, provide summary data that illustrate a deterioration in water quality in the lower reaches of the Orange River (Vioolsdrift site) from an irrigation perspective, with just over 50% of samples only lying within the "Ideal" range for irrigation (< 40 mS/m), although the rest remained in the Acceptable range. These compared with over 75% of samples being in the Ideal range at the nearest assessed monitoring site at Upington. Sulphate and orthophosphate concentrations at Vioolsdrift were also elevated compared with the upstream site, with more than 35% lying in the "Tolerable" range and the rest in the Acceptable range. These authors suggested largescale mining activities to be the key source of sulphates, while return flows from irrigation areas contribute salinity and nutrients to the river. Salinity is exacerbated by high rates of evaporation.

Elevated orthophosphates have resulted in a history of cyanobacterial blooms in the lower river, leading at times to odour and colour problems in the river and affecting the intake water to various water treatment plants (Coleman and van Niekerk 2007).

4.4.3.3 Water quality in ephemeral rivers and arid estuaries

DWS (2017a) comments that water quality in at least some of the ephemeral watercourses and small estuaries and micro-outlets south of the Orange River Estuary mouth was also affected by:

- Groundwater abstraction for mining, which reduces flows and leads to increased salinities in groundwater fed systems (e.g. Groen River Estuary);
- Discharges of nutrient-enriched and otherwise contaminated water from WWTWs;
- Nutrient inflows (often as seepage) from areas irrigated with treated effluent from WWTWs and from ablution facilities at resorts located near to watercourses (e.g. Groen River Estuary);
- Inflows of suspended sediments (during flood conditions), from catchment scale erosion, exacerbated by mining, poorly designed road culverts, poor livestock farming practices and overgrazing.

That said, the above report also notes that water quality in the small estuaries in the present study area generally remained in a fairly good condition, compared with their reference state.

4.4.3.4 Impacts of waste water treatment works

Table D2 (Appendix D) summarises Critical Risk Ratings (CRRs) for the WWTWs in the four municipalities making up the present study area. The CRRs presented were obtained from the DWS 2024 Green Drop Report (DWS, 2023). Of the 16 WWTWs assessed in the report, 14 had a CRR of 100%, reflecting the highest possible risk rating ("Critical"), indicative of systemic failures throughout the works that resulted in complete failure to achieve physical or chemical compliance. The remaining two WWTWs assessed had CRRs of 80 – 90%, rated as High Risk. All 16 WWTWs showed major declines in performance since 2011, when three were rated as Low Risk; two as Medium Risk; and only two of the (then assessed 13 WWTWs) were rated Critical.

Data regarding individual effluent disposal methods from these WWTWs are limited. Where treated effluent is used for industry, agriculture, irrigation of golf courses and other amenities, and/or discharged into watercourses or allowed to infiltrate into the water table, the quality of final effluent for such uses is important in determining its impacts. Where WWTWs are dysfunctional, all of these uses could present an increasing risk of contamination of groundwater as well as of surface water courses, including the Orange River, which receives effluent from three of the listed WWTWs within the study area (Appendix D). Poorly treated effluent would contribute to the elevated nutrients already noted as a problem in the Orange River and affecting some of the ephemeral tributaries and their estuaries.

4.4.4 Surface and groundwater interactions

The Namakwa region experiences low rainfall and high potential evaporation rates, which have a significant impact on the net recharge of local aquifers (Nakwafila, 2015). The only perennial river system in the region is the Orange River, along which only two catchments are listed as contributing baseflow; neither of which fall within the study area. Consequently, groundwater plays a minimal role in maintaining baseflow in rivers in the region (DWS, 2016). Watercourses in the region are ephemeral and only flow after heavy rainfall events that occur once every several years (Makubalo and Diamond, 2020).

In the study area, alluvial aquifers have been associated with ephemeral rivers, paleochannels and coastal plains. Ephemeral surface water provides recharge to alluvial groundwater systems through typically dry riverbeds. The aquifers associated with ephemeral river systems have generally been observed to be shallower than those associated with the coastal plain (Pietersen et al., 2009). Groundwater-surface water interaction has not been sufficiently studied in the Northern Cape due to limited surface water, however, surface water fed alluvial aquifer systems are considered to be important pathways for groundwater recharge to the weathered and bedrock zone aquifers (Adams et al., (2004).

4.5 AQUATIC ECOSYSTEMS

4.5.1 Overview

Aquatic ecosystems considered in this chapter include inland and estuarine ecosystems, as defined in Section 4.1.5. Included among the latter are the small, highly ephemeral micro-outlets, described in Van Niekerk *et al.* (2020), while the inland ecosystems include rivers, wetlands, pans and springs, variously connected to surface and/or groundwater sources. **Figure 4-5.1** shows the main rivers and estuaries within the study area, in the context of regional topography. The figure highlights the extensive north-south running mountain ranges just inland from the coast with its undulating dunes and sandy soils. The mountain ranges include the Kamiesberg, within the western section of the Namaqua National Park. In the north of the study area, the Orange River Canyon includes the Orange River and the Richtersveld area, with its steep, rocky terrain that drops down to the fertile Orange River floodplain below. For the rest, the topography is generally flat with undulating sands and some areas characterised by large pans or endoreic areas.

This section (Section 4.5) provides an overview of these systems, to inform subsequent considerations of the ecological implications of the proposed Boegoebaai Port development and associated likely regional expansion of renewable energy in the Namakwa region. The section deals with inland and estuarine aquatic ecosystems separately.

4.5.2 Inland aquatic ecosystems

4.5.2.1 Ecoregions

Ecoregions are areas within which groups of rivers share similar physiography, climate, geology, soils and potential natural vegetation. An ecoregional classification produced by Kleynhans *et al.* (2005) divided South Africa's rivers into 31 distinct ecoregions. These are shown in **Figure E1** (Appendix E), in the context of the present study area.

The study area straddles four ecoregions, namely the Western Coastal Belt ecoregion, which runs in a relatively narrow band parallel with the coast; the Namaqua Highlands ecoregion, which coincides with the north-south mountains and hills described above and includes part of the Richtersveld National Park; the Nama Karoo ecoregion, which covers the largest part of the study area; and the Orange River Gorge ecoregion, which includes the Orange River and its rocky gorge, as well as sections within the Richtersveld National Park.

These ecoregions are all characterised by very low and highly variable rainfall, with the Nama Karoo and Western Coastal Belt ecoregions generally having few river watercourses, compared with medium to high drainage density and stream frequency in the other two ecoregions. Rain, when it does fall, tends to occur in late summer to winter in the Orange River Gorge ecoregion, versus winter rainfall in the other ecoregions. These subtle differences as well as differences in geology and geomorphology (see Section 4.2) help to account for differences in aquatic biodiversity in rivers through these areas and are the basis on which Ecosystem Threat Status is assigned to different groups of rivers in the National Biodiversity Assessment (Van Deventer *et al.,* 2019).

Table 4-5.1 summarises the relative Threat Status of different river types in the above ecoregions. Of the various river types, perennial /seasonal lowland rivers in the Western Coastal Belt, and all perennial /seasonal rivers in the Namaqua Highlands ecoregion are the most threatened (Critically Endangered or Endangered).

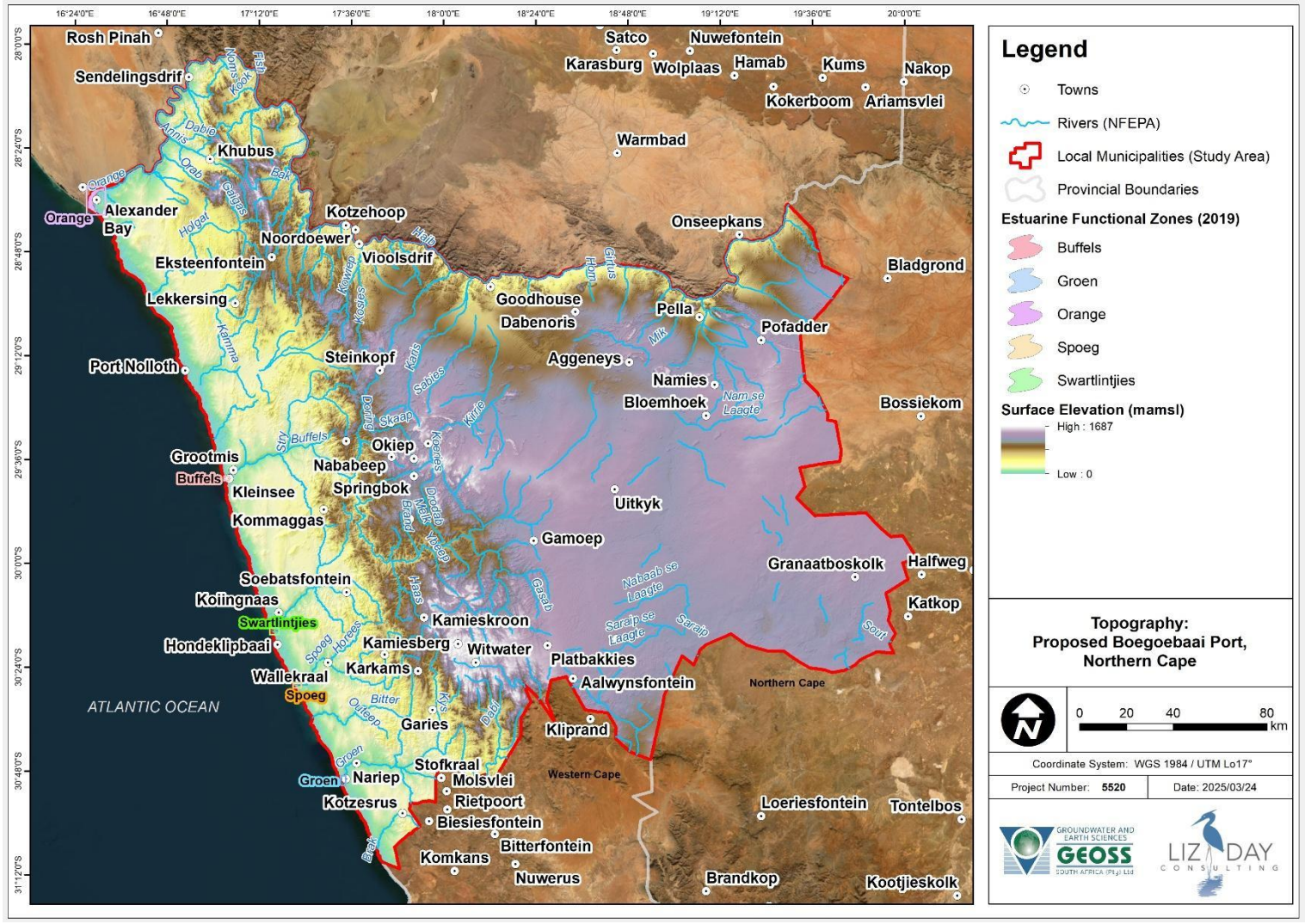

Figure 4-5.1: Main (1:500 000) rivers and mapped estuaries within the study area, in the context of regional topography

Table 4-5.1: Threat Status of different river types per ecoregion. Data from Van Deventer *et al.* (2019).

See Appendix E, Figure E1 for ecoregion map. Critically Endangered systems highlighted in red.

Level 1 ecoregion	Flow variability	River type	ETS	EPL
Western Coastal Belt	Ephemeral	Lowland river	LT	WP
		Lower foothill	LT	WP
		Mountain stream	VU	PP
		Upper foothill	LT	MP
	Perennial/Seasonal	**Lowland river**	**CR**	**NP**
		Lower foothill	LT	WP
Nama Karoo	Ephemeral	Lowland river	LT	NP
		Lower foothill	EN	NP
		Mountain stream	LT	PP
		Upper foothill	LT	NP
	Perennial/Seasonal	**Lowland river**	**CR**	**PP**
		Lower foothill	EN	NP
		Mountain stream	**CR**	**NP**
		Upper foothill	**CR**	**NP**
Namaqua Highlands	Ephemeral	Lowland river	LT	NP
		Lower foothill	LT	PP
		Mountain stream	LT	MP
		Upper foothill	LT	MP
Orange River Gorge	Ephemeral	Lowland river	LT	WP
		Lower foothill	LT	WP
		Mountain stream	LT	PP
		Upper foothill	LT	WP
	Perennial/Seasonal	Lowland river	LT	MP
		Lower foothill	LT	NP
		Upper foothill	LT	WP

4.5.2.2 River FEPA status

The National Freshwater Ecosystem (NFEPA) Programme (Driver *et al.,* 2011) includes rated Freshwater Ecosystem Priority Areas (FEPAs). These are described and their spatial extent in the study area illustrated in extent in Appendix E (Section E1 and **Figure E2**). The latter figure indicates that:

- Most of the sub-quaternaries in the Orange River Gorge ecoregion have been accorded **FEPA** status, recognising the importance of this river system and its associated wetlands;

- Other parts of the study area that have FEPA status include least-impacted sub-quaternaries in the Spoeg, Groen and Swartlintjies catchments, all of which support important downstream estuaries on the West Coast (See Section 4.5.3.3) as well as ephemeral to seasonal wetlands within the mapped FEPA sub-catchments;

- The sub-quaternaries of the upper reaches of the ephemeral Holgat River have also been mapped as river FEPAs, along with the sub-quaternary of the ephemeral Kwaganap River, which is too ephemeral to support any functional estuary but is relatively unimpacted along its river reaches;

- Large areas of the study area have been accorded **Upstream FEPA** status. These sub-quaternaries lie mostly in the Namaqua Highlands ecoregion, and feed into the important Holgat, Swartlintjies and Buffels River systems but include the Goob se Laagte sub-quaternary, which is one of the few rivers that flow (albeit ephemerally) into the Orange River near the northeastern site boundary. Management of these systems in good condition is intended to protect important downstream ecosystems – in this case, the Orange River;

- Six sub-quaternaries along the Orange River just upstream of its estuary have been rated as Fish Corridors that are important for the protection of vulnerable or near-threatened indigenous fish species, in this case, [2]*Barbus hospes* (Namaqua barb);

- Phase 2 FEPA status has been assigned to the lower reaches of the Groen and Swartlintjie subcatchments, as well as to the sub-quaternary in the northwestern corner of the site, associated with and draining into the Orange River. The Orange River estuary has been accorded Ramsar wetland status, indicative of a wetland with extremely high conservation importance, at an international level, and rehabilitation of areas surrounding the estuary and its associated wetlands would support its conservation;

- Many subcatchments in the study area have no River FEPA status – these are largely areas that drain towards the west, but in which there are no watercourses or those that occur are too ephemeral to support downstream ecosystems of ecological importance. Sub-catchments within the largely to wholly endoreic quaternary catchments D82B-D are included among these (see **Figure E3** in Appendix D). These areas do not support any river systems – but include important ephemeral pans, discussed later in this section.

4.5.2.3 Regional conservation planning data (Northern Cape Biodiversity Planning data)

Regional conservation planning data from the Northern Cape Biodiversity Planning dataset (Northern Cape Department of Environment and Nature Conservation 2018) were accessed for this assessment and overlain as GIS data over the study area and surrounds. These data do not differentiate between aquatic and terrestrial ecosystems, as shown in **Figure E4** (Appendix E). However, the overlays of rivers and NBA (2018) wetlands do show where aquatic ecosystems may contribute to high conservation status in some areas. The data show that virtually the whole study area has some level of status in biodiversity planning, with large areas in the central and east to south eastern parts of the study area being mapped as "Other Natural Areas" (indicating relatively low levels of development overall in this region), while extensive Critical Biodiversity Areas (CBAs) level 1 and level 2 extend along the Orange River Gorge, Namaqua Highlands and Western Coastal Belt ecoregions. These areas include rivers, wetlands and pans, within a broader terrestrial matrix.

The numerous pans that occur in the southeastern corner of the site have been rated as "Other Natural Areas" only, with the exception of a few of the larger ones, rated as Ecosystem Support Areas.

Parts of the western portion of the study area, particularly along the coastal area in the north, have not been included among conservation priorities, presumably due to extensive mining and other development in these areas.

[2] Note that *B. hospes* has subsequently been re-named *Enteromius hospes* – this species is rated as Least Threatened and is likely to have benefited from more continuous base flows (from dam releases) compared with natural conditions (SANBI data: https://speciesstatus.sanbi.org/assessment/last-assessment/47/, Accessed November 2025)

4.5.2.4 Wetland bioregions

Data from the National Biodiversity Assessment (NBA) of aquatic ecosystems (Van Deventer *et al.* 2018) show that aquatic ecosystems within the study area fall within the following bioregions:

- Bushmanland Bioregion, which comprises the dry inland quaternaries that slice from south of the Orange River in the centre of the site, across to the south western site boundary and including the endoreic areas mapped in **Figure E3** (Appendix E) – most of the mapped wetlands (pans) are wetland depressions, rated as Critically Endangered wetland types (see **Table 4-5.2**);

- Richtersveld Bioregion, comprising wetlands in the Richtersveld area, south of the Orange River, within the Orange River Gorge ecoregion;

- Gariep Desert Bioregion, comprising wetlands (pans) in the northeastern part of the site;

- Namaqualand Sandveld Bioregion, including wetlands (pans) along the entire coastal strip within the site;

- Namaqualand Cape Shrublands Bioregion, comprising wetlands in the southern section of the high-lying Namaqua Highlands;

- Namaqualand Hardeveld Bioregion (with only one "wetland seep" mapped in this area;

- Southern Namib Desert Bioregion, including a few wetlands just south of the Orange River Estuary.

The conservation status of different wetland types within these bioregions is summarized in **Table 4-5.2** and the distribution of mapped wetlands is illustrated in **Figure E5** in Appendix E. It must however be noted that in some instances there is evidence of extensive historical mining / disturbance within mapped CBA regions. Nevertheless, the CBA status of the above areas remains, and even disturbed areas may contribute towards the maintenance of ecological corridors, particularly along the coastal zone.

Note that the wetlands of the Orange River estuary itself are classified as estuarine ecosystems and discussed in Section 4.5.3.2.

Table 4-5.2: Distribution (by quaternary catchment) and conservation status of different wetland types within the study area, classified using the hierarchical classification system of Ollis *et al.* (2013) and the bioregions and Ecological Threat Status provided in NBA (2018). DEP=Depression; VBW=Valley bottom wetland; FLOOD=floodplain wetland; Seep=seep wetland. Cr=Critically Endangered; EN=Endangered; V=Vulnerable; LC=Least Concern

Bioregion	Quaternaries in Study Area (with wetlands)	Wetland Ecosystem Threat Status			
		Dep	VBW	Flood	Seep
Bushmanland Bioregion	D82B, D82C, D82D, D53F, D53G, E31A, E31G	CR	CR	CR	V
Gariep Desert Bioregion	d82A, d82E, d82F, d82g, d82g, d82g, d81E, D81g	LC	CR	-	CR
Namaqualand Sandveld Bioregion	f40D, f40E, f40F, f40H, f50G, f60A	CR	CR	-	LC
Namaqualand Cape Shrublands Bioregion	f30A, f30C, f50E, f30C, f30C, f30C,	CR	CR	LC	LC
Namaqualand Hardeveld Bioregion	F50A, F50B, F50E, F50B,	LC	CR	-	CR
Southern Namib Desert Bioregion	D82L	LC	-	-	-
Richtersveld Bioregion	D82a, d82c,	EN	V	-	LC

4.5.2.5 Description of main inland aquatic ecosystems in the study area

Inland aquatic ecosystems in the study area can usefully be separated out into those associated with the Orange River, which is the only large, perennial river that passes into and through the site, driven primarily by upstream flows from its inland catchment; and the ephemeral rivers, pans and wetlands that occur in the remainder of the site, and which are characterised by an arid climate, with low, unpredictable rainfall and at times long periods (months to several years) of no rainfall (see Section 4.2). **Figure E7** (Appendix E) suggests that, over a 30-year period (based on modelled data derived from Schütte *et al.* 2023), there would be:

- At least four periods where there was no rainfall within 200 days;
- At least five periods where there was no rainfall within two years;
- At least two periods where there was no rainfall within three years;
- At least one period where there was no rainfall within six years.

The above data highlight the aridity of the study area and illustrate the conditions to which natural ecosystems are adapted. **Figure E7** also highlights how these figures will alter in a climate change scenario, with at least one period in 30 years where there would be no rainfall for six years.

4.5.2.6 The Orange River and its tributaries

Within the study area, none of the tributaries of the Orange River contribute significantly to flows in the river or its estuary. In fact, the RSA tributaries entering the Lower Orange Sub-WMA (an area much larger than the present study area) account for only about 1.9% of total flows in the Lower Orange River (DWS 2016a).

DWS (2016a) summarises ecoclassification results for the Lower Orange River, drawing on previous studies (e.g. Louw and Koekemoer (2010) and Louw *et al.* (2013)). Of the four riverine EWR sites used to determine ecological flow requirements in the Lower Orange River, two are located within the study area (EWR 04 and EWR 05, at Vioolsdrift and Sendelingsdrift, respectively). Ecoclassification results for these sites indicate a Present Ecological State (PES) (at least at the time of these studies) of Category C (moderately modified) and Category B/C (largely natural to moderately modified) for these sites respectively, suggesting improvement with distance downstream. Both sites were accorded Ecological Importance and Sensitivity (EIS) ratings, and the report notes that degradation from natural conditions at both sites is the result of loss of frequency of large floods; agricultural return flows; higher low flows than natural in the dry season; decreased low flows at other times; sediments from dam releases; the presence of alien fish; mining activities; alien vegetation; and grazing and trampling by livestock.

EIS was rated as High for both sites, and this contributed to the Recommended Ecological Categories (REC) for the sites of Category B/C and B respectively, implying a need for improvement in river condition. These recommendations are also in line with requirements for improvement in the Orange River Estuary condition, rated as of Very High EIS (see Section 4.5.3).

Measures to improve watercourse condition in the above reaches so as to achieve their respective RECs should focus on increasing wet season base flows; clearing of alien vegetation; controlling grazing and trampling (EWR04); and reinstating dry season droughts (EWR05) (DWS 2016a).

Five resource units (RUs) along the Orange River reaches within the study area have been included as Priority Resource Units for the development of Resource Quality Objectives (RQOs) in the Lower Orange River Water Resource Classification Project (DWS 2024b). These comprise the river in its reaches from Augrabies Gorge to Pella (that is, including all the river reaches in the study area as far as Pella); Pella to Vioolsdrift weir; Vioolsdrift weir to quaternary D82H; the downstream river reaches within the Richtersveld National Park; and the upstream portion of quaternary D82L to the start of the estuary. These units all received prioritisation scores >0.7 (0.87 -1.00) and were thus included among priority RUs. The prioritisation scores were derived from a number of rated criteria. Of relevance to the present study were the high scores (1.00) accorded to Threats Posed to Users (dependent on water use) and Threats Posed to Ecological Components (that is, the level of ecological threat posed by human activities) for all of these RUs, with the exception of the (protected) Richtersveld river reaches, where these threats were scored 0.5 only.

Note that the Orange River Estuary itself is a Ramsar wetland – this important system is discussed in Section 4.5.3.

4.5.2.7 Other river systems

[3]Eight mainstem ephemeral watercourses in the study area flow into the Atlantic Ocean via estuaries or micro-outlets, while others (e.g. the Kamma River and numerous other unnamed systems) dissipate into deep sands or pans, and never flow into the sea. These watercourses lie in the Coastal Orange Sub-WMA. DWS (2016a) indicates that their condition is generally good, with all of these rivers categorized as PES Category B/C or B, with the exception of the Kwaganap River (PES Category C), the Bitter River (PES Category C to D) and tributaries of the Groen (Hartbees into the Swart-Doring River) (PES Category C). The main impacts affecting rivers in these catchments comprise (variously and in no order of scale) road infrastructure that traps ephemeral water flows and changes flood patterns; mining; alien vegetation; over-grazing that increases erosion and sediment loads; groundwater abstraction and other forms of human disturbance (DWS 2017a).

[3] These rivers (excluding the perennial Orange River) comprise the Holgat, Kwaganap, Buffels, Swartlintjies, Spoeg, Bitter, Groen and Brak Rivers (see Figure 5.1).

The REC for the above rivers is the same as their PES, reflecting generally good condition, although the REC for the Kwaganap and Bitter Rivers requires an improvement from PES Category C to an REC Category B /C.

Ephemeral rivers in the Namaqua National Park in the south western portion of the study area have been described in a little more detail in SANParks (2024) and include the upper and middle reaches of the Swartlintjies River and the lower/ estuarine reaches of the Spoeg, Bitter and Groen Rivers (**Figure E6**, Appendix E). The latter document notes the lack of ground-truthing of mainly desk-top classified and modelled watercourses (an issue presumed to be applicable to most watercourses in the study area as a whole). The report also identifies five key pressures on rivers in the park, namely:

- Modifications to the natural variation of hydrological regime;
- Impacts to water quality;
- Loss of natural habitat, habitat degradation and fragmentation;
- Spread of invasive (plant) species; and
- Over-exploitation of (plant) species.

Poorly monitored and poorly understood degradation in watercourse condition in these areas is also highlighted in this study. These changes would be expected to be exacerbated under climate change conditions (Van Deventer *et al.* 2019). It is assumed for the purposes of this report that if watercourses in protected areas are undergoing degradation, it is likely that this is occurring to at least the same if not greater degrees in unprotected areas.

It is however noted that ephemeral rivers in arid areas are less likely to be impacted to the same degree by issues that plague perennial and lower salinity systems elsewhere in rural areas, where abstraction, impoundment and nutrient enrichment impact on these systems to a much greater degree, because the water resources are often of better quality from a livestock and irrigation perspective and thus are more likely to be exploited.

4.5.2.8 Pans

Endorheic pans are the most common wetland type in arid and semi-arid environments (Allan et al. 1995), and are generally thought to form as a result of the synergy of a number of factors and processes, including low rainfall, sparse vegetation, flat to gently sloping topography, disrupted drainage, geology, grazing and deflation. The present study area indeed includes numerous ephemeral pans, classified as depression wetlands in the NWM (v5). The largest of these are located in the south eastern corner of the site (quaternaries D53F and E31A in Figure E3 (Appendix E), where they comprise sometimes extensive areas of occasionally (sometimes only after years) inundated wetland, where water perches on a hardpan substrate. These wetlands lie west of large pans such as Grootvloer and Verneukpan, and although much smaller, are assumed to be important biodiversity features. Other (generally smaller) ephemeral pans are located in the (100% endoreic) areas of quaternaries D82B and D82C, and in fact, ephemeral pans occur throughout the study area, generally driven by impermeable near-surface layers that allow perching of infrequent rainfall over periods of weeks to months. In some areas (e.g. in the proposed Boegoebaai Port SEZ area), some pans associated with areas of perennial water and characterised by stands of *Phragmites australis* reeds and (salt-tolerant) *Sarcocornia cf. perenne* dominated margins are believed to comprise coastal salinas - that is, lagoons that have their own natural supply of ground water, usually in the form of sea water seepage (or vestigial sea water lenses from past sea levels) rather than rain runoff, and usually have local encrustations of gypsum or common salt. They would have been formed originally at higher sea levels, and were then abandoned as sea levels fell (see Desmet 1996).

The ephemeral pans and pools in the study area are likely to support communities of invertebrate fauna that are adapted to life in transient aquatic conditions, with adaptations commonly including rapid hatching under inundated conditions, fast development, high fecundity, and short life spans. Such fauna could include branchiopod crustaceans, with taxa from four orders all associated with temporary freshwater habitats (Conchostraca (clam shrimps); Cladocera (water fleas – e.g. daphnia); Notostraca (tadpole shrimps of the genus *Triops* (Rayner 1996)); and Anostraca (fairy shrimps)). Species richness in temporary waterbodies relates to the size and habitat diversity

of the water body and to habitat duration (Ebert and Balko (1987); Hamer and Rayner (1996); and Mabidi *et al.* (2016)).

4.5.2.9 Wetlands excluding ephemeral pans

The aridity of most of the study area means that wetlands other than the ephemeral pans described above are limited to areas along the perennial Orange River and some seasonal, rather than ephemeral seeps, wetlands and rivers, mostly occurring in the Kamiesberg area, in the southern portion of the Namaqua Highlands Ecoregion. None of the "High" and "Very High" priority wetlands identified in DWS (2016b) lie within the present study area – these priority areas were however identified in that study from the perspective of their potential to contribute to water resource availability for non-ecological requirements. The study notes that wetlands in the Lower Orange WMA that were identified as ecologically important were mostly those with **low water resource use importance.** Those with high water resource use importance were confined to the Orange River. This aspect is considered further in this chapter, with regard to the assignation of aquatic ecosystem versus water resource use sensitivity (see Section 4.7.4).

The valley bottom wetlands and hillslope seeps in the Kamiesberg uplands and surrounds (south western portion of the study area, quaternaries F50E, F30C and F30A) provide a critical support system for livestock, owing to their ability to continue to retain water and quality forage throughout the dry summer months of the year (Samuels 2013; Kotze *et al.* 2010, Black *et al.* 2016). These wetlands, located on shallow soils in often steep terrain with high run-off from the upper catchments of the Kamiesberg act to reduce flow velocities, allowing water to permeate through the underlying soil and recharge shallow sub-surface water, the presence of which is vital to the existence of springs and water levels that are accessible to livestock in excavated wells (Kotze et al. 2010 and Black *et al.* 2016). Despite their high importance for sustaining local livelihoods, over 60 per cent of these wetlands have been severely degraded by the removal of indigenous vegetation, over-burning, cultivation, overgrazing, roads, over-abstraction of water and alien vegetation (Helme and Desmet 2006). These wetlands are furthermore highly vulnerable to climate change where it affects the frequency of rainfall events in areas such as these, where average no-flow days/annum are already 336 to 345 days per year (**Figure E7** Appendix E).

Note that the Ramkamp and Xharas wetlands in the Kamiesberg Uplands have been rated as particularly important and least impacted wetlands and are the only wetlands within the present study area that have been prioritised for the development of Resource Quality Objectives (RQOs) in the Lower Orange River Water Resource Classification Project (DWS 2024b).

4.5.3 Estuaries

4.5.3.1 General

The largest and most ecologically significant estuary in the study area is the Orange River Estuary, which enters the Atlantic Ocean on the northern boundary of South Africa and Namibia, forming the northwestern boundary of the study area. In addition to this estuary, described in more detail below, the study area includes the Brak, Groen, Bitter, Spoeg, Swartlintjies, Buffels, Kwaganap and Holgat River outlets to the sea, classified variously as Cool Temperate Arid Predominantly Closed (CTAPC) estuaries and micro-outlets (Van Niekerk *et al.* 2020). These are all indicated in **Figure 4-5.2**.

4.5.3.2 The Orange River Estuary

The Orange River Estuary, with an area of some [4]2 298 ha (DWS 2024), straddles the South African / Namibian border, and lies between the towns of Alexander Bay (RSA side) and Oranjemund (Namibian side). The estuary outlet is described in DWS (2024b) as a delta type river mouth, made up of a braided channel system located between sandbanks covered with pioneer vegetation; a 2 to 3 m deep tidal basin; and extensive areas of salt marsh along the southern bank. It extends some 14 km upstream, with its upper boundary extending some 3 km upstream

[4] Note that the NBA (2018) (Van Deventer et al., 2019) shows the estuary as an area of 3019.5 ha

of the Sir Ernest Oppenheimer Bridge crossing (as shown in the 2018 NBA (van Niekerk *et al*., 2019). The estuary mouth is now almost permanently open.

This estuary is of international importance, having been declared a Ramsar Wetland site in 1991 (South African side) and 1995 (Namibian side). It is also of national importance in both Namibia and South Africa, being one of only two estuaries along the Namibian coastline and having been ranked as the seventh most important estuary in South Africa in terms of its conservation importance (Turpie *et al.* 2002). Van Niekerk *et al.* (2013) scored its Ecological Importance as 99 out of 100, associated with High importance, with the highest scores allocated for its size, habitat diversity and functional importance. The latter relates mainly to the importance of the estuary as a supply of sediment to beaches north of the river mouth and for the provision of near-shore sandy habitat for West Coast sole (*Austroglossus microlepis*) (DWS 2017b).

REASONS FOR RAMSAR STATUS

The estuary supports more than 1% of the world population of three species of waterbirds that are endemic to southern Africa (Cape Cormorant, Hartlaub's Gull and Damara Tern) as well as more than 1% of the Southern African populations of six species of waterbirds (Black-necked Grebe, Lesser Flamingo, Chestnut-banded Plover, Curlew Sandpiper, Swift Tern and Caspian Tern).

It is regarded as one of the most important coastal wetlands in southern Africa in terms of the number of birds supported, at times supporting more than 20,000 waterbirds of between 50 and 57 species and is thus also recognized as an Important Bird Area. (data from http://www.saramsar.com/, downloaded April 2025).

The estuary was however placed on the [5]Montreux Record in 1995, in recognition of the severely degraded condition of the saltmarsh wetland on the southern bank. [6]Degradation is attributed largely to the impacts of adjacent mining, upstream flow regulation and the construction of an embankment through the estuary, causing a substantial decrease in the amount of fresh water entering the saltmarsh, which has dried out substantially. Moreover, regulated water flows entering the estuary as a result of upstream hydro-electric and irrigation releases from dams result in more constant water flows, less frequent flooding and a reduction in sediment input, in contrast to its more natural hydro-regime when the river mouth would dry out temporarily during dry periods (August-September) before being re-flooded in wet periods.

Van Niekerk *et al.* (2013) highlighted the following major impacts affecting the condition of the estuary, namely:

- Significant freshwater flow modification (loss of floods and increased dry season baseflows);
- Lack of mouth closure and associated back flooding of salt marshes with fresher water;
- Road infrastructure in the estuary;
- Nutrient enrichment from upstream;
- Gill netting of indigenous fish species;
- Levees preventing back flooding of riparian areas;
- Grazing and hunting;
- Mining activities; and
- Wastewater disposal (sewage and mining effluent).

Based on the above, the Present Ecological State (PES) of the estuary was assessed as Category D (highly modified) (Van Niekerk *et al.* 2013). DWS (2024b) notes however that, given the high ecological importance of the estuary, its Recommended Ecological Category (REC) should ideally be set at Category A. Achieving this condition was however considered unfeasible, and the REC was thus set at Category C – a condition that would still require

[5] The Montreux Record is a listing of Ramsar wetlands that are in a degraded condition. Wetlands placed on this list are expected to undergo focused rehabilitation, in order to retain their status

[6]Source: Ramsar wetland site datasheets [https://rsis.ramsar.org/RISapp/files/119/documents/ZA526lit.pdf]

significant intervention to achieve. The Ecosystem Threat Status (ETS) for this estuary is Endangered (Van Niekerk et al. 2019).

4.5.3.3 Other estuaries

In addition to the Orange River Estuary, four CTAPC estuaries occur within the study area within the Coastal Orange Sub-WMA, namely the Groen, Spoeg, Swartlintjies and Buffels River estuaries. Estuary condition, functional and estuarine importance, the main sources of impact, PES and REC have all been assessed for these systems (see DWS 2017a), while Van Niekerk *et al.* (2019) include Conservation Priority and Ecosystem Threat Status (ETS) ratings for estuaries in the 2018 National Biodiversity Assessment (NBA). These data are summarized in **Tables 4-5.3** and **4-5.4**.

Note that estuarine functional importance ratings for these systems were largely driven by their contribution to a very limited wetland habitat type for estuarine and coastal birds along the coast.

Table 4-5.3: Summary data relating to condition, PES, REC, ETS and Conservation Priority for the Cool Temperate Arid Predominantly Closed (CTAPC) estuaries within the SEA study area (data from DWS 2017a)

Estuary	PES (DWS 2017a)	Functional importance (DWS 2017a)	Estuarine importance (DWS 2017a)	REC (DWS 2017a)	Conservation priority (NBA 2018)	ETS (NBA 2018)
Groen	B	Important	Average importance	B	Priority – "No Take" estuary	Endangered
Spoeg	A/B	Very important	Average importance	A/B	Priority – "No Take" estuary	Endangered
Swartlintjie	B	Important	Average importance	B	Not a priority estuary	Endangered
Buffels	D (deteriorating)	Very important	Average importance	D	Not a priority estuary	Endangered

Table 4-5.4: Main causes of impacts to estuary condition (from DWS 2017a)

Rated High, Moderate, none

Estuary	Groen	Spoeg	Swartlintjie	Buffels
Groundwater abstraction resulting in loss of freshwater inflows	Moderate	Moderate		High
Road infrastructure / embankments trapping river flows	Moderate	Moderate	High	High
Mining activities incl. dust and salinisation	[future threat]	[future threat]	High	High
Roads in the EFZ	Moderate		Moderate	High
Floodplain development (e.g. golf courses, houses	Moderate			High
Diffuse sewage runoff (irrigation, ablutions)	Moderate			High
Grazing in catchment affecting sediment structure through erosion	Moderate	Moderate	Moderate	Moderate
Invasive alien plants				High
Human disturbance	High			High
Saltworks				
Artificial; breaching / mouth manipulation				High

4.5.4 Micro-outlets

The Brak, Bitter, Kwaganap and Holgat Rivers are all small, ephemeral rivers that flow into the sea after major storms. Their flows are, however, too rare to sustain functional estuaries and they are instead classified as micro-outlets (Van Niekerk *et al.* 2020). Moreover, although the catchments of several of these systems have been rated as near-natural (e.g. the Holgat River), their outflows in many cases have been highly altered by mining-associated activities.

Other rivers such as the Kamma, which also flow towards the sea, never in fact reach it, with their ephemeral flows dissipating into the sands, where they contribute to groundwater recharge or evaporate from pans.

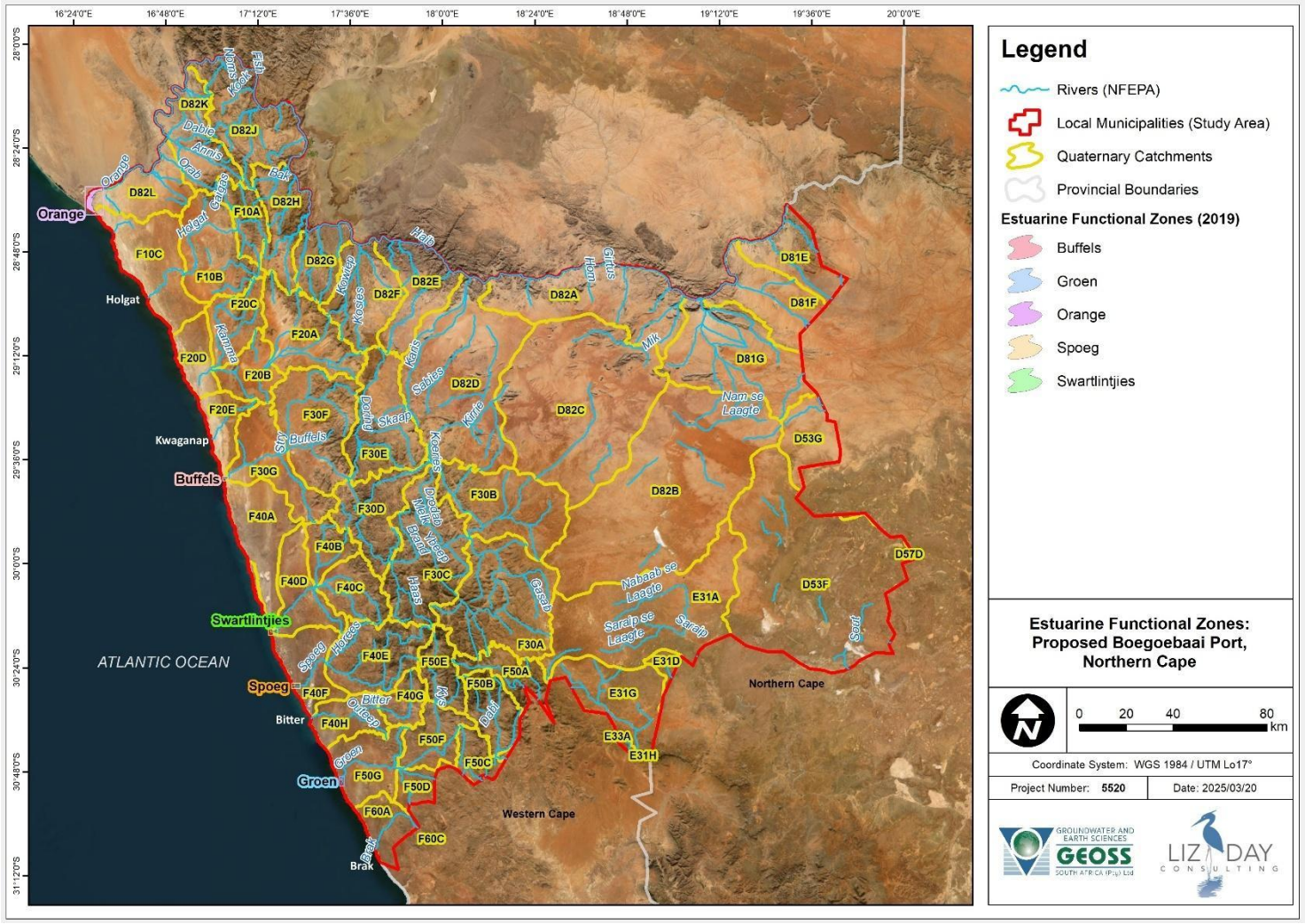

Figure 4-5.2: Study area showing estuaries (mapped as Estuarine Functional Zones (EFZ) and micro-outlets of highly ephemeral watercourses that lack estuary function (Van Niekerk et al. 2020) (labelled in white)

4.6 WATER RESOURCE AVAILABILITY AND DEMAND

4.6.1 Water users

The main water users in the study area are the irrigated agriculture sector (mainly along the lower Orange River), mining (extraction of alluvial diamonds and a number of minerals), domestic and industrial water supply and recreational purposes, with the lower Orange River supporting tourist activities such as canoe safaris. These water uses are supported by a combination of surface water supplies from the Orange River, driven primarily by flows entering from the Upper Orange River catchment; groundwater abstraction; and some desalination schemes.

4.6.2 Main current and planned water sources

4.6.2.1 Groundwater use

The low MAP for the Namaqualand region combined with limited surface water resources means that the area is strongly dependent on groundwater to support human populations and economic activities (Van Gend et al., 2021). The Greater Namakwa Region that is being evaluated in this assessment covers a vast number of quaternary catchments, falling within the Lower Orange and the Olifants-Doorn Water Management Areas. Invariably, due to the aridity of the region, all of these quaternary catchments have a general authorization (GA) of 0 m^3/ha/a for groundwater use and all groundwater use needs to be registered. The primary source of water supply across the Richtersveld, Kamiesberg and Nama Khoi Local Municipalities (LMs) is groundwater pumped from municipal boreholes, but the primary source of water supply for Khai-Ma Municipality is not stated (DFFE, 2023).

Registered water use is available on national databases, namely the Water Authorisation and Registration Management System (WARMS) Database and the National Groundwater Archive (NGA). The latest accessible version of the WARMS Database has been updated in 2025. Water use on the WARMS database is categorised by resource type: rivers/streams, dams, surface water schemes, springs/eyes and boreholes. A total of 48 registered boreholes were found to be registered on the WARMS database in the study area (the four delineated LMs), and a total volume of 2 975 902 m^3 per annum has been allocated for groundwater use (see **Figure B8** (Appendix B)). Water use is predominantly for water supply (56%) as many towns are reliant on groundwater as a sole source (Conrad et al., 2003). Other water uses include mining (26%), agricultural irrigation (10%), industrial use (4%), power generation (3%) and livestock watering (1%). A breakdown of the water use in the area is presented below.

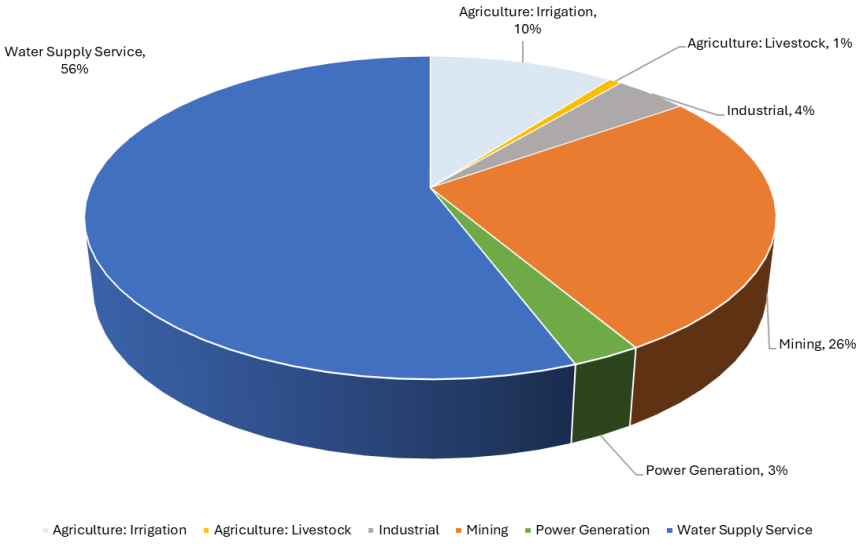

Figure 4-6.1: Breakdown of registered groundwater use in the 2025 WARMS database for the four LMs.

The NGA Database indicates a total of 5 693 boreholes present in the study area, installed into various aquifers across the region. The database does not contain information on the groundwater volume used and therefore, groundwater use is likely much higher than what is reported. It is, however, important to note that the number of groundwater users in the area may not be entirely accurate. There may be more groundwater users in the area as not all groundwater use tends to be registered. The number of boreholes retrieved from the NGA database date back to as far as 1914, and some of these holes may no longer be used or yielding water.

4.6.2.2 Surface water use

Surface water use is essentially limited to the Lower Orange River, with water use elsewhere in this arid study area being largely reliant on groundwater or desalination.

The simulated Mean Annual Runoff contributing to the Orange River, without abstractions, is 24 400 Mm3/annum (Schütte et al. 2023). However, considerable abstractions occur. The current urban, industrial and mining abstractions from the Orange River overall are estimated to be 360 Mm3/annum, while future abstractions (2040) could reach 479 Mm3/annum (DWS 2012). Average annual river losses between the Vanderkloof Dam and the river mouth are estimated at 615 Mm3/annum, mainly due to evaporation from the river surface area, but also include seepage losses and evapo-transpiration from riparian and instream vegetation. In the EFR study of Louw et al. (2013), the in-stream MAR was estimated at 11 306 Mm3/annum, so considerable additional abstractions are evident.

4.6.3 Other water sources: Desalination

Desalination / reverse osmosis technologies are currently used in some areas to supplement water supply, including the Kamiesberg Municipality, which is implementing a desalination plant in Garies to improve groundwater quality (Kamiesberg Municipality 2017).

4.6.4 Water supply schemes

While most of the domestic, urban and mining requirements for water in the study area come from the Lower Orange River mainstem sub-area (ORASECOM 2020), water is also transferred from the Orange River to the Coastal Orange Sub-WMA. Water demand in these areas is generally relatively low and associated with small towns such as Springbok, Steinkopf and Port Nolloth as well as the mines in the area (DWS 2024).

Water demand in Port Nolloth, which escalated from 2020 to 2040, is planned to be supplied by the Alexander Bay Bulk Water Scheme. The Springbok Regional Water Supply Scheme is also relevant to the current project, supplying the towns of Springbok, O'Kiep, Carolusburg and Kleinsee as well as local mines (DWS 2024). The planned Namakwa Bulkwater Scheme would extend this scheme further south and serve additional small towns and mining areas (DWS 2012).

Figure 4-6.2 (after DWS 2024) shows irrigation and water supply schemes and the main irrigation areas in the Lower Orange Catchment, as produced in DWS (2004), while Figure 4-6.3 shows updated bulkwater and other supply schemes (after DWS 2023).

4.6.5 Irrigation schemes

Linked to the water supply schemes are various irrigation schemes, of which those relevant to the present study area are (data from DWS 2024):

- The Onseepkans Irrigation Scheme, which supplies water from the Orange River to some 314 ha of irrigation land;

- The Namakwaland Irrigation Area, which is supplied with water from the Orange River, released from the Vanderkloof Dam (upstream of the study area), allowing for irrigation of some 2 439 ha;

- The Vioolsdrift Irrigation Scheme, which receives water via a canal system fed by the Vioolsdrift Weir on the Orange River within the study area. This allows for irrigation of some 600 ha and also supplies Namibia with irrigation water in the Noordoewer area, for some 284 ha. \

4.6.6 Overview

The study area is generally arid to hyper-arid with limited surface water supplies and a high dependence on groundwater, much of which has water quality limitations on its fitness for use.

Existing municipal infrastructure does not appear to have capacity to meet its current needs in all areas, and any future expansion resulting in increased water demand would need to include substantial investment in water treatment and reticulation; sewage reticulation, treatment and disposal; and other aspects of municipal service delivery (e.g. road infrastructure and solid waste management).

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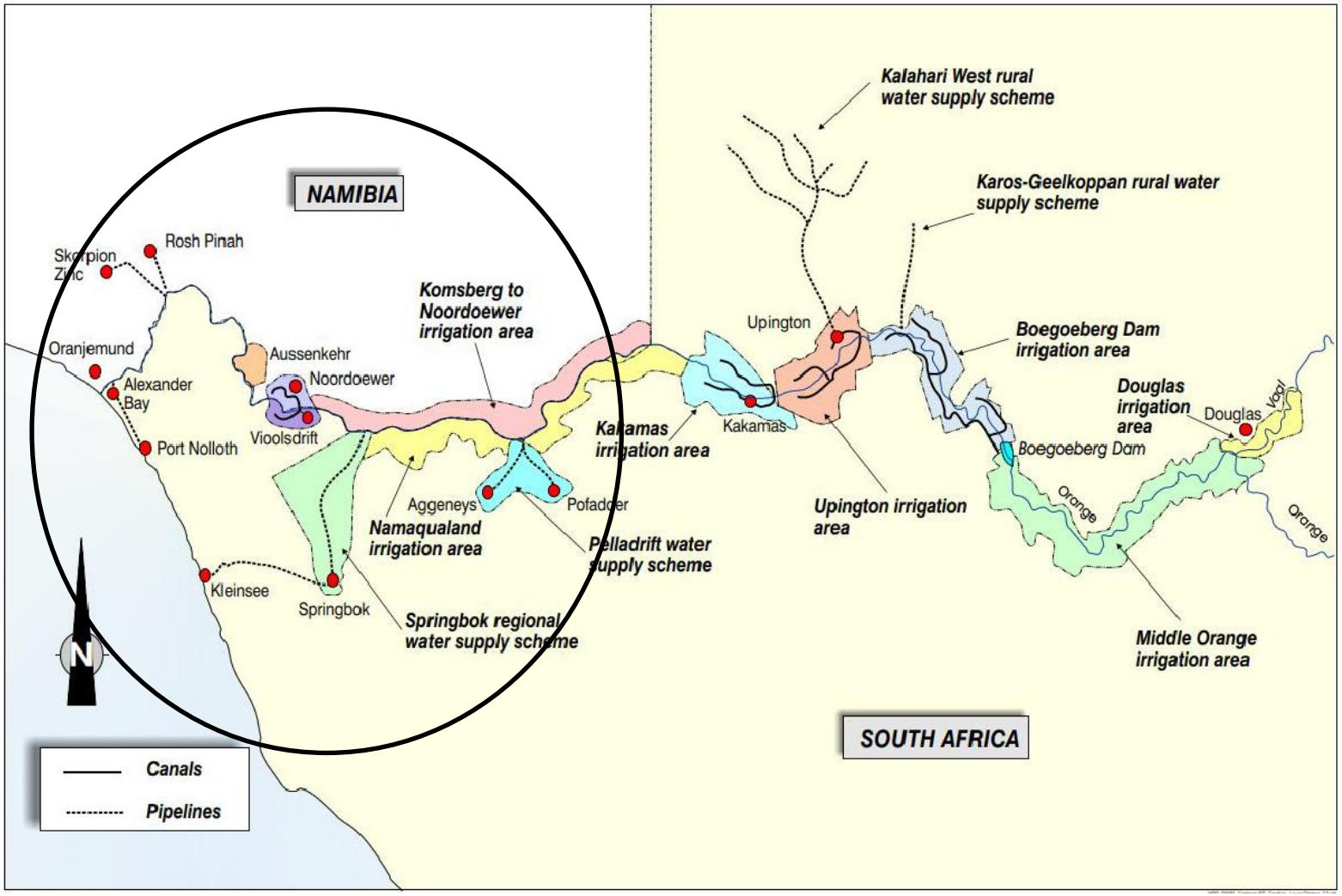


Figure 4-6.2: Irrigation and water supply schemes and the main irrigation areas in the Lower Orange Catchment, as shown in DWS (2004) (Figure after DWS 2024). Schemes relative to the current study area are roughly circled.

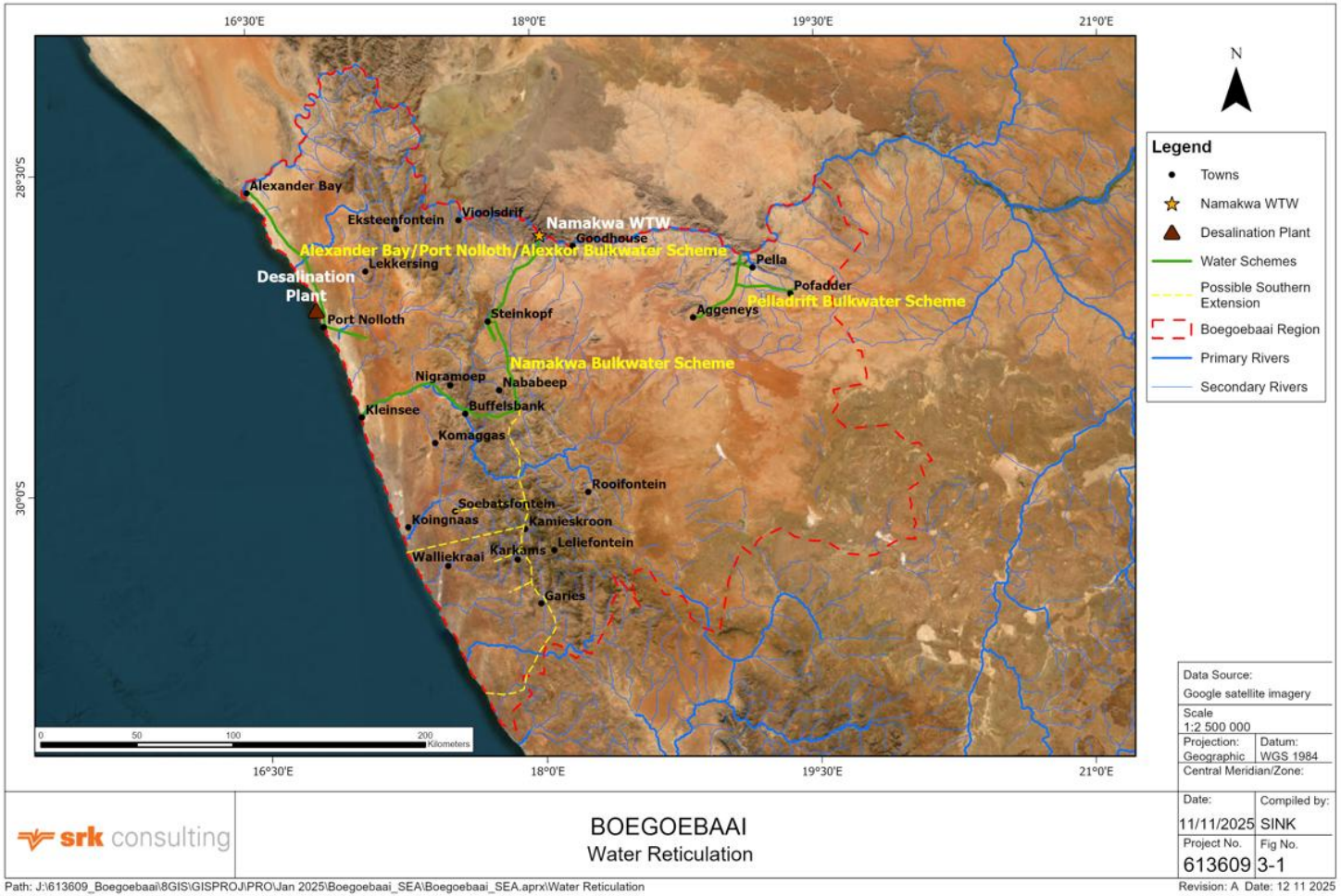


Figure 4-6.3: Updated existing and planned bulkwater and other supply schemes (after DWS 2023).

4.7 SENSITIVITY CLASSIFICATION

4.7.1 Approach

An important part of this project is defining particular water resource sensitivities in a development context. This will allow early differentiation of different areas, on the basis of their sensitivity to development associated with expansion of green energy and associated infrastructure, in response to the proposed Green Hydrogen development at the proposed Boegoebaai Port.

It is important to note however that not all activities associated with the proposed development would necessarily impact on all areas mapped as sensitive. That is, the "sensitivity" mapping included in this project includes an element of ecological importance, and not all activities associated with the proposed development(s) would be incompatible with maintaining these important areas, which in some cases would not be sensitive to the actual impacts associated with those activities.

The following sections outline the various criteria used in identification of different levels of sensitivity of different areas to (unspecified) activities. These are unpacked more usefully in Section 4.9, with regard to actual projected activities and their impacts in different areas.

4.7.2 Groundwater Sensitivity Classification

4.7.2.1 Background

Groundwater is vulnerable to contamination from a wide range of anthropogenic activities, with groundwater sensitivity being dependent on factors such as geological characteristics, landscape, importance to people, etc. These factors are discussed in the sections below, and used to delineate overall areas of groundwater sensitivity. It is also recognised that some aquifers are more vulnerable to contamination than others. A distinction is thus made between aquifer vulnerability and aquifer susceptibility. Vulnerability describes the likelihood of surface-based contaminants reaching the groundwater system whereas susceptibility indicates both resource importance and vulnerability (Parsons and Conrad, 1998).

4.7.2.2 Aquifer System Management Classes

Aquifer system management classes are categorised by evaluating resource accessibility in comparison to its exploitability. Aquifer management classes speak to the importance of the resource and are described in **Table 4-7.1** and **Table 4-7.2** below. Aquifers with high exploitability and accessibility are classified as major aquifer systems whereas aquifers with low accessibility and exploitability are considered as poor or non-aquifer systems. Descriptions of these aquifer systems are described in **Table 4-7.2**.

Table 4-7.1: Application of the aquifer system management classification to the borehole prospecting map of Vegter (1998).

Accessibility	Exploitability					
	<10%	10% - 20%	20% - 30%	30% - 40%	40% - 50%	> 50%
>60%	Poor	Minor	Minor	Major	Major	Major
40% - 60%	Poor	Poor	Minor	Minor	Major	Major
<40%	Poor	Poor	Poor	Minor	Minor	Major

Table 4-7.2: Definitions of aquifer management classes (Parsons and Conrad, 1998).

Aquifer	Description
Major Aquifer System	Highly permeable formations, usually with a known or probable presence of significant fracturing. This may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m).
Minor Aquifer System	These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable.
Non-Aquifer System	These are formations with negligible permeability that are generally regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable.

4.7.2.3 Aquifer Vulnerability Classification

The national scale groundwater vulnerability classification, which was developed according to the DRASTIC methodology (Conrad and Munch 2007), indicates that the study area has varying vulnerabilities to surface-based contaminants. The DRASTIC method considers the following factors:

D	=	depth to groundwater	(5)
R	=	recharge	(4)
A	=	aquifer media	(3)
S	=	soil type	(2)
T	=	topography	(1)
I	=	impact of the vadose zone	(5)
C	=	conductivity (hydraulic)	(3)

The number indicated in parenthesis after each factor description is the weighting or relative importance of that factor.

4.7.2.4 Aquifer Susceptibility Classification

The aquifer contamination susceptibility map (see **Figure B7** (Appendix B)) is a product of the aquifer system management classification map and the aquifer vulnerability map. The classes used for each base map were used to develop susceptibility classes as indicated in **Table 4-7.3** below. Poor groundwater regions with a low vulnerability are defined as having a low susceptibility to contamination. Conversely, major aquifer regions with a high vulnerability are regarded as having a high susceptibility to contamination (Parsons and Conrad, 1998).

Aquifer susceptibility generally ranges from “low” to “medium” along the West Coast and “very low” to “low” along the South African-Namibian border. As one moves inland from the coast and the Orange River (Namibian border), groundwater vulnerability tends to be more variable, ranging between medium to very high. “Very high” vulnerability is mapped for the high-yielding aquifer located between Springbok, Garies and Kliprand (see **Figure B7** (Appendix B).

Table 4-7.3: Basis for assigning aquifer contamination susceptibility classes (Parsons and Conrad, 1998).

Aquifer System Management Class	Vulnerability Class		
	Low (1)	*Medium (2)*	*High (3)*
Poor Groundwater Region (1)	Low susceptibility (1)	Low susceptibility (1)	Medium susceptibility (3)
Minor Aquifer Region (2)	Low susceptibility (2)	Medium susceptibility (4)	High susceptibility (6)
Major Aquifer Region (3)	Medium susceptibility (3)	High susceptibility (6)	High susceptibility (9)

4.7.2.5 Strategic Water Source Areas (SWSAs)

Strategic Water Source Areas (SWSAs) are defined as areas of land that either: (1) supply a disproportionately large quantity of mean annual surface water runoff in relation to their size and are therefore, considered nationally important; or (2) have high groundwater recharge and where groundwater forms a nationally important resource; or (3) areas that meet both criteria (1) and (2). SWSA aquifers sustain baseflow, contribute to runoff and, especially, contribute to dry season flows. Sustained river flows are important as they support people and communities who depend directly on rivers for their water, especially during the dry season and droughts. (CSIR, 2017).

Groundwater SWSAs cover approximately 9% of South Africa's land surface. They account for up to 42% of the river baseflow generated by these water source areas and play a key role in sustaining surface water flows during the dry season (CSIR 2017). Three sub-national groundwater SWSAs have been identified in the study area, namely the Port Nolloth, Kamieskroon and Komaggas SWSAs which make up 2.65% of national SWSAs. These SWSAs are indicated in **Figure B9** (Appendix B) and have been further classified as areas of very high sensitivity in this study.

4.7.2.6 Groundwater Resource Units (GRUs)

A number of GRUs have been delineated in the Lower Orange WMA. A GRU, classified as a groundwater body that has been delineated or grouped into a single significant water resource, is based on one or more characteristics that are similar across that unit. Classification is based on a number of factors, including: topography (primary delineation by quaternary catchment boundary), aquifer type, interaction with surface water bodies (pans and baseflow) and possibly dependent ecosystems, recharge, resource accessibility and exploitability, quality and resource dependence.

In order to identify and prioritise the most important GRUs, the following assessment criteria were used: (1) importance of the GRU to users (degree of groundwater dependence); (2) threat posed to water resource quality for users (aquifer vulnerability); (3) threat posed to water resource quality for the environment (baseflow) and (4) degree of use (stress index). Using the aforementioned criteria, a number of GRUs were categorised as intermediate and high priority. These GRUs are indicated in **Figure B9** (Appendix B) and will subsequently be identified as high and very high sensitivity areas, respectively. In-depth analyses and assessment of the various GRUs are presented in the Lower Orange Reserve Determination Report (2016).

4.7.2.7 Sensitivity Classification

Based on the above sections, descriptions of groundwater sensitivity areas are presented in **Table 4-7.4** below. These are mapped in **Figure 4-7.1.**

Table 4-7.4: Groundwater sensitivity classifications

Sensitivity	Description
Low	Classified as having very low to low vulnerability according to DRASTIC methodology; typically falling within a poor groundwater region or minor aquifer system with low accessibility and exploitability. Low susceptibility to surface-based contamination.
Medium	Classified as having low/medium to medium vulnerability according to DRASTIC methodology; typically falling within a minor to major aquifer system with moderate accessibility and exploitability. Medium susceptibility to surface-based contamination.
High	Classified as having high vulnerability according to DRASTIC methodology; typically falling within a major aquifer system with good accessibility and exploitability. High susceptibility to surface-based contamination. Possibly also classified as an intermediate priority GRU as per DWS (2016).
Very High	Classified as having high vulnerability according to DRASTIC methodology; typically falling within a major aquifer system with high accessibility and exploitability. High susceptibility to surface-based contamination. Possibly also classified as a Strategic Water Source Area or a high priority GRU as per DWS (2016).

4.7.3 Surface Water Sensitivity Classification

Surface water sensitivity has been assessed for linear and distributed criteria. Linear features subject to impacts are the drainage network (river system) and the Orange River abstraction and reticulation network. Distributed features include aridity levels and the density of farm dams, all mapped at a quaternary level.

4.7.3.1 Drainage Networks

Although surface water discharge only occurs occasionally in the drainage network, the responses are generally rapid and can be intense when they do occur. The drainage networks are particularly sensitive to disturbance (road crossings, bridges, encroachment into the flood plain) and the alluvial flood plains are critical for groundwater recharge, which occurs mainly during flood events.

Disturbances and restrictions in the drainage network (ephemeral rivers) could give rise to extensive upstream flooding and, if breaches occur, downstream damage could result. Restrictions in watercourses could also give rise to increased velocities and scour damage to stream banks and beds. Where riverbeds comprise mostly sands and floodplains mostly silts, disturbances are likely to cause significant changes in sediment transport and scour.

With the very low occurrence of runoff events and long periods without runoff, all rivers and floodplains are considered fragile to disturbance, being dry most of the time and unable to resist disturbance when it does occur. It is also considered that river networks would be unable to reconfigure from disturbance within periods of several decades (Fryirs 2017).

4.7.3.2 Water Supply Reticulation

The extensive use of groundwater in the area has stretched the resource to a limit and further groundwater exploitation in the region is limited. The current abstractions from the Orange River and reticulation into the interior of the region are also aging and often do not yield their design demand, which continues to increase (DWS 2012; BVI 2023a). These abstraction works and reticulated networks, including planned extensions and improvements, are considered extremely sensitive, since they have been assessed as being the only viable source for sustaining water supply to the region.

These systems may be supplemented by coastal desalination works, but there is some concern over the capacity of local operators to cope with the more sophisticated technology.

4.7.3.3 Aridity

All quaternary catchments in the study area are categorised as either arid or hyper-arid. It is considered that hyper-arid areas would be insensitive to water supply impacts as the yield is negligible. These areas are considered unsuitable for crops or grazing. In arid regions, some grazing systems may be supported, but no crops would be viable without irrigation. Aridity indices (defined as the ratio between average annual evapotranspiration to precipitation) above 20 are classed as hyper-arid and those between 5 and 20 as arid. It is deemed that the quaternaries with low aridity indices (5 to 10) would be highly sensitive to disturbance, since these would be the most suited to cattle farming. Quaternaries with aridity indices between 11 and 20 would be considered having medium sensitivity (see **Figure C1.1** (Appendix C).

4.7.3.4 Farm Dams

In a similar way to the aridity indices, areas with small farm dams are also considered sensitive (see **Figure 4-2.9**). Disturbances in these areas that might restrict replenishment of the dams would impact on their capacity to water livestock.

4.7.3.5 Sensitivity Classification

Linear and areal sensitivity criteria are summarised in Table 4-7.5 and mapped in Figure 4-7.2.

Table 4-7.5: Sensitivity rating categories for surface water resources

Sensitivity	Sensitivity Feature	Motivation
Very High	• Orange River and buffer area • Water supply reticulation pipeline from the Orange River and desalination plants, including towns they supply • NFEPA river systems	DWS current and future supply schemes (Figures 4-6.2 and 4-6.3) River systems (Figure 4-5.1)
High	• Areas with more than 50 farm dams per quaternary or • Areas classified as Arid, but with Aridity index less than 10 • 1:50 000 rivers layer	Mantel and Hughes 2023 Gunkel and Lange 2017.
Medium	• Areas with fewer than 50 farm dams per quaternary or • Aridity Index greater than 10, but in Arid classification (Aridity Index less than 20) • [7]River buffers	Mantel and Hughes 2023 Gunkel and Lange 2017. Impacts
Low	• Areas classified as Hyper-Arid (Aridity Index greater than 20). • No surface water supply or storage	Schütte, *et al*. 2024; Gunkel and Lange 2017 (While these areas may be sensitive to hyper-arid ecosystems, they are not considered sensitive to surface water supply).

[7] In discussion between the project hydrologist and the freshwater ecologist, it was agreed that appropriate buffers would comprise: 20 m around dams and artificial wetlands / pans; 50 m around all wetlands; 100 m for NFEPA rivers and EFZs

4.7.4 Aquatic ecosystem sensitivity classification

4.7.4.1 Sensitivity defined

This section considers inland aquatic and estuarine ecosystems in the context of their likely sensitivity to the various activities associated with the proposed development. Although aquatic sensitivity is generally defined as the capacity of an aquatic ecosystem (inland or estuarine) to tolerate disturbance, "sensitivity" in the present context includes an element of ecological importance. That is, although some aquatic ecosystems may be "sensitive" (i.e. respond directly) to certain impacts, if they are of low ecological value, their sensitivity rating would not correspond to their actual response rating. Thus in this assessment, the term "sensitivity" includes elements of both the ecological importance and the sensitivity of the impacted system.

4.7.4.2 Inland aquatic ecosystem sensitivities

The inland aquatic ecosystems described in Section 4.5.2 are likely to be particularly sensitive to the following changes, some of which have a bearing on the kinds of impacts that might be anticipated as a result of climate changes and/or the direct and indirect effects of the proposed Boegoebaai Port and SEZ developments and their associated roll-out of green energy production areas and associated infrastructure:

- Changes in hydroperiod:
    - Increases in hydroperiod – that is, increased duration and frequency of inundation of naturally seasonal systems that could result in significant changes to habitat type and the biota that they support, potentially (and subject to water quality) increasing dominance by *Phragmites australis* reedbed, at the expense of biota including temporary pan zooplankton assemblages, adapted to life in ephemeral systems. Such increases in hydroperiod would be most likely to result from discharges of WWTW effluent into watercourses;
    - Decreases in hydroperiod – these would potentially also alter existing established aquatic ecosystems, drying out existing sources of relatively fresh water and the plants that they sustain, and thus impacting on food and/or water sources for both terrestrial and aquatic fauna – disruption of existing water sources could stem from surface hardening (particularly of sand dunes that act as local aquifers); diversion of stormwater from watercourses and pans usually linked to upstream seepage and flows; and changes in climate involving a reduced frequency of rainfall events;
- Changes in water quality:
    - Artificial "freshening" of inflows into pans, wetlands or other ephemeral watercourses (i.e. decreasing salinities) would potentially impact on natural / existing plant and animal communities that have adaptations to ecosystems that are characterised by brackish to saline conditions, increasing in some systems to hypersaline late-season periods. Freshening would be likely to favour increasing dominance by freshwater-adapted species such as *Phragmites australis* at the expense of existing plant communities, particularly along the margins of the few permanent and seasonally inundated systems. Freshening could be associated with managed stormwater flows into pans and wetlands from hardened surfaces such as roads and development platforms for new infrastructure;
    - Nutrient enrichment: All aquatic ecosystems would be assumed to have high sensitivity to pronounced and sustained nutrient enrichment, particularly in the forms of phosphorus and ammoniacal nitrogen, potentially associated with receipt of seepage or runoff from septic tanks, soakaways and treated sewage effluent;

- Physical disturbance: The natural pans, wetlands, springs and ephemeral drainage lines that occur in the study area all have high sensitivity to physical disturbance, which could disrupt existing flows into adjacent areas. These could result in subtle differences in topography, affecting inundation regime and also potentially exposing accumulations of organic material in seasonal wetland / spring areas, affecting rates of decomposition, nutrient cycling and aquatic ecosystem interactions. In the arid study area, physical disturbance (e.g. the creation of ruts and churning of surface sediments by machinery) would be unlikely to be re-set by natural processes such as flooding and could result in permanent changes. In rocky outcrops, activities such as blasting or rock harvesting could destroy locally or regionally important ephemeral aquatic habitats and their biota;

Given their creation through excavation, artificial pans and depressions are assumed to have lower sensitivity to physical disturbance, although even artificial systems may support important biota – Bird and Malan (2010) for example found rare invertebrate fauna typical of ephemeral wetland habitat even in artificial roadside borrow pits in the region (e.g. notostracans of the genus *Triops*);

- Changes in surface runoff patterns:
  - All pans and other watercourses would be sensitive to changes in surface runoff velocities, potentially stemming from stormwater management systems for hardened surfaces including roads. Increased velocities would potentially lead to localised erosion and changes in aquatic ecosystem hydroperiod and habitat quality;
- Fragmentation from other watercourses and supporting terrestrial areas:
  - Hydrological fragmentation: New roads, built infrastructure and other development on a large scale could contribute to hydrological fragmentation, where this interrupts surface or groundwater inflows into aquatic ecosystems or seepage or flows from them, or disrupts aquifer recharge areas;
  - Physical (surface) fragmentation: The study area is currently relatively undeveloped and it is assumed that there is faunal movement between watercourses, at least at times, and particularly in areas such as the Kamiesberg, where moisture-retention in wetlands provides dry-season foraging material and water. Extended linear and concentrated non-linear development could potentially isolate some systems, disrupting ecological corridors.

4.7.4.3 Estuary sensitivity and importance

4.7.4.4 The Orange River Estuary

The Orange River Estuary has high importance and would be sensitive to activities / impacts that resulted in:

- Changes in freshwater flows (as a result of increased demand for fresh water, with water demand in Alexander Bay being met at least in part by flows from the Orange River upstream of the estuary (Hattingh 2016)) - such demand could increase with an increased population in Alexander Bay, as a result of actual and perceived increases in local employment opportunities;
- Increased road infrastructure across the estuary, affecting flows into the estuarine saltmarshes (such impacts seem unlikely);
- Increased nutrient input – this could be associated with increased treated sewage effluent discharge from the Alexander Bay Waste Water Treatment Works (WWTW), as a result of local population increases;
- Increased fishing, as a result of a locally increased population, leading to increases in gill netting of indigenous fish species and fishing effort in the estuary;

- Increased grazing and hunting activities, particularly linked with a likely influx of population into the Alexander Bay area as a result of perceived or real employment opportunities;

- Increases in physical disturbance as a result of vehicle and other traffic into the estuary for bird viewing and other recreational activities – if such activities resulted in increased traffic across saltmarsh areas and increased localised dumping of solid waste in a seemingly largely unpoliced area, then significant estuarine degradation could accrue.

4.7.4.5 Ephemeral estuaries along the West coast

These estuaries are rated as very important to important from a functional perspective, largely as a result of the rarity of estuarine systems along this part of the West Coast, particularly from the perspective of coastal birds (DWS 2017a), although their ecological importance is rated only "average" (see Section 4.5.3.3). These estuaries would be sensitive to activities / impacts that resulted in:

- Any deterioration in condition;

- Increased nutrient inputs (e.g. from WWTW discharges or septic tanks);

- Disruptions to surface inflows during storm events (e.g. as a result of upstream impoundments, stormwater attenuation or berms /other barriers to flows), leading to reduced frequency of breaching and reduced efficacy of fish recruitment;

- Reduced freshwater inflows, potentially as a result of increased groundwater abstraction;

- Roads or other infrastructure within or through estuaries;

- Alien invasion;

- Vehicle traffic / trampling / compaction.

4.7.4.6 Micro outlets along the West coast

These are considered less sensitive to changes in flows in their catchment, as they are by definition too ephemeral to support estuarine conditions. They would however be sensitive to:

- Physical disturbance, including activities that resulted in concentrations of flows into these outlets, potentially triggering erosion;

- Pollution from water quality inflows;

- Sustained sources of treated or other effluent, that created permanently to seasonally inundated to saturated conditions, resulting in a major change in ecosystem type;

- Invasion by alien vegetation.

Table 4-7.6: Sensitivity rating categories for surface water resources

Sensitivity rating categories for inland aquatic ecosystems and estuaries

Sensitivity	Sensitivity Feature	Data
Very High (no development area)	• Critically Endangered (CR) and Endangered (EN) wetland types from the NBA (Van Deventer *et al.* 2019a) • CBA1 and CBA2 wetlands (NWM_5) • NFEPA rivers • Critically Endangered (CR) and Endangered (EN) estuaries (NWM-2)	NBA (2018a) NFEPA rivers NWM 5 (aquatic) NWM-v5.2
High	• All other wetlands included in the NWM 5 • FEPA sub-catchments • Upstream sub-catchments as identified in the NFEPA programme • All watercourses as mapped in 1:50 000 rivers layer and NFEPA river layer • Artificial pans • Dams • All other estuaries (Estuary Functional Zones)	NWM-v5 River FEPA 1:50 000 layers NBA(2018c): artificial
Medium	• All watercourse buffers / development setback areas • Micro-outlets into the sea (as per Van Niekerk *et al.* 2020)	20 m buffer round dams / artificial wetlands 50 m buffer for 1:50 000 rivers 50 m buffer for all wetlands 100 m buffer for NFEPA rivers EFZ data (NBA 2018b)
Low	• Rest of site – i.e. non aquatic areas outside of recommended aquatic ecosystem buffer zones	

4.7.5 Results of Sensitivity assessments

Figures 4-7.1 to 4-7.3 illustrate the results of geohydrological, surface water resources and aquatic ecosystems sensitivity mapping, applied as per the rules / logic outlined in Sections 4.7.1 to 4.7.4.

The sensitivity layers have been developed separately for each of these disciplines, on the basis that some activities might affect groundwater resources but not surface resource use or availability or aquatic ecosystems and *vice versa*, and that to overlay all of them on one map would suggest greater sensitivity and the need for avoidance of large areas than would otherwise be the case.

In this regard it is further noted that while the maps have denoted "sensitive areas", not all areas mapped as sensitive would necessarily be sensitive to all activities in the proposed development scenarios.

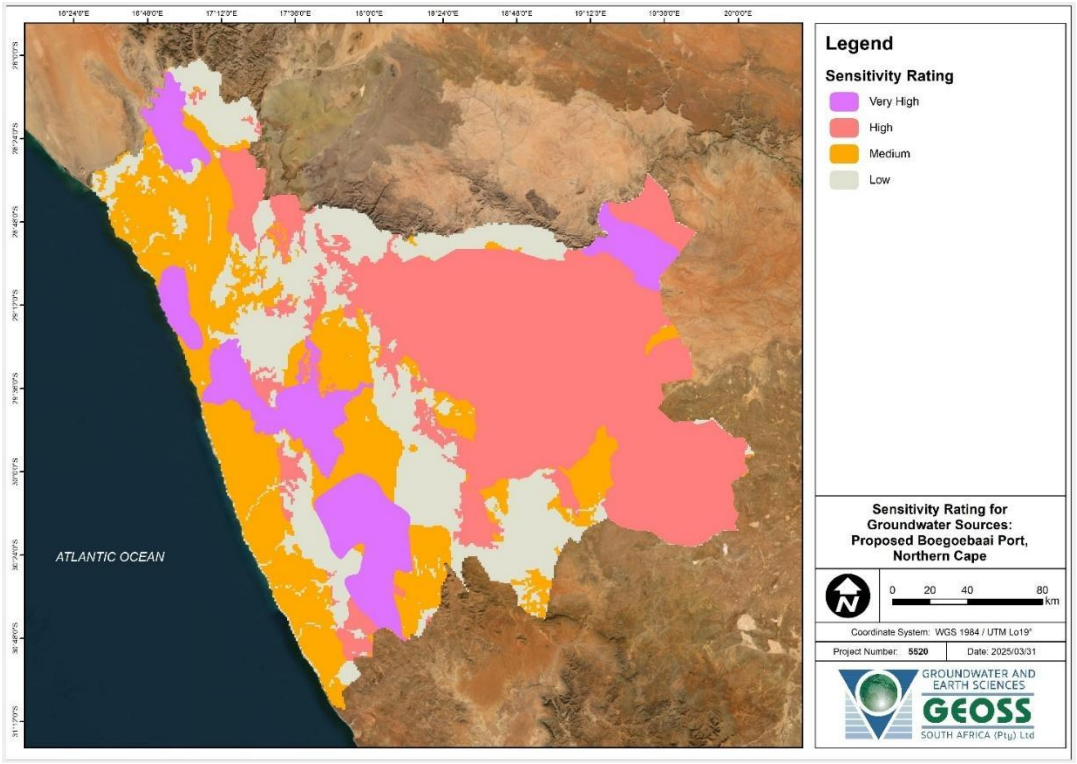


Figure 4-7.1: Results of application of the groundwater sensitivity classification presented in Table 4-7.4 , in the SEA study area

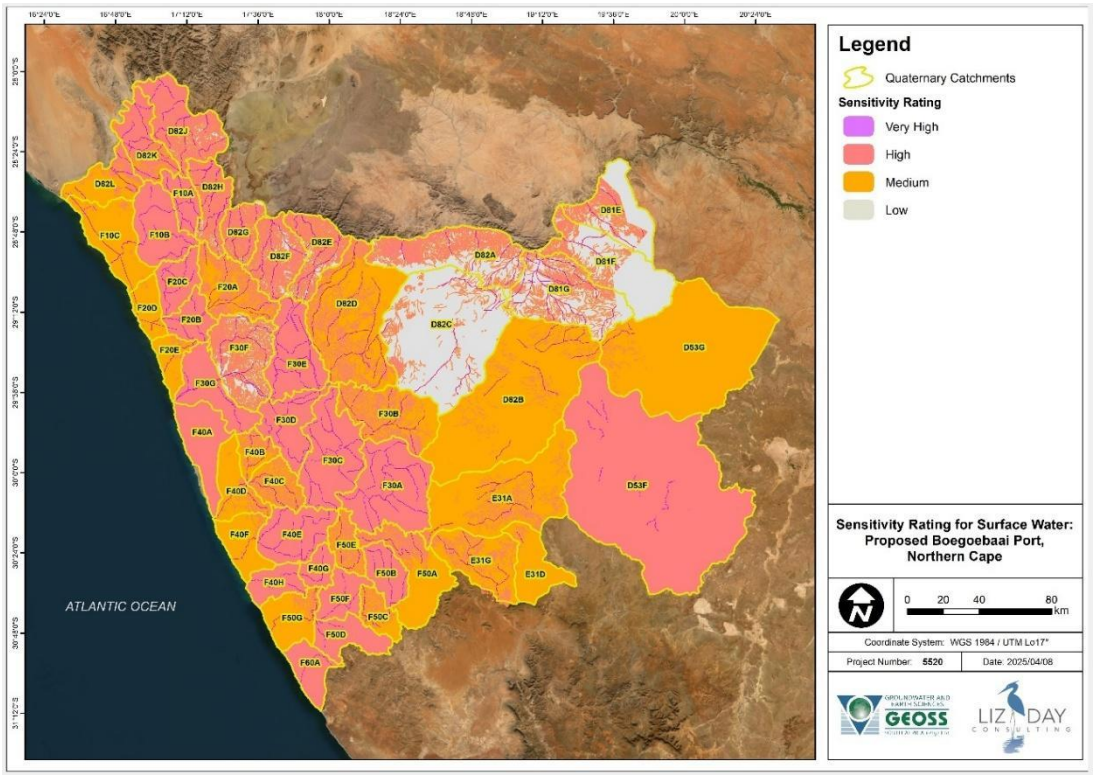


Figure 4-7.2: Results of application of the surface hydrology sensitivity classification presented in Table 4-7.5, in the SEA study area

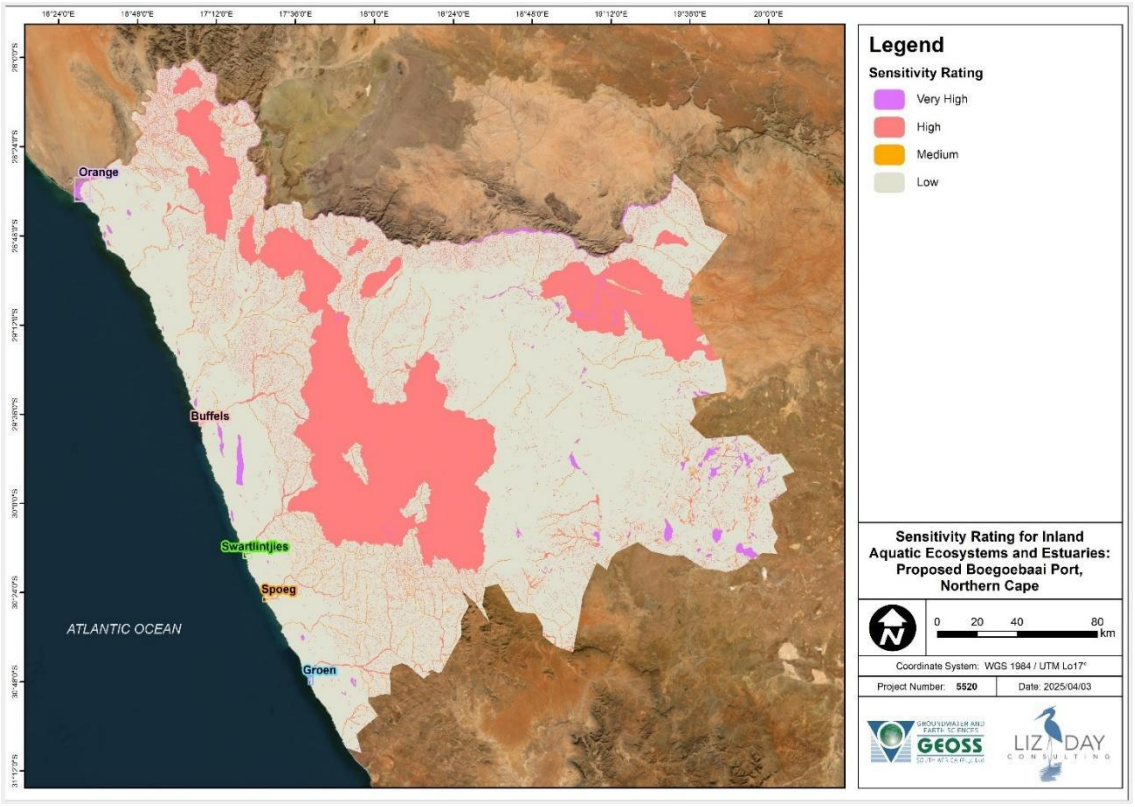


Figure 4-7.3: Results of application of the inland and estuarine aquatic ecosystem sensitivity classification presented in Table 4-7.6 in the SEA study area

4.8 IMPLICATIONS OF DEVELOPMENT SCENARIOS FOR WATER RESOURCES

4.8.1 Assessed development scenarios

Assessment of the implications of a large Northern Cape Green Hydrogen-driven economy has been assisted in this study by consideration of three development scenarios, namely:

- Scenario 0 - A dynamic baseline, over the period 2023-2050, that considers climate change but assumes no green hydrogen development in the Northern Cape. This scenario does assume current development trends, including renewable energy development;
- Scenario 1 - Small green hydrogen development (by 2035) and associated expansion of renewable energy generation and transmission infrastructure in the area, in support of the proposed Boegoebaai Port and SEZ development;
- Scenario 2 -Upscaled green hydrogen development (by 2050) and associated expansion of renewable energy generation and transmission infrastructure in the area.

The likely development infrastructure and other aspects of the two development scenarios are detailed in CSIR (2024).

Table 4-8.1: Explanation of symbols used in this section, to indicate resource trajectory.

Trend direction	Explanation
	Evidence/experience suggests a substantial decrease in the driver or its quality
	Evidence/experience suggests a moderate decrease in the driver or its quality
	Evidence/experience suggests no change in the driver or its quality
	Evidence/experience suggests a moderate increase in the driver or its quality
	Evidence/experience suggests a substantial increase in the driver or its quality
	Insufficient Evidence/experience to predict the direction of the driver or its quality, or evidence/experience is conflicting

4.8.2 Projected impacts for regional groundwater

4.8.2.1 Baseline Scenario (Scenario 0)

Evidence suggests that temperatures in Namaqualand have been increasing over the last century, and that the rate of warming has been increasing, most notably over the last two decades. There has been an increase in the frequency of hot days and a corresponding decrease in the frequency of cool days (Davis et al. 2016). Climate change projections for the Namakwa District indicate increasing temperatures and shifting rainfall patterns resulting in drier, hotter conditions in the region. It is predicted that the region will experience a 3 – 4°C increase in temperature (Christensen et al., 2007) and a 10 – 20% decrease in annual runoff by 2041 – 2060, relative to the period 1900 – 1970 (Milly et al., 2005). Mean Annual Precipitation (MAP) is projected to decrease by between 10 – 20% in most places, but between 0 – 10% in other locations (WRC 2024). It is also projected that Mean Annual Potential Evapotranspiration (MAPE) will increase by 6 – 10% (WRC, 2023).

These projected climate trends are expected to significantly increase pressure on water resources, exacerbating water scarcity (Bourne et al., 2015). Overutilisation of the already stressed Orange River is anticipated to add additional pressure on the groundwater resources in the region. Consequently, groundwater abstraction is anticipated to increase, as many towns in the region rely on groundwater for sole supply (Conrad et al., 2003). There will be reduced groundwater availability in the alluvial aquifers due to decreased rainfall (CSIR, 2023), particularly a decrease in rainfall events that will be able to sufficiently infiltrate into the aquifer systems to provide recharge. Increased extreme runoff events are unlikely to improve or lessen recharge to riparian aquifers. Reduced recharge to alluvial aquifers will result in reduced recharge to dependent fractured aquifers. Groundwater recharge, however, is a complex hydrological process affected by many conditions such as precipitation, evaporation, soil, vegetation, topography, geology (Fu et al., 2019; Moeck et al., 2020). Groundwater recharge threshold conditions which are defined as the necessary conditions required and the specific values that these conditions must reach to trigger a groundwater level rise (Moeck et al., 2020), requires further investigation in the region. Limited studies from the area indicate that with a rainfall threshold of >20 mm, less than 1% to seldom more than 10% of precipitation can infiltrate the subsurface to reach the groundwater (DWAF, 2008a).

In a baseline scenario where no significant developments are anticipated to occur, populations of the four local municipalities are anticipated to increase by 25 – 86% of the 2021/2022 surveyed populations by 2050. In many cases, aquifers are already stressed due to over-abstraction for various reasons, including high demand, poor infrastructure and improper management (Pietersen et al., 2009). Heavy reliance on groundwater in the region has already resulted in declines observed in water levels of monitoring boreholes between 1990 – 2008 (DWS 2008a). Increased development and settlement will exacerbate this.

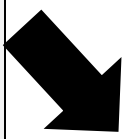
Basic access to water is calculated to be 25 L/p/day (The Strategic Framework for Water Services, 2003) whereas 'sufficient' access to water is considered to be in the range of 42 – 50 L/day (UCT, 2017). These estimates, however, are considered to be highly conservative and sufficient for survival, not taking into account actual water use. Governmental data released for the 2020/2021 water use reports indicate that the actual average water consumption per capita for Namakwa District Municipality is 147 L/day (DWS, 2023). Assuming groundwater usage per capita remains constant, water use will increase by the same percentage range. The area will become increasingly water stressed under the baseline scenario.

Marine aerosols contribute to increased groundwater salinity through dry deposition in coastal areas. Additionally, the presence of salt-rich heuweltjies in the region has been linked to elevated groundwater salinity (Francis et al., 2022). Projected increase in runoff extremes may result in the flushing of concentrated salts from these mounds, into the groundwater, exacerbating salinization (Van Gend et al., 2021). Increased salinity in the alluvial aquifers is likely to affect basement aquifers which are dependent for indirect recharge, possibly leading to increasing salinisation of groundwater in the region over time.

Table 4-8.2 presents the assumed key drivers of groundwater resources, and their trajectory over the time frames considered in this SEA (by 2030 and up to 2050), in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure in the Namakwa area. These assumed trajectories form the basis for assessment of the likely impacts of Scenarios 1 and 2.

Table 4-8.2: Assumed key drivers of groundwater resources, and their trajectory over the time frames considered in this SEA (2025 to 2050), in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure.

Symbols as per Table 4-8.1. All of these drivers would be exacerbated in Scenarios 1 and 2 (Sc1 and Sc2).

Theme/Driver Groundwater resources	Trend	Explanation Scenario 0
Water Use		Climate change projections for the Namakwa District indicate drier, hotter conditions, heightening water demand. This trend is expected to significantly increase pressure on water resources, with rising temperatures and reduced rainfall exacerbating water scarcity (Bourne et al., 2015). Groundwater abstraction is anticipated to increase, as many towns in the region rely on groundwater for sole supply (Conrad et al., 2003).
Water Demand		Increasing MAPE, reduction in average rainfall and rainfall frequency (WRC 2023) will intensify the pressure on existing and future water resources. Consequently, over-utilisation of water sources like the Orange River will likely increase surface water scarcity in the region. The depletion of surface water in the region will result in increased demand on groundwater resources (CSIR, 2023).
Water Quality		Marine aerosols contribute to increased groundwater salinity through dry deposition in coastal areas. Additionally, the presence of salt-rich heuweltjies in the region has been linked to elevated groundwater salinity (Francis et al., 2022). Projected increase in runoff extremes may result in the flushing of concentrated salts from these mounds, into the groundwater, exacerbating salinization (Van Gend et al., 2021). Increased salinity in the alluvial aquifers is likely to affect basement aquifers which are dependent for indirect recharge.
Water Availability and Recharge		Reduction in groundwater availability in the alluvial aquifers due to decreased rainfall (CSIR, 2023), particularly a decrease in rainfall events that are able to sufficiently infiltrate into the aquifer systems to provide recharge. Higher extreme runoff events are not likely to improve or lessen recharge to riparian aquifers. Reduced recharge to alluvial aquifers will result in reduced recharge to dependent fractured aquifers. In many cases, aquifers are already stressed due to over-abstraction for various reasons, including: high demand, poor infrastructure and improper management (Pietersen et al., 2009). Increased development and settlement will exacerbate this. Heavy reliance on groundwater in the region has already resulted in declines observed in water levels of monitoring boreholes between 1990 – 2008 (DWS, 2008a).

4.8.2.2 Further Development (Boegoebaai Port) (Scenarios 1 and 2)

It has been proposed that incoming residents would be accommodated in two of the larger towns, namely Alexander Bay and Port Nolloth (see SEA Infrastructure chapter). Based on the assumption of an average household size of 4.3 people, Alexander Bay would gain between 2 573 to 3 048 people while Port Nolloth would gain between 4 780 to 5 663 people over the long-term operation of the port. These additional residents may result in increased groundwater demand of 1.081– 1.281 ML/a. These numbers could be significantly higher should more employees bring their families.

Such a significant increase in population in conjunction with the population projections for the baseline scenario may lead to water shortages in the area if there is insufficient and appropriate planning for bulk supply. The Port Nolloth area is categorised as both a high priority GRU (F20D) as well as a groundwater SWSA, indicating that the area hosts important groundwater resources that are stressed, requiring careful management. East of Alexander Bay, between Sanddrift and Sendelingsdrift, another high priority GRU (D82K) is delineated. This is a possible indication that the groundwater resources are insufficient to sustain the growing demand at the current consumption rate.

Due to lack of available funding, the state of the DM's bulk water supply network is under strain and refurbishments are needed. Further development is also identified in a number of areas. Examples include Kharkams, which is mostly reliant on groundwater, but supply is already unable to meet peak demand with refurbishment of bulk water supply infrastructure underway. Groundwater development is earmarked for the settlements of Hondeklip Bay, Lekkersing, Eksteenfontein and Kuboes. Additionally, there has been upgrade and refurbishment of the existing boreholes in Kamiesberg and Richtersveld LMs (DWS 2025). Consultation of the DWS project list for the DM indicates that the municipality is struggling to meet current water demand and added pressure may have severe consequences.

4.8.3 Projected impacts for surface water resources

4.8.3.1 Baseline Scenario (Scenario 0)

Both groundwater withdrawals and the reticulated supply from the Orange River are severely stressed in the region. Assessment studies point to augmenting the abstractions and reticulation of supply from the Orange River (BVI 2023a; DWS 2012). Desalination of ocean water and borehole water has been assessed as a supplementary option, but studies warn of the lack of current capacity to operate this sophisticated technology.

With expected growth remaining at 1.68% per annum in the Port Nolloth Bulk Water supply scheme, the current system will require augmentation to supply some 917 000 kL/annum (based on consumption of 125L/person/day plus losses and municipal use, making 145 L/person/day). The Alexander Bay pipeline is designed to deliver approximately 504 000 kL/annum, and even this is not systematically delivered. Groundwater may yield some 345 000 kL/annum, but this is increasingly subject to desalination requirements prior to household consumption.

4.8.3.2 Further Development (Boegoebaai Port) (Scenario 1 and 2)

The predicted increase in population to include the Boegoebaai SEZ in the Port Nolloth supply area amounts to some 76% by 2040, being a population increase from 7 078 to 12 503. Other areas may also see significant increases in population. Development of the SEZ and the associated population increase in the surrounding towns are moreover likely to attract additional industrial and residential development in the region. The increase in water demand, however, cannot be qualitatively assessed at this stage.

A combination of Orange River abstractions from the Port Nolloth Bulk Water Supply scheme, Namakwa Supply scheme as well as desalination of borehole and ocean water would be required to meet the expected increase in demand in the region.

The required dependence of new development and expanded populations on desalination infrastructure does mean that these would be highly vulnerable to energy disruption caused by infrastructure failure, mismanagement or power outages. **Table 4-8.3** presents the assumed key drivers of surface water resources, and their trajectory over the time frames considered in this SEA (by 2030 and up to 2050) in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure in the Namaqua area. These assumed trajectories form the basis for assessment of the likely impacts of Scenarios 1 and 2.

Table 4-8.3: Assumed key drivers of surface water resources, and their trajectory over the time frames considered in this SEA (2025 to 2050), in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure.

Symbols as per Table 4-8.1. All of these drivers would be exacerbated in Scenarios 1 and 2 (Sc1 and Sc2).

Theme/Driver Surface Water resources	Trend	Explanation
Evapotranspiration	↗	Projected increase in Mean Annual Potential Evapotranspiration (MAPE) of 6 to 10% (WRC 2023). Increased vegetation uptake will impact agriculture and ecosystems. Human comfort levels will deteriorate, and water demand will increase. Stored open water bodies will experience higher losses.
Rainfall	↘	Mean Annual Precipitation (MAP) has reduced from 100 years ago, but over the past 50 years has been stable (Benito 2011). MAP is projected to decrease between 10-20% in most places, but some locations between 0 -10% (WRC 2024). Less local water in quaternary catchments.
Mean Runoff	↓	Runoff has been dropping marginally over the past 50 years in Namaqualand (Benito *et al*. 2011). Mean Annual Runoff (MAR) is projected to reduce by up to 50% in most quaternary catchments but may increase by up to 25% in a few places. The sporadic nature of runoff events offers very limited opportunity for usable storage. Some small farm dams are concentrated in the mountainous areas of the Buffels river and in the salt pan areas of quaternaries D53F and D53G.
Runoff Extremes	→	Flood events are not likely to increase in intensity. Present to Near-Future Climate change GCMs predict a 20% reduction in maximum discharge. Riparian areas will be subjected to reduced flood levels and crossings exposed to ongoing flood damage.
Dry Periods	↑	The current average duration of runoff-free periods is 350 days, with some places reporting dry periods of several years (SRK Quaternary Runoff Analysis). These dry intervals are likely to increase (Climate change GCMs predict slight increase in average duration – 1%, but large increases in the maximum dry periods up to 45%). Nine of the quaternary catchments are likely to change classification from Arid to Hyper-Arid in the near future. Extended runoff-free dry periods will impact ecosystems and agriculture.
Water Demand	↑	Increasing MAPE, reduction in average rainfall and decrease in rainfall frequency (WRC 2023) will intensify the pressure on existing and future water resources.
Water Scarcity	↑	Within quaternary catchments, higher MAPE and lower MAP will increase water scarcity. Higher extreme runoff events are not likely to improve or lessen recharge to riparian aquifers, although salinity may increase due to the higher MAPE (Benito 2011). However, predicted increase in flows in the Orange River due to future MAP increase in Lesotho and eastern RSA may allow for increased abstractions, depending on upstream water use in the Orange-Vaal system.
Bulk Water Supply	↗	Increase in demand will be met from Orange River abstractions due to projected increase in Orange River MAR at points of abstraction due to predicted Climate Change increases in runoff in Lesotho and eastern RSA (WRC 2023). However, availability for abstraction will depend on upstream water use in the Orange-Vaal systems.

4.8.4 Projected impacts for inland and estuarine aquatic ecosystems

4.8.4.1 Baseline Scenario (Scenario 0)

The changes in geohydrology and surface hydrology predicted above would have implications for aquatic ecosystems, even in the absence of the escalated development associated with a green hydrogen economy in the study area. Although the area is characterised by ephemeral rivers and pans, adapted to infrequent and unpredictable inundation, there are assumed to be (unquantified) thresholds of inundation frequency and, more particularly, duration, beyond which natural faunal and plant life cycles cannot be completed. This would be particularly applicable to the ephemeral pan systems, which are infrequently inundated but, when they are inundated, retain water for days to several weeks, and long enough for often complex invertebrate communities to complete their life cycles (e.g. Allan *et al*. 1995). If reduced frequency of rainfall, coupled with increased temperature-driven evaporation rates resulted in inundation periods that are too short for invertebrate and plant life cycles, there may be significant biodiversity loss in these systems, many of which are poorly studied.

Other ecological impacts associated with decreased rainfall frequency and extended periods of no rainfall would be deterioration in the condition of riparian vegetation along many watercourses, as access to shallow groundwater or periodic rainfall decreased, making these systems increasingly vulnerable to erosion in sandy areas.

Changes in water quality are also likely, as a result of increased evapotranspiration and decreased surface water, affecting aquatic habitat quality and, in estuarine areas in particular, increasing salinity in systems that are already subject at times to hypersalinity (e.g. the Swartlintjies and Groen) (DWS 2017a). Decreases in groundwater flows and increases in groundwater salinity would be of even more concern for water quality in all four CTAPC West Coast estuaries, where fresher groundwater inflows support sedge and reedbed habitat in their upper reaches.

A reduction in the frequency and magnitude of floods in the lower reaches of ephemeral rivers with estuarine outlets would also potentially further impact on estuarine connectivity, by reducing breaching episodes and thus limiting fish recruitment into these systems. Recruitment success is currently also limited by excessive estuarine salinity, at least at times (DWS 2017a), and this too would be likely to be increasingly experienced going forwards.

Other water quality impacts would be associated with population increases, and increased sewage effluent production in affected areas, adding to already generally inefficient and overloaded WWTWs in the study area (see **Table D3**, Appendix D).

Without active intervention, existing impacts on the Orange River Estuary would continue and additional flood reduction impacts including changes in sediment regime are also possible, if the proposed large dam upstream of the study area (Vioolsdrift Dam) is constructed (DWS 2017b). However, if the non-flow related remedial measures outlined in DWS (2017b) were in fact implemented, some improvement in estuary condition towards its REC might also occur. The confidence in such measures being implemented is however low – 14 years have elapsed since they were first mooted in Van Niekerk *et al.* 2013).

Table 4-8.4 presents the assumed key drivers of aquatic ecosystem condition and extent, and their trajectory over the time frames considered in this SEA (by 2030 and up to 2050) in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure in the Namakwa Region. These assumed trajectories form the basis for assessment of the likely impacts of Scenarios 1 and 2. It is noted however that these ecosystem drivers are tightly linked to the predicted ground- and surface water resource trajectories, outlined in **Tables 4-8.2 and 4-8.3**.

Table 4-8.4: Assumed key drivers of inland aquatic ecosystem and estuarine ecosystems (including micro-outlets) and their trajectory over the time frames considered in this SEA (2025 to 2050), in the absence of the proposed Green Hydrogen project and its associated Boegoebaai Port development, SEZ and associated expansion of renewable energy developments and infrastructure. Symbols as per Table 4-8.1.

All of these drivers would be exacerbated in Scenarios 1 and 2 (Sc1 and Sc2).

Theme Aquatic ecosystems: Inland and Estuarine ecosystems	Trend	Explanation
Water quality	↓	Water quality in aquatic ecosystems is expected to be on a deteriorating trajectory, with increasing salinities associated with predicted decreased rainfall (Benito 2011). Increases in populations in some local municipalities means increased loads of sewage, and associated increased risks of nutrient enrichment and possible microbial and other contamination of local watercourses, depending on WWTW efficacy (see Table D3 in Appendix D).
Ephemeral pans	↘	Reduced rainfall will be compounded by increased evapotranspiration. Pan hydroperiod may decrease – if it decreases over thresholds of concern (e.g. inundation period is too short for temporary pan-adapted fauna to complete lifecycles) then aquatic biodiversity will be impacted, while terrestrial fauna dependent on pans for water for parts of the year would also be impacted. Plants in and around pans could also be impacted if conditions become hotter, drier and more saline. If plants die back, this will impact on the value of some pans for provision of grazing material.
Seasonal and temporary rivers	↘	Where extended dry periods result in loss of riparian vegetation, ephemeral and seasonal rivers will be more vulnerable to erosion when flooding occurs, particularly at road crossings, where episodic flows are concentrated. These systems are already impacted in some areas by over-grazing, focused along riverine channels, and this would be expected to be ongoing, with its impacts exacerbated by vegetation under increasingly water-stressed conditions.
Wetlands	↓	Extended dry periods and reduced MAP will impact on wetland condition, shifting permanently saturated and seasonally wetlands towards seasonal to ephemeral systems. Although such wetlands are limited in the study area they do occur (e.g. Kamiesberg mountains) where wetlands retain water and allow drinking and foraging by indigenous biota and livestock throughout the year (Samuels 2013; Kotze *et al.* 2010) and provide other benefits, such as erosion control and flow regulation (Kotze et al. 2010, Black and Turpie 2016). Changes in wetland condition and type may trigger erosion and reduce crucial wetland ecosystem services in these areas.
Orange River and estuary	↓	Increased water stress may increase abstraction from the Orange River near Alexander Bay and (potentially) in its upstream river reaches (possibly offset by increase in MAP in upper catchment). Increased salinity in the lower estuarine salt marshes may be exacerbated by increased MAP and MAPE, in the absence of remedial measures (see DWS 2017b). Upstream dam construction would lessen flood flows into the estuary and change sediment regime in the lower river (DWS 2017b). Shifts in the river / estuarine interface could also occur, including estuary shrinkage, with implications for estuarine productivity as well as faunal community assemblages and distribution and, importantly, habitat availability for estuarine fish species.
Other estuaries	↓	Estuaries already impacted by hypersalinity (e.g. the Groen River Estuary) would be further impacted by increasingly saline surface and (especially) groundwater inflows, and reduced groundwater flows as a result of increased abstraction. Fish recruit into the Arid Predominantly Closed estuaries in the study area when peak flow periods overtop the estuary and link it to the sea – but hypersalinity in these estuaries affects fish survival (DWS 2024). Reduced flood frequency would lessen breaching events and thus impact on estuary flushing periodicity and fish recruitment opportunities. Such changes would potentially impact on habitat quality and estuarine macrofauna, in turn impacting on habitat quality for coastal and migratory birds. Reduced MAP and increased MAPE, leading also to increased pressure on water resources, may further threaten ground-water dependent systems (e.g. upper Spoeg and Groen estuaries), leading to loss of reedbed habitat, associated with inflows of lower salinity groundwater.

4.8.4.2 Further Development (Boegoebaai Port) (Scenarios 1 and 2)

The Scenario 1 and 2 developments would include development of Boegoebaai Port and SEZ, the implications of which have already been unpacked from an inland aquatic ecosystem and estuarine perspective in Day (2025). In addition to the intense development in the Boegoebaai area associated with the proposed port and SEZ, the associated roll-out of green energy production and transmission installations across the study area could have significant effects on aquatic ecosystems, with the following being the main considerations:

- Locally increased concentrations of flows from hardened surfaces, when rainfall occurs, resulting in the possible localised creation of eroded gullies in watercourses;
- Barriers to flood flows in the form of inappropriately designed roads and culverts over watercourse crossings, affecting downstream watercourse condition including estuarine flushing and water quality;
- Encroachment of new built infrastructure into watercourses, including construction of roads, pylons and pipelines through these systems – these might extend hundreds of kilometers across the study area;
- Fragmentation of sensitive ecosystems as a result of road construction – overall biodiversity (terrestrial and aquatic) would be negatively impacted by fragmentation that interrupts mosaic terrestrial and ephemeral aquatic systems;
- Impacts associated with expanding human populations and both formal and informal settlements, with such impacts including:
    - Increased sources of solid waste into open spaces including watercourses;
    - Increased volumes of variously treated sewage effluent, potentially discharged into watercourses but also irrigated, from where it can reach aquatic ecosystems via groundwater or flushing (DWS (2017a) note that the Buffels River Estuary is already impacted by golf course irrigation with treated sewage water);
    - Increased threats of sewage and solid waste associated with informal settlements – the latter are likely to expand with the expectation of improved job opportunities in the area;
    - Increased pressure on estuaries as recreational nodes for a growing population, and associated increases in fishing pressure, at least in the Orange River;
- Negative cumulative impacts of all of the above, potentially interacting at scale across multiple ecosystems.

The above impacts are expected to be relevant to Scenario 1 and to be sharply ramped up in Scenario 2 (as a guide, the former would be associated with a 21 082 ha infrastructure footprint and the latter with a 142 240 ha footprint (CSIR 2024)).

4.9 RISK / OPPORTUNITIES ASSESSMENT

4.9.1 General approach

A systematic risk / opportunity assessment is required in this chapter. Risk and opportunity are determined by estimating the **likelihood** of occurrence of different impacts or trends, in relation to their **consequences**. A structured assessment of these two components is provided in **Figure 4-9.1**. Note that in this chapter, the term "likelihood" refers to the likelihood of an impact occurring, if it is located within each of the variously rated sensitive areas. It does not refer to the likelihood that there would be desirability to locate an activity with its associated impacts in areas of differing sensitivity.

In order to provide a transparent and consistent approach to consequence ratings, these have been defined in this chapter for each of groundwater, surface hydrology and aquatic ecosystems (inland and estuarine ecosystems), as shown in **Table 4-9.1**. Risk and opportunity categories (Very Low to Very High) are defined in CSIR (2024).

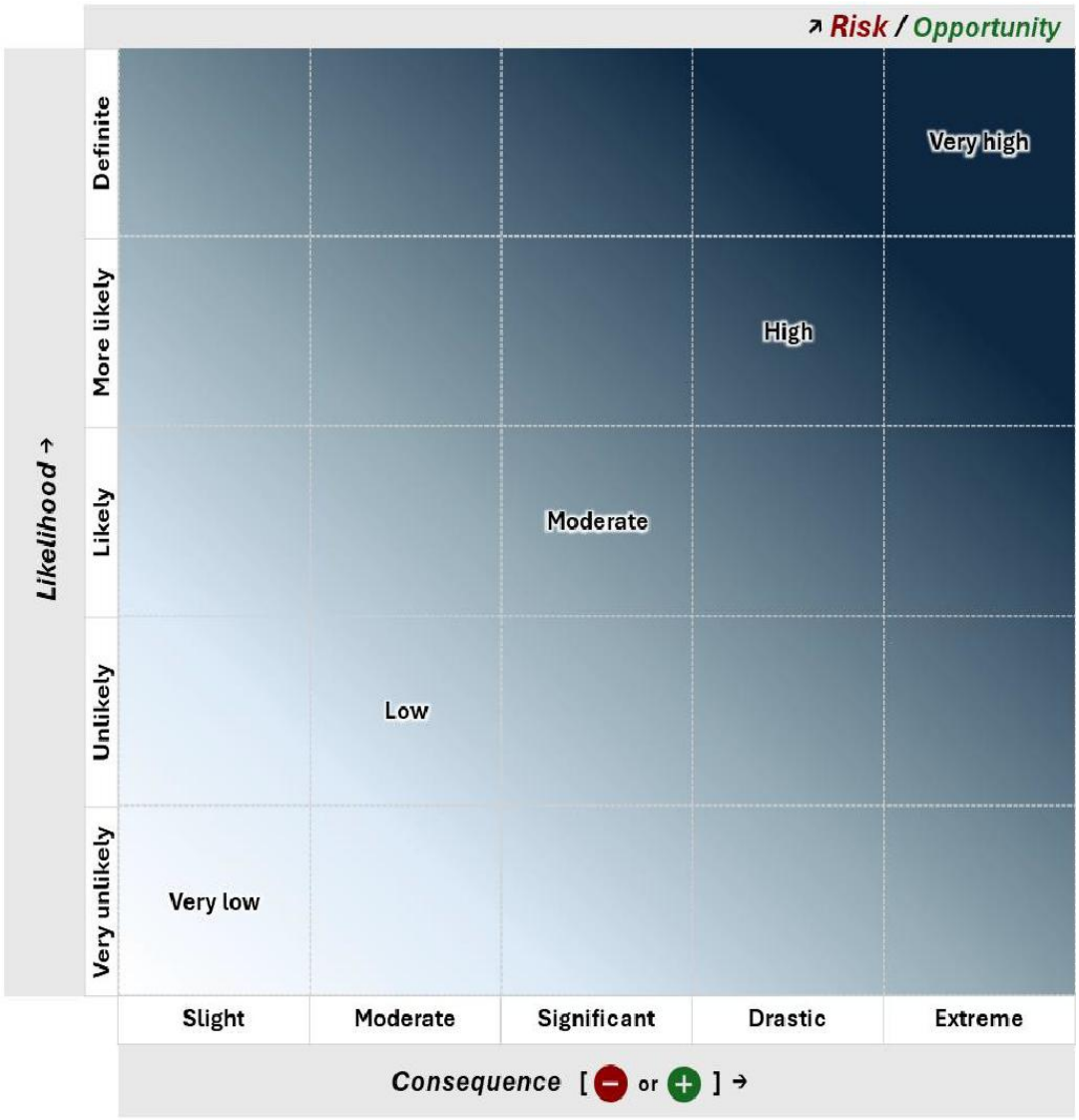


Figure 4-9.1: Schematic showing qualitative derivation of Risk and Opportunity by multiplying the likelihood of an impact (positive or negative) by the severity of the consequences for a particular theme. Figure after CSIR (2014).

Table 4-9.1: Description of Consequences (positive and negative) as defined for geohydrology, surface hydrology and inland and estuarine aquatic ecosystems, based on expert judgement. Consequence categories as per CSIR (2024) requirements.

		Geohydrology	Surface Hydrology	Inland and estuarine aquatic ecosystems

	Nature of Consequence	Consequence Description		
	Negative (-)	Impacts would harm the receiving (groundwater) environment (including people).	Impacts would reduce surface water availability, reliability or quality, affecting socio economic activities and /or human health and well being	Impacts would degrade aquatic ecosystem condition (compared to natural) and /or decrease resilience
	Positive (+)	Impacts would benefit the receiving (groundwater) environment (including people).	Impacts would improve surface water availability, reliability or quality, affecting socio economic activities and /or human health and well being	Impacts would improve aquatic ecosystem condition (compared to natural) and /or improve resilience

	Consequence	Geohydrology	Surface Hydrology	Inland and estuarine aquatic ecosystems
Negative	Slight	The effect on groundwater resources or human wellbeing (as a consequence of environmental change) would be minimal; impacts would be well within environmental quality standards or targets (RQOs), or legal requirements (determined threshold limits). There would be no need for mitigation.	Current flow regimes would largely remain constant. • Low rainfall-runoff intensity and duration of no-runoff increase at local extent and persist for medium term • Low rainfall-runoff intensity and duration of no-runoff increase at medium extent and persist for short term • Low to medium rainfall-runoff intensity and duration of no-runoff increase at local extent and persist for a short term. • Slight change to discharge or access of Orange River abstractions.	These would comprise: • No change in resource ecostatus class, although some reduction in resource quality or aspects of resource quality could be discernible. • No reduction in capacity to meet RQOs (compared to present); • Effects would be limited in extent (site specific) and would be readily reversible at any time and/or of short-term duration. • The impact should not have an influence on, or require to be significantly accommodated in the development design.
	Moderate	There would be little material effect on the resource or human wellbeing; impacts would be well within environmental quality standards or	• Moderate change to flow regimes	• Some degradation in resource ecostatus / possible change in PES class;

	Consequence	Geohydrology	Surface Hydrology	Inland and estuarine aquatic ecosystems
		targets (RQOs), or legal requirements (threshold limits). Minor mitigation measures may be required to manage potential impacts. The extent of the impact would likely be site-specific and duration would be short-term.	• Manageable impacts to ecosystems, drainage crossings, access points • Moderate reduction in discharge or abstraction potential of Orange River flows.	• Reduced capacity to meet all RQOs (compared to present); • Impacts however readily reversible once activity ceases; • Impacts well within the tolerance levels or adaptive capacity of aquatic ecosystems relying on the resource; • The impact should not have an influence on development decision-making, provided that recommended measures to mitigate negative impacts are implemented.
	Significant	There would be a material effect on the receiving resource (including people). Legal requirements would still be met but thresholds of potential concern with regard to environmental quality may be crossed. Mitigation measures (avoidance, minimization, rehabilitation/restoration, and in some cases offsets/ compensation) would be needed to reduce the impact significance. The extent of the impact would likely be local and duration would be medium-term.	• Substantial change to flow regimes. • Higher extreme events and longer dry periods result in substantial deterioration of ecosystems, drainage crossings and access points. • Substantial reduction in discharge or abstraction potential of Orange River flows.	• Marked degradation in resource ecostatus (deterioration by one or two classes) • Capacity to meet RQOs compromised (meeting REC unlikely) • Beyond the adaptive capacity of aquatic ecosystems to maintain key biotic elements • Impacts potentially reversible once activity ceases • The impact could have an influence on the environment and would require modification of the development design; alternative mitigation; and/or ecological offsets.
	Drastic	There would be major effects on the receiving resource to the extent where environmental quality standards or targets may be exceeded, legal requirements may not be met, and the health, safety, livelihoods and/or wellbeing of affected people could be endangered. Mitigation measures (avoidance/impact prevention, minimization, rehabilitation/restoration, and offsets/ compensation) are essential to	• Severe changes to flow regimes. • Increase in extreme events and longer dry periods between events lead to loss of income in agriculture and hardships in health, livelihoods and income. • Severe reduction in discharge or abstraction potential of Orange River flows.	• Considerable degradation in resource ecostatus (more than two classes); • Impacts reversible only with human intervention over decades; • System unable to meet RQOs and REC thus permanently compromised, unless impacts reversed;

	Consequence	Geohydrology	Surface Hydrology	Inland and estuarine aquatic ecosystems
		substantially reduce the impact significance. The extent of the impact would likely be regional and duration would be long-term.		• The impact could have a no-go implication for the development or a component of the development, regardless of any possible mitigation).
	Extreme	There would be severe effects on the receiving resource to the extent where environmental quality standards or targets would be exceeded, there would be non-compliance with legal requirements, and the health, safety, livelihoods and/or wellbeing of affected people would be jeopardized. Unmitigated impacts would be considered to be irreversible. Mitigation measures – avoidance or prevention of impacts as a priority would be required, since impacts are unacceptable. The extent of the impact would likely be regional and duration would be long-term to permanent.	• Extreme flow regime changes. • Increase in extreme events and extension of dry periods between events lead to irreversible, severe effects to income in agriculture and hardships in health, livelihoods and income for urban communities. • Extreme reduction in discharge or abstraction potential of Orange River flows.	• Extreme degradation in resource status (more than two classes); • Resource impacts irreversible and remediation impractical; • The level of impact should strongly influence decision-making and further steps should be investigated to avoid impacts.
Positive	Slight	The effect on the groundwater resource or human wellbeing (as a consequence of environmental change) would be minimal; impacts would remain within expected environmental quality standards (RQOs) or targets, or legal requirements (threshold limits). There is little to no appreciable benefits.	• Perturbations to flow regimes would not impact ecosystem, agriculture and human demand. • No shortfall in Orange River discharge and access.	• Impacts would reduce risk to aquatic ecosystems – but resource ecostatus class would not change; • Limited in extent (site specific); • Reversible at any time and/or of short-term duration (so not necessarily long-lived); • The impact would be positive but would not drive decision-making.
	Moderate	There would be little positive material effect on the resource or human wellbeing, and available quantities and qualities of the resource would be well within baseline/historical ranges for the resource. There is little appreciable benefit to human wellbeing. The extent of the impact would likely be site-specific, and duration would be short-term.	• Perturbations to flow regimes marginally improve supply to agriculture, ecosystems and human demand. Drainage systems remain intact and riparian system benefit. • Moderate improvement in discharge and abstraction potential of Orange River flows.	• Measurable improvement in resource ecostatus / possible change in PES class; • Improved capacity to meet all RQOs; • Positive impacts associated with the lifetime of the project – thus reversible once activity ceases;

	Consequence	Geohydrology	Surface Hydrology	Inland and estuarine aquatic ecosystems
				• The impact would be positive and should not drive decision-making but would be a factor to consider.
	Significant	There would be a material positive effect on the receiving resource (or human wellbeing), and available quantities and qualities of the resource may be within baseline/historical ranges for the resource, but are typically improved beyond what is considered 'normal'. There would be tangible benefits to human wellbeing. The extent of the impact would likely be local and duration would be medium-term.	• Substantial improvement to flow regimes. • Lower extreme events and shorter dry periods result in substantial improvement to ecosystems, drainage crossings and access points. MAR increase. • Substantially improved discharge and abstraction potential in Orange River flows.	• Marked improvement in resource ecostatus (improvement by one or two classes); • Capacity to meet RQOs markedly improved (meeting REC likely); • Positive impacts could be reversible once activity ceases; • The positive impact should have an influence on decision-making (for local or regional activities).
	Drastic	There would be major positive effects on the receiving resource to the extent where historical environmental quality ranges and available quantities would be improved beyond baseline/historical ranges leading to general improvement in quality and availability of the resource. The health, safety, livelihoods and/or wellbeing of affected people could be improved. The extent of the impact would likely be regional and duration would be long-term.	• Severe improvements to flow regimes. • Decrease in extreme events and shorter dry periods between events lead to access of quaternary catchment water and improvement to agriculture productivity, health, livelihoods and income. • Severe increase in discharge and abstraction potential of Orange River flows.	• Considerable improvement in resource ecostatus (more than two classes)' • Long-term conservation status secured at least locally' • System able to meet RQOs and REC' • The impact should influence decision-making.
	Extreme	There would be excessively positive effects on the receiving resource to the extent where historical environmental quality ranges and available quantities would be vastly improved beyond baseline ranges, leading to overall abundance. The health, safety, livelihoods and/or wellbeing of affected people would be vastly improved. The extent of the impact would likely be regional and duration would be long-term to permanent.	• Extreme improvements in flow regimes. • Decrease in extreme events and reduction of dry periods between events lead to improvements to income in agriculture and livelihoods and income for urban communities. Surface water storage becomes possible in quaternary catchments. • Extreme improvement in discharge and abstraction potential of Orange River flows satisfy all demands and provide excess for storage.	• Major improvement in resource status (at least two classes); • Long-term conservation status in perpetuity secured at locally to regionally; • The level of impact should strongly influence decision-making.

4.9.2 Risk and opportunity (impact) assessments

This section identifies broad impacts to water resources that are likely to be associated with the proposed Boegoebaai Port, SEZ and associated at-scale green energy production and infrastructure that would be rolled out in the Namakwa Region. The comments and identified issues outlined in Section 4.8 form the basis for the thinking in this section, which seeks to amalgamate multiple potential impacts into more general themes for risk and opportunity assessment.

It should be stressed that the impacts identified here are not intended to be all-encompassing but only to highlight major issues and opportunities that would have a bearing on decision-making regarding the feasibility and acceptability of the proposed development. More detailed impact identification, assessment and description of auditable impact avoidance, mitigation and management measures would be required on a site-by-site and project-specific basis, in the event that the principle of this development is supported.

Drawing on the above, **Table 4-9.2** broadly categorises some of the main activities likely to be associated with impacts to water resources within the study area, in terms of the level of "risk" posed by each. These risk categories are then assessed in the individual geohydrology, surface hydrology and aquatic ecosystem assessment sections that follow.

Table 4-9.2: Identification of development-related activities likely to be associated with different levels of risk to water resources (groundwater, surface and aquatic ecosystems)

Degree of Risk	Associated Activities
High	This grouping includes development aspects affecting recharge, surface water velocities and flow paths; encroaching into watercourses and estuaries; and water quality contaminants of serious concern (e.g. toxins, corrosives) namely: All hardened surfaces (buildings, roads, paving, loading and parking areas) for development of railways and portside access paths (port and SEZ area) as well as additional regional access roads; hardened surfaces for internal roads, wind turbine access roads, solar panel arrays and associated electrical infrastructure (e.g. pylons, BESS, substations and other buildings); storage of bulk liquid items such as green ammonia and diesel and the dispensing of these products via pipeline; water treatment facilities for green hydrogen production which includes nitrogen, hydrogen and oxygen storage and pipelines (port and SEZ area)
Medium	Disposal of treated and untreated sewage and other effluent from expanding settlements, and sewage pipelines
Low	Installation of bulk water supply pipelines; transmission lines; fences

4.9.3 Potential Groundwater Impacts

4.9.3.1 Impact description

The biggest risk associated with the development is likely to be the strain that additional groundwater users will have on the water supply system in an already water-stressed arid environment.

Two key impacts are identified on groundwater resources in the region:

- **Reduced groundwater availability and security:** Activities such as extensive development of hardened surfaces for roads are likely to reduce direct recharge to alluvial aquifers;
- **Reduced groundwater quality: Changes** in climate trends as well as the existing physical features in the region (e.g. heuweltijies) are likely to result in increased salinity of the groundwater with time. High-risk activities such as storage of bulk liquid items such as green ammonia and diesel, and the dispensing

thereof via pipeline, as well as facilities for green hydrogen production which include, nitrogen, hydrogen and oxygen storage and pipelines, pose a high risk to groundwater quality should contamination occur. Some categories of land use have higher associated risks as they may affect the groundwater recharge and quality more so than others. Categories of activities associated with the development are categorised in **Table 4-9.2**.

4.9.3.2 Mitigation measures

Mitigation measures would need to include preventing high risk development-associated activities in areas of high to very high sensitivity. High risk activities would need to be confined to areas of Low sensitivity, while Medium risk activities could potentially be applied in areas of High and Medium sensitivity, provided they included impact mitigation. Low risk activities could be applied in all areas, provided they were carried out with attention to Best Practice and a view to avoid or minimize contamination and disturbance.

Mitigation for the potential impacts identified in this chapter would be likely to prove complex and costly, as the main impacts are driven by the natural environment. Mitigation measures would probably require significant financial investment, as they might include support to municipal structures to assist in improving infrastructure and the management of groundwater resources in the area. Despite groundwater resources not being optimally managed at present, it remains that supply is limited. Additional measures to address water scarcity, albeit very costly, may include supplying treated, desalinised water to nearby communities. Consideration should be given to the fact that although provision of desalinised water may alleviate regional water scarcity, the operational requirements and potential mismanagement are accompanied by environmental and ecological risks, especially to marine ecosystems. This may ultimately result in a spatial transference of risk and impacts from the proposed development. The ecological, practical and financial feasibility of this mitigation measure, however, would need to be investigated.

Groundwater quality can be protected by ensuring that groundwater resources are protected from high-risk activities by implementing stricter regulations and requiring adherence thereto. Deterioration of water quality due to poorly functional water treatment facilities, as well as industrial and agricultural activities can be prevented. Investment into the current water supply infrastructure and into training schemes for municipal staff may improve wastewater quality released from treatment facilities. The use of appropriately treated wastewater can be considered as an alternative source of water in the area. Training schemes may also enhance borehole management, mitigating certain issues such as iron biofouling. With the exception of the introduction of a managed aquifer recharge schemes, the possible natural increasing salinisation of groundwater (baseline scenario and both development scenarios) may not, however, be mitigable.

4.9.3.3 Impact assessment

Tables 4-9.3 and **4-9.4** provide formal ratings of the above impacts, considering their application to areas of different groundwater sensitivity (Very High to Low sensitivity, as mapped in **Figure 4-7.1**) , for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2).

The ratings are carried out separately, with and without the recommended mitigation and management measures outlined above. **Table 4-9.3 Assessment of potential impacts on groundwater availability and security**

Table 4-9.3: Assessment of potential impacts on groundwater availability and security

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With Management (Financial and Legislative Intervention: policies, investment, training)		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Drastic	Likely	High	N/A	N/A	N/A
	S1: Small GH2		Drastic	Likely	High	Significant	Likely	Moderate
	S2: Big GH2		Extreme	Likely	Very High	Drastic	Likely	High
	S0: Baseline	High Sensitivity	Moderate	More Likely	Moderate	N/A	N/A	N/A
	S1: Small GH2		Drastic	Likely	High	Significant	Likely	Moderate
	S2: Big GH2		Drastic	Likely	High	Significant	Likely	Moderate
	S0: Baseline	Medium Sensitivity	Moderate	Likely	Low	N/A	N/A	N/A
	S1: Small GH2		Significant	Likely	Moderate	Slight	Likely	Very Low
	S2: Big GH2		Significant	Likely	Moderate	Moderate	Likely	Low
	S0: Baseline	Low Sensitivity	Slight	Likely	Very Low	N/A	N/A	N/A
	S1: Small GH2		Moderate	Likely	Low	Slight	Likely	Very Low
	S2: Big GH2		Moderate	Likely	Low	Slight	Likely	Very Low
Impact	**Scenario**	**Spatial receiving environment or receptor**	**Without Management**			**With Management (Physical Intervention: desalination, MAR)**		
			Consequence (+)	**Likelihood**	**Opportunity**	**Consequence (+)**	**Likelihood**	**Opportunity**
Positive	S0: Baseline	Very High Sensitivity	N/A	N/A	N/A	N/A	N/A	N/A
	S1: Small GH2		N/A	N/A	N/A	Significant	Likely	Moderate
	S2: Big GH2		N/A	N/A	N/A	Significant	Likely	Moderate
	S0: Baseline	High Sensitivity	N/A	N/A	N/A	N/A	N/A	N/A
	S1: Small GH2		N/A	N/A	N/A	Significant	Likely	Moderate
	S2: Big GH2		N/A	N/A	N/A	Significant	Likely	Moderate
	S0: Baseline	Medium Sensitivity	N/A	N/A	N/A	N/A	N/A	N/A
	S1: Small GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S2: Big GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S0: Baseline	Low Sensitivity	N/A	N/A	N/A	N/A	N/A	N/A
	S1: Small GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S2: Big GH2		N/A	N/A	N/A	Moderate	Likely	Low

Table 4-9.4: Assessment of potential impacts on groundwater quality

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Moderate	Likely	Low	N/A	N/A	N/A
	S1: Small GH2		Drastic	Unlikely	Moderate	Significant	Unlikely	Low
	S2: Big GH2		Extreme	Unlikely	Moderate	Drastic	Unlikely	Moderate
	S0: Baseline	High Sensitivity	Moderate	Likely	Low	N/A	N/A	N/A
	S1: Small GH2		Drastic	Unlikely	Moderate	Significant	Unlikely	Low
	S2: Big GH2		Extreme	Unlikely	Moderate	Drastic	Unlikely	Low
	S0: Baseline	Medium Sensitivity	Moderate	Likely	Low	N/A	N/A	N/A
	S1: Small GH2		Significant	Unlikely	Low	Moderate	Unlikely	Low
	S2: Big GH2		Significant	Unlikely	Low	Moderate	Unlikely	Low
	S0: Baseline	Low Sensitivity	Slight	Unlikely	Very Low	N/A	N/A	N/A
	S1: Small GH2		Moderate	Likely	Low	Slight	Likely	Very Low
	S2: Big GH2		Moderate	Likely	Low	Slight	Likely	Very Low

4.9.4 Potential impacts to surface water resources

4.9.4.1 Impact description

The entire study area is classified as either arid or hyper-arid. Water for life and livelihoods is limited and is likely to become increasingly scarce, without effective alternative water supplies. Potential impacts to surface water resources include:

- Increasing stresses on a limited water supply from the Orange River, for an increasing population;
- Increasing shortage of water to sustain life and livelihoods where areas change from arid to hyper-arid in the future.

4.9.4.2 Mitigation measures

Mitigation measures, particularly in the north-west of the delimited area, would need to include:

- Appropriate estimation of future needs, design and implementation of new and augmented water supply schemes from the Orange River, in alignment with the EFR and RQOs for the estuary and lower Orange River;
- Implementation of effective desalination plants to meet additional water demand;
- Effective capacity building and proper operation and maintenance of abstraction works, reticulation and local water supply infrastructure;
- Prevention of pollution to the abstraction works, where Orange River water is drawn from riparian subsurface (to allow for abstraction of filtered Orange River yield).

It is however noted that the required dependence of new development and expanded populations on desalination infrastructure does mean that these would be highly vulnerable to energy disruption caused by infrastructure failure, mismanagement or power outages.

4.9.4.3 Impact assessment

Table 4-9.5 provides formal ratings of the above impacts, considering their application to areas of different surface water sensitivity (Very High to Low sensitivity, as defined in Section 4.7.3 and mapped in **Figure 4-7.2**) , for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2).

The ratings are carried out separately, with and without the recommended mitigation and management measures outlined above.

Table 4-9.5: Assessment of potential impacts on surface water resource availability, quality and security

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Severe	More likely	Very High	Substantial	Less Likely	Moderate
	S1: Small GH2		Extreme	Likely	Very High	Substantial	Less Likely	Moderate
	S2: Big GH2		Extreme	Likely	Very High	Substantial	Less Likely	Moderate
	S0: Baseline	High Sensitivity	Substantial	More likely	High	Moderate	Unlikely	Low
	S1: Small GH2		Severe	Likely	High	Moderate	Unlikely	Low
	S2: Big GH2		Severe	Likely	High	Moderate	Unlikely	Low
	S0: Baseline	Medium Sensitivity	Moderate	More likely	Moderate	Moderate	Unlikely	Low
	S1: Small GH2		Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S2: Big GH2		Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S0: Baseline	Low Sensitivity	Slight	Likely	Low	Slight	Unlikely	Very Low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Unlikely	Very Low
	S2: Big GH2		Moderate	Unlikely	Low	Slight	Unlikely	Very Low
Positive	S0: Baseline	Very High Sensitivity	N/A	N/A	N/A	Substantial	Less Likely	Moderate
	S1: Small GH2		N/A	N/A	N/A	Substantial	Likely	Moderate
	S2: Big GH2		N/A	N/A	N/A	Substantial	Likely	Moderate
	S0: Baseline	High Sensitivity	N/A	N/A	N/A	Moderate	Less Likely	Low
	S1: Small GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S2: Big GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S0: Baseline	Medium Sensitivity	N/A	N/A	N/A	Moderate	Less Likely	Low
	S1: Small GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S2: Big GH2		N/A	N/A	N/A	Moderate	Likely	Low
	S0: Baseline	Low Sensitivity	N/A	N/A	N/A	Slight	Less Likely	Very Low
	S1: Small GH2		N/A	N/A	N/A	Slight	Likely	Very Low
	S2: Big GH2		N/A	N/A	N/A	Slight	Likely	Very Low

4.9.5 Potential impacts to inland aquatic ecosystems

4.9.5.1 Impact description: Degradation of inland aquatic ecosystems

The discussions in Section 4.8.4 and **Table 4-8.4** highlight a number of potential drivers of inland aquatic ecosystem degradation, both in the Baseline Scenario (Sc0) and in Scenarios 1 and 2. In the Baseline Scenario, these mainly comprise possible potential changes in pan ecosystem diversity; possible water quality deterioration (increasing salinity and nutrients); reduced riparian resilience as a result of reduced frequency of flows and extended no flow periods; increased vulnerability of ephemeral systems to erosion, grazing and trampling; and increased vulnerability of naturally ephemeral systems to the receipt of additional flows from treated and/or untreated effluent.

In the context of large-scale expansion of linear, hardened infrastructure such as roads across the Namakwa Region, with development likely to require new roads, widening and upgrading of existing roads, and new internal roads for wind farms in particular, as well as potentially hundreds of kilometers of pylons and transmission lines, impacts such as concentrated flows into watercourses, erosion, changes in sediment regimes and ecosystem fragmentation are all likely, along with indirect impacts also discussed, such as nutrient enrichment from variously treated or untreated effluent discharges, possibly brine discharges and potentially expanding urban formal and informal settlement footprints.

Construction phase impacts could be particularly damaging for aquatic ecosystems, if these occur near or within them, or require the movement of large vehicles / machinery through or near them.

Many of the aquatic ecosystems within the study area are, moreover, Critically Endangered or Endangered ecosystems (**Table 4-5.1**), and any impacts to such systems would be significant.

4.9.5.2 Avoidance, mitigation and management measures

The following broad measures would be recommended to reduce concerns around aquatic ecosystem degradation:

i. Measures to **avoid** impacts:

- No new development should be located in areas mapped in **Figure 4-7.3** (see also **Table 4-7.6**) as Very High Sensitivity;
- No new development should ideally take place in any areas mapped in **Figure 4-7.3** as High Sensitivity – however, limited Low Risk activities might be considered, provided there is adequate mitigation. In the case of (essential) road crossings, design mitigation could potentially reduce risks to Medium or Low, with significant input into design and construction phase mitigation, but such crossings should be minimised;
- Only Low Risk activities should be located in buffer areas (mapped as Medium Sensitivity);
- High Risk activities should be located only in areas of Low Sensitivity;
- Medium Risk activities may be mitigated to low, and could take place in areas of Low Sensitivity and some Medium sensitivity areas (excluding buffer areas);

ii. Measures to **mitigate against** impacts:

- WWTWs that discharge treated or untreated effluent into any watercourse or areas within 500 m of any watercourse should be required to treat such effluent to better than the DWS Special Effluent Limits (GN 383 of 2019), and rather to standards that are in line with the DWAF (1996) water quality guidelines for aquatic ecosystems, for mesotrophic systems, with regard to phosphorus and nitrogen nutrient;

- Developments or parts of developments entailing hardening of surfaces should be subject to meeting the requirements of a stormwater management plan that allows for recharge and appropriately attenuated runoff into the buffers of natural watercourses, and (where appropriate) requires separation of clean and polluted water on site, and treatment of the latter to ecologically acceptable standards;

- Buffer areas should be managed free of activities likely to impact negatively on their associated watercourses – thus there should be no hardening of surfaces in buffer areas, or disturbance likely to render these areas less effective as buffers;

- Road crossings over watercourses should be designed to allow for natural flows (including flood flows) to pass under or over the roads without concentration of flows downstream (e.g. as a result of passing through narrow culverts that result in narrower channels downstream) – culverts under road crossings should allow for the full width of flows in all watercourses to pass under the road, without creating concentrated flow paths;

- Where water pipelines are routed through areas of High sensitivity, construction measures must be managed to reduce disturbance, and final levels over the pipelines should be set to pre-development levels (i.e. without raised mounds over pipelines);

- The passage of vehicles through pans and ephemeral watercourses, particularly during construction phases, should be stringently avoided;

iii. Measures to **manage** impacts:

- Attention must be paid to the pre-development upgrading of WWTWs in areas likely to expand urban populations in response to perceived and actual opportunities associated with the proposed development – since many of these WWTWs are poorly performing at present, attention must also be paid to upskilling of WWTW management and staff, particularly in the larger urban areas. This is a strategic management action, and is included in Section 4.10.

4.9.5.3 Impact assessment

This impact is rated in **Table 4-9.6**, considering its application to areas of different inland aquatic ecosystem sensitivity (Very High to Low sensitivity, as mapped in **Figure 4-7.3**) , for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2).

The ratings are carried out separately, with and without the recommended mitigation and management measures outlined above.

4.9.6 Potential impacts to estuaries

4.9.6.1 Impact description: Degradation of estuarine ecosystems and resultant potential biodiversity impacts

Section 4.8.4 and **Table 4-8.4** highlight the following key impacts on estuarine ecosystems and micro-outlets that would be associated with the Baseline Scenario (Sc0):

- Increased salinity: Projected increases in evapotranspiration and reductions in surface water inputs are likely to elevate salinity levels in estuarine environments. Systems already prone to hypersalinity, such as the Swartlintjies and Groen estuaries, are expected to be particularly vulnerable;

- Changes in groundwater quality and quantity: Lower groundwater flows and rising groundwater salinity pose significant risks to estuarine water quality, particularly in the four CTAPC West Coast estuaries, where fresher groundwater inflows support critical sedge and reedbed habitats in upper estuarine reaches;

- Altered flood regimes and estuarine connectivity: A projected reduced frequency of flooding in ephemeral rivers may reduce the frequency of breaching of estuary mouths, decreasing opportunities for fish recruitment. Existing recruitment challenges, already constrained by elevated salinity levels, are thus expected to be further exacerbated;

- Deterioration in water quality as a result of urban expansion: Population growth and associated increases in sewage effluent volumes are anticipated to further strain wastewater treatment works (WWTWs), many of which are already operating beyond capacity and with limited efficiency;

- Impacts on the Orange River Estuary: Without active intervention, current degradation of the Orange River Estuary is expected to persist and would be heightened by construction of the proposed Vioolsdrift Dam.

In the context of Scenarios 1 and 2, the above impacts would be expected to be exacerbated, as demand for groundwater increases, and in the light of likely increases in effluent discharges, impacting on surface and groundwater quality. Road upgrades for the construction of windfarm and solar plant installations are furthermore likely, and could perpetuate and worsen existing estuarine impacts in the form of attenuated floods upstream of road berms and barriers, that reduce the frequency and duration of estuary breaching that is necessary for fish recruitment and water quality maintenance in the estuaries.

At the same time, however, the potential need for road upgrades in the river reaches upstream of the CTAPC estuaries could provide opportunities to remedy existing impacts to these estuaries, particularly those associated with artificially attenuated flood flows.

4.9.6.2 Impact avoidance, mitigation and management measures

The following broad measures would be recommended to reduce concerns around estuarine degradation:

i. Measures to **avoid** impacts:

   - No new development including roads should be located in areas mapped in **Figure 4-7.3** (see also **Table 4-7.6**) as Very High Sensitivity – all four CTAPC estuaries have been rated as Very High sensitivity, given their Endangered ETS;

   - Only Low Risk activities should be located in buffer areas and micro-outlets (mapped as Medium Sensitivity);

   - The discharge of treated or untreated effluent into any estuary in the study area, or into their upstream river reaches, should be avoided – this is because these systems have high sensitivity to changes in water quality and quantity and furthermore because treatment of effluent to the required quality is unlikely to be achievable, given the current performance of WWTWs.

ii. Measures to **mitigate against** impacts:

   - Developments or parts of developments entailing hardening of surfaces should be subject to meeting the requirements of detailed stormwater management plans that allow for recharge and appropriately attenuated runoff into estuaries and micro-outlets and (where appropriate), should require separation of clean and polluted water on site, and treatment of the latter to ecologically acceptable standards – attenuation should be aimed at mirroring natural conditions and should not impact on the frequency or duration of estuary breaching;

   - No new road crossings should be allowed through estuaries;

   - The passage of vehicles through estuarine saltmarsh and other areas during construction (and other) phases, should be stringently avoided;

   - Where existing roads through estuarine areas would require upgrading or widening to accommodate windfarm and/or solar installations or other activities associated with the proposed

overall development, existing impacts to estuaries associated with upstream road berms and inadequate culverts that attenuate flood flows and thus reduce estuary mouth breaching frequency and duration should be addressed, and road crossings should be re-configured to allow more natural passage of flows into downstream areas – this measure provides an opportunity to improve existing conditions;

- The non-flow-related requirements for the Orange River Estuary to meet its REC should be implemented as a pre-requisite for any further development in this area (as per DWS 2017b);

iii. Measures to **manage** impacts:

- Where discharge of treated effluent into an estuary is unavoidable or is required to meet the Ecological Reserve for that estuary, such effluent (including irrigation water within 500 m of any estuary) must be treated to better than the DWS Special Effluent Limits (GN 383 of 2019), and rather to standards that are in line with the DWAF (1996) water quality guidelines for aquatic ecosystems, for mesotrophic systems with regard to phosphorus and nitrogen nutrients. This stipulation is made because the DWS effluent limits assume a degree of dilution by receiving aquatic ecosystems, which is not the case in ephemeral watercourses and arid, predominantly closed estuaries. Alternatively, where these are available, effluent may be discharged within gazetted or otherwise stipulated RQOs for that estuary;

- Again, attention must be paid to the pre-development upgrading of WWTWs in areas likely to expand urban populations in response to perceived and actual opportunities associated with the proposed development – since many of these WWTWs are poorly performing at present, attention must also be paid to upskilling of WWTW management and staff, particularly in the larger urban areas. This is a strategic management action, and is included in Section 4.10.

4.9.6.3 Impact assessment

This impact is rated in **Table 4-9.7**, considering its application to areas of different estuarine ecosystem sensitivity (Very High to Low sensitivity, as mapped in **Figure 4-7.3**) , for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2).

The ratings are carried out separately, with and without the recommended avoidance, mitigation and management measures outlined above.

Table 4-9.6: Assessment of the impacts of degradation of inland aquatic ecosystems (rivers, wetlands and pans). Assessment of the Scenario 0 (S0) assumes current development trajectory (without specific mitigation) and climate change. S1 and S2 assessments are based on the development impacts only.

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With recommended management and mitigation, and assuming avoidance		
			Consequence (-) for inland aquatic ecosystems	Likelihood	Risk	Consequence (-) for inland aquatic ecosystems	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Drastic	Likely	Moderate to high	N/A	N/A	N/A
	S1: Small GH2		Extreme	More likely	High	None – avoided	Likely	Very Low
	S2: Big GH2		Extreme	More likely	High	Drastic	Likely	Moderate to High
	S0: Baseline	High Sensitivity	Drastic	Likely	Moderate to high	N/A	N/A	N/A
	S1: Small GH2		Extreme	More likely	High	Significant (with major avoidance)	Likely	Moderate
	S2: Big GH2		Extreme	More likely	High	Drastic	Likely	Moderate to High
	S0: Baseline	Medium Sensitivity	Significant	Likely	Moderate	N/A	N/A	N/A
	S1: Small GH2		Significant	Likely	Moderate	Moderate	Likely	Low to Moderate
	S2: Big GH2		Drastic	Likely	Moderate to high	Significant	Likely	Moderate
	S0: Baseline	Low Sensitivity	Moderate	Likely	Low to Moderate	N/A	N/A	N/A
	S1: Small GH2		Moderate	Likely	Low to Moderate	Slight	Likely	Very Low
	S2: Big GH2		Significant	Likely	Moderate	Moderate	Likely	Low to Moderate

Table 4-9.7: Assessment of the impact of degradation of estuaries (including the Orange River Estuary) and micro-outlets. Assessment of the Scenario 0 (S0) assumes current development trajectory (without specific mitigation) and climate change. S1 and S2 assessments are based on the development impacts only. Impacts to estuaries would stem largely from catchment activities.

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With recommended management and mitigation, and assuming avoidance		
			Consequence (-) for estuaries	Likelihood	Risk	Consequence (-) for estuaries	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Drastic	Likely	Low to Moderate	N/A	N/A	N/A
	S1: Small GH2		Extreme	More likely	High	None – avoided	Likely	Very Low
	S2: Big GH2		Extreme	More likely	High	Drastic	Likely	Moderate to High
	S0: Baseline	High Sensitivity	Significant	Likely	Moderate to high	N/A	N/A	N/A
	S1: Small GH2		Extreme	More likely	High	Significant (with major avoidance)	Likely	Moderate
	S2: Big GH2		Extreme	More likely	High	Drastic	Likely	Moderate to High
	S0: Baseline	Medium Sensitivity	Moderate	Likely	Moderate	N/A	N/A	N/A
	S1: Small GH2		Significant	Likely	Moderate	Moderate	Likely	Low to Moderate
	S2: Big GH2		Drastic	Likely	Moderate to high	Significant	Likely	Moderate
	S0: Baseline	Low Sensitivity	Moderate	Slight	Low to Moderate	N/A	N/A	N/A
	S1: Small GH2		Moderate	Likely	Low to Moderate	Slight	Likely	Very Low
	S2: Big GH2		Significant	Likely	Moderate	Moderate	Likely	Low to Moderate

4.9.7 Potential opportunities

The previous sections focused on risks to water resources associated with the proposed development of GH2 and GH2 supporting infrastructure in the study area. It must however also be noted that such development could bring with it opportunities for development in some areas, if the availability of fresh water increased as a result of affordable desalination projects, thus changing current development constraints. Such opportunities would however themselves be associated with increased risks from a biodiversity perspective, and their realisation would be contingent on meeting the challenges already highlighted around effective upgrading, expansion and maintenance of WWTW and water treatment infrastructure; improved water reticulation; and management of human populations, and the likely expansion of informal settlements in particular.

In addition to increasing fresh water supplies, GH2 development and its supporting infrastructure could also contribute positively towards upgrading of water supply networks and improved training opportunities that result in better maintenance and operational services at WWTWs, Orange River abstraction points and desalination plants.

4.9.8 Recommended Strategic Management Actions

The previous section included various high-level avoidance, mitigation and management measures to address the key impacts associated with the kinds of activities and interventions that would be anticipated in a GH_2 development scenario in Boegoebaai and the Namakwa Region. There are, however, a number of strategic actions that should also be considered, in taking this project further towards a sustainable outcome from a water resources perspective.

These comprise:

- Generally:
    - Ensuring that the additional water volume (and associated water quality) that would be required by the proposed development would in fact be available – this would require consideration by the DWS Water Resource Classification team, currently engaged in this assessment;
    - Adding to this is a requirement for the immediate implementation (or re-constitution) of effective long-term monitoring of surface and groundwater quantity and quality across the Namakwa region. This is critical to inform the detailed accounting of water supply and demand across the region, and to identify areas where over-abstraction or excess waste water discharges are affecting the sustainability of the resource and its dependent human communities and natural ecosystems.
- From a groundwater perspective:
    - Investment in improvement in infrastructure and management of groundwater resources in the study area, including a focused investment in supplying treated, desalinised water to serve projected increased demand from domestic and industrial users in a GH_2 scenario;
    - Protection of groundwater quality from high-risk activities by implementing stricter regulations and requiring adherence thereto;
    - Investment in currently poorly functional WWTWs, including training to upskill municipal management and other staff and infrastructure upgrades – if successful, such measures could allow for WWTW effluent to be used as an alternative water source;
    - Investment in training schemes to enhance borehole management, in particular regarding mitigation of issues such as iron biofouling;
    - Investment in managed aquifer recharge schemes, including appropriate investment in training, human resources and infrastructure, to mitigate against possible natural increasing salinisation of groundwater;

- From a surface hydrology perspective:
    - Provision for (allowed-for) abstraction from the Orange River, in keeping with the Ecological Reserve and RQOs for the estuary, and reticulation to the level of Scenario 1 demand;
    - Provision for adequate maintenance of the (authorised) abstraction, treatment, reticulation and storage works;
    - Provision for the protection of abstraction works and reticulation pipelines;
    - Investment in the urgent development / out-sourcing of expertise to operate desalination plants at proposed coastal locations;
    - Minimisation of disturbance to river systems and floodplains, particularly at infrastructure crossings;
    - Prevention of encroachment of structures or dwellings into the 1:100-year floodplains of watercourses;
    - Ensuring that the water demand (volume and quality) for Scenarios 1 and 2 can be met, based on sustainable use of available surface and groundwater resources, including supplementation with groundwater and marine water sources;
- From an inland and estuarine ecosystem perspective:
    - Avoidance of inland and estuarine aquatic ecosystems in any development context, given that these ecosystems are regionally rare, sensitive and of (generally) high ecological importance, as well as the fact that their degradation could result in multiple other impacts, including impacts on road infrastructure (e.g. as a result of erosion and/or sedimentation);
    - Upfront investing in improved WWTW management and infrastructure and ensuring that all municipal WWTW effluent in areas likely to expand urban populations in response to perceived and actual opportunities associated with the proposed development meet their required (licensed) limits before embarking on any development that will exert greater stresses on such infrastructure – since many of these WWTWs are currently poorly performing, attention must also be paid to upskilling of WWTW management and staff;
    - Investment in enhanced wastewater treatment facilities so that effluent can be re-used beneficially without resulting in nutrient enrichment of surface or groundwater or changing natural watercourse function (e.g. changing from ephemeral to seasonal or perennial waste conveyance systems);
    - Implementation of the non-flow related rehabilitation requirements for the Orange River Estuary, as outlined in DWS (2017b and 2024b);
    - Considered assessment of the practical implications of any required need for aquatic ecosystem offsets (i.e. where the post mitigation residual impact is greater than a Low significance) – such assessment should consider the availability, affordability and practical manageability of offset receptor sites, and should also consider pro-active watercourse offset banking, in combination with terrestrial offset requirements to ensure holistic biodiversity conservation across all habitat types;
    - Upfront investment in maintenance / improvement in road design, to ensure that flood flows into estuaries are not artificially attenuated (e.g. by upstream berms), while also ensuring that flows under roads do not result in concentrated flows, likely to cause channelisation, narrowing and resultant erosion of river channels;
    - Ensuring that the recommended EWR for the lower Orange River and the Orange River Estuary in particular can still be met, and is in no way jeopardised by the proposed development – this would require investment in desalination of both seawater and groundwater.

4.10 CONCLUSIONS

This chapter has considered water resources in the study area from both the perspective of the limitations these resources place on future development and the sensitivity of these systems themselves to some aspects of development. The greatest risks are posed by activities resulting in changes in water quality; reductions in water availability or predictability; and physical disturbance that reduces natural downstream flushing (e.g. estuaries) or increases channel erosion, especially in the vicinity of road crossings. Surface and groundwater flows and quality are interlinked, and changes in one can have impacts on the other. These resources are moreover already under threat as a result of climate change and existing demand.

Given the arid to hyper-arid character of the study area, water and its sustainable management must thus be recognized as critical factors in any future development planning in the area. In this regard, it seems evident that the Boegoebaai Port, SEZ and the associated (required) large-scale roll-out of renewable energy in the region should only be considered in a context where allowance is also made for large-scale desalination of seawater and/or groundwater to provide for the increase in direct and indirect water demand likely to be associated with such development. Such an approach would come at great potential ecological risk, as the naturally ephemeral watercourses and pans in the area have high biodiversity value and would be vulnerable to changes in hydroperiod, including receipt of additional (potentially nutrient enriched) water from ancillary developments such as expanded WWTWs and effluent outflows, as well as increased salinities from brine disposal from desalination works. Attention to creating a circular water economy that does not change aquatic ecosystem function would be important if the proposed development were to proceed. At the same time, it is possible that such development could be used in part to redress existing impacts to aquatic ecosystems, such as the impacts of roads and effluent outflows on some of the estuaries – there is however very low confidence attached to the reality of any such outcome being achieved.

Risk assessments presented in this chapter show that a high degree of avoidance of aquatic ecosystems, their floodplains and groundwater recharge areas would be required, to reduce the high likelihood of major consequence for water resources including inland and estuarine aquatic ecosystems.

Overall, it must be stressed that while solar and wind energy sources in the study area may be amply available, the limited availability of water resources and the high sensitivity of aquatic ecosystems in this particular region is a major constraint for such development at the outset, taking into account current and future demands; projected climate change impacts; and the existing capacity constraints of water, sanitation and other services in the region.

It must be stressed that multiple regulatory authorisations including water use licenses, Environmental Authorisations and others would be needed if the proposed GH_2 Development were to proceed further. These would all require in-depth assessments, and would need to be supported by biodiversity, hydrological and geohydrological data relevant to the study area as a whole, as well as to discrete developmental units.

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4.12 APPENDICES A - F

SEPARATE DOCUMENT

APPENDIX A: DATA ACCESSED IN DEVELOPMENT OF THE WATER RESOURCES CHAPTER
APPENDIX B: GEOHYDROLOGY MAPS
APPENDIX C: SURFACE HYDROLOGY APPENDICES
APPENDIX D: WATER QUALITY
APPENDIX E: AQUATIC ECOSYSTEMS
APPENDIX F: SPECIALIST HYDROLOGICAL REPORT

CHAPTER 4: WATER RESOURCES AND AQUATIC ECOLOGY

APPENDICES A to F

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APPENDIX B: GEOHYDROLOGY MAPS _____3
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APPENDIX A: DATA ACCESSED IN DEVELOPMENT OF THE WATER RESOURCES CHAPTER

A1 Surface water assessment

The surface water assessment drew on the following datasets:

- Catchment runoff, dry periods and meteorological data (Current and Near Future) extracted and interpreted from databases of Schütte *et al*.(2023)
- Mean Annual Runoff, Rainfall and Evaporation from WR2012 (Herold and Bailey, 2016) used for comparative purposes.
- Daily runoff record for the Buffels river derived from published figure in Benito *et al.* (2011)
- Orange River abstractions, current and future water demands lifted from DWS (2012), DWS (2023), BVI (2023a) and BVI (2023b)
- Farm dam density distribution lifted from Mantel and Hughes (2023)
- Aridity definition and limits lifted from Gunkel and Lange (2017).

A2 Groundwater assessment

The following datasets were accessed as part of the groundwater assessment:

- WARMS 2025 Database
- NGA Database
- 1:250 000 and 500 000 Geological Maps (CGS)
- 1: 500 000 Hydrogeological Maps (DWS)
- Soil Classification Maps from the Water Resources of South Africa (WRC 2012).
- Overlays of National Strategic Groundwater Resources data

A3 Aquatic ecosystems

The aquatic ecosystems assessment has drawn on the following datasets:

- Data from the National Freshwater Ecosystems Priority Area (NFEPA) project (Driver *et al.* 2011);
- National data from the most recent National Wetland Map (NWM Ver 5)
- National Biodiversity Assessment (NBA) for aquatic ecosystem data including estuaries (Van Deventer *et al.* 2018);
- Overlays of the national 1:50 000 rivers and topographical GIS layers;
- Overlays of national Strategic Surface and Groundwater Resources data;
- Ecoregion data (Kleynhans *et al.* 2005)

- Bioregion data (from the NWM dataset)
- The 2018 Northern Cape biodiversity spatial plan, including aquatic ecosystems (Northern Cape Department of Environment and Nature Conservation 2018)
- Outputs from available water resource classification studies in the study area (e.g. Lower Orange River Classification study, currently under way)
- Reporting and datasets (DWAF 2017a and b)
- DWS Water quality data – DWS (2024a)
  https://www.dws.gov.za/iwqs/wms/data/WMS_WMA_txt.asp
- The findings of the groundwater and surface hydrological studies for this project.

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Figure B2: Geological groups mapped for the larger Namakwa study area, Northern Cape (1:250 000 Alexander Bay, 2816 (CGS 2011)). 5
Figure B3: Geology of the proposed Boegoebaai Port SEZ area, Northern Cape (1:250 000 Alexander Bay, 2816 (CGS 2011)). 6
Figure B4: Soil types of the study area, proposed Boegoebaai Port, Northern Cape (WRC 2012; Herold and Bailey 2016). 7
Figure B5: Regional aquifer yield (L/s) (DWAF 2001). 8
Figure B6: Regional groundwater quality (EC in mS/m) from DWAF (2002). 9
Figure B7: Susceptibility rating (DWAF 2005) and groundwater depths (mbgl). 10
Figure B8: Registered groundwater users in the greater Namakwa Region, Northern Cape. 11
Figure B9: Intermediate and high priority GRUs in the greater Namakwa Region, Northern Cape. 12

Figure B1: Location of the proposed Boegoebaai Port in comparison to the broader Namakwa Region, Northern Cape.

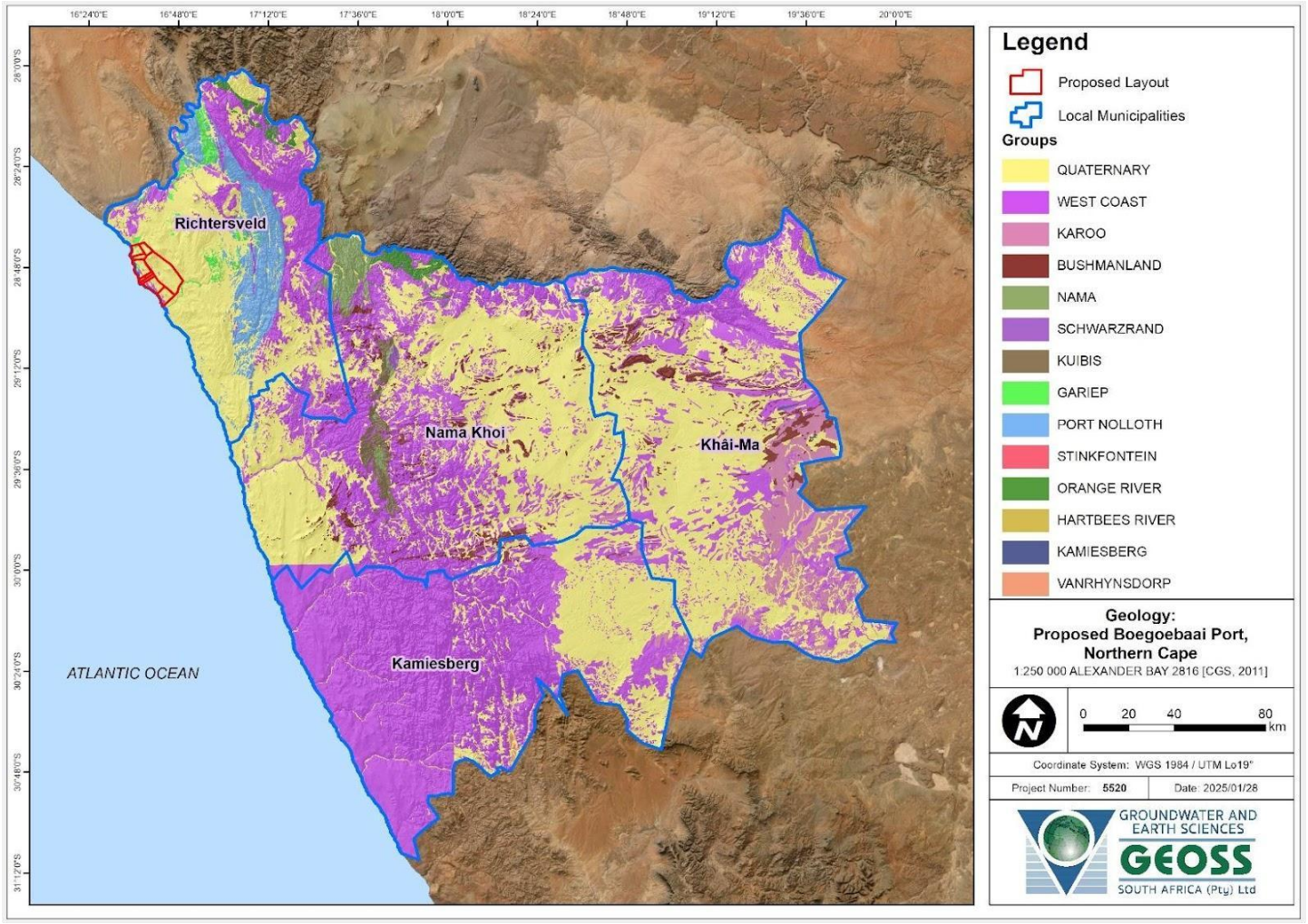


Figure B2: Geological groups mapped for the larger Namakwa study area, Northern Cape (1:250 000 Alexander Bay, 2816 (CGS 2011)).

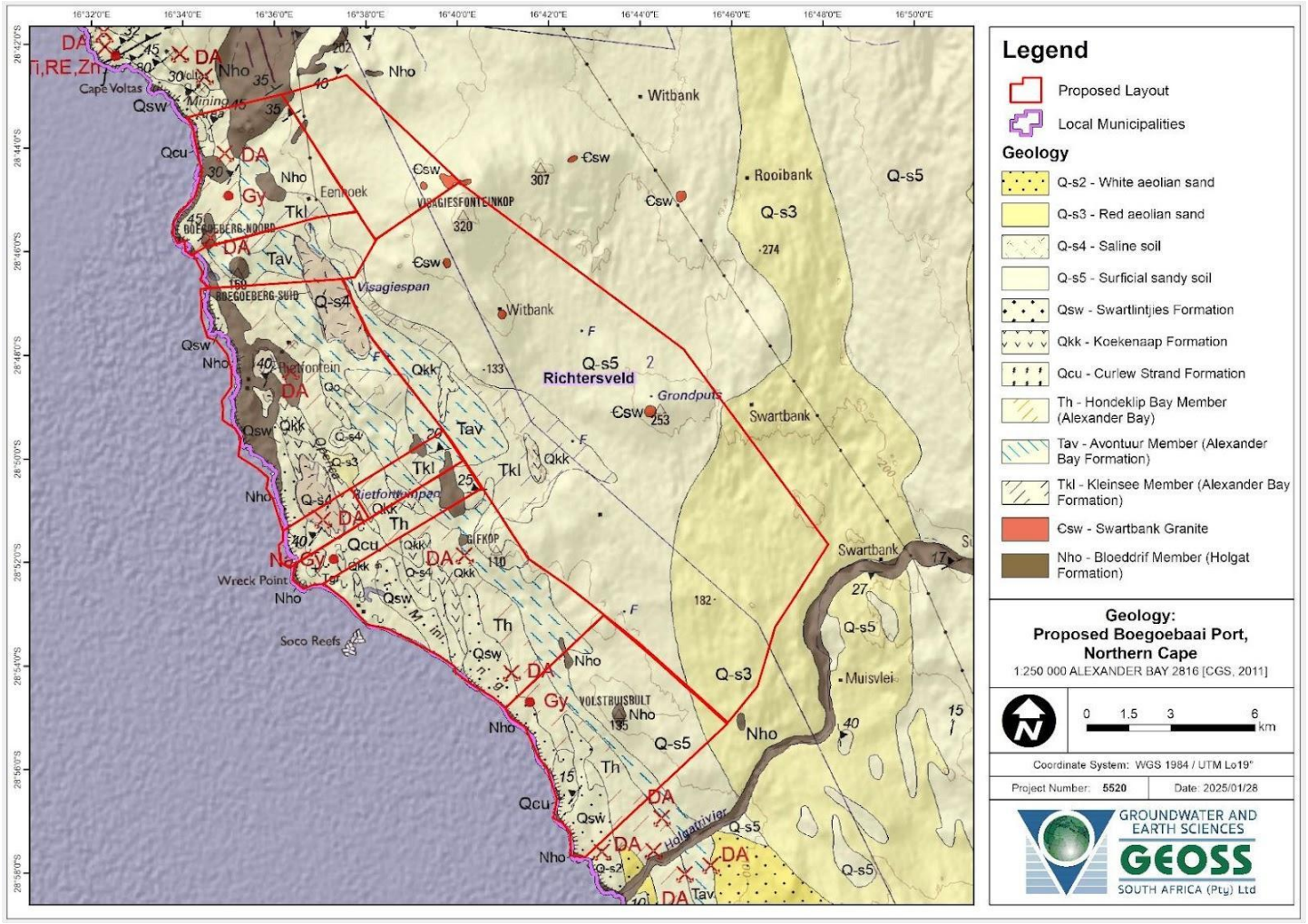


Figure B3: Geology of the proposed Boegoebaai Port SEZ area, Northern Cape (1:250 000 Alexander Bay, 2816 (CGS 2011)).

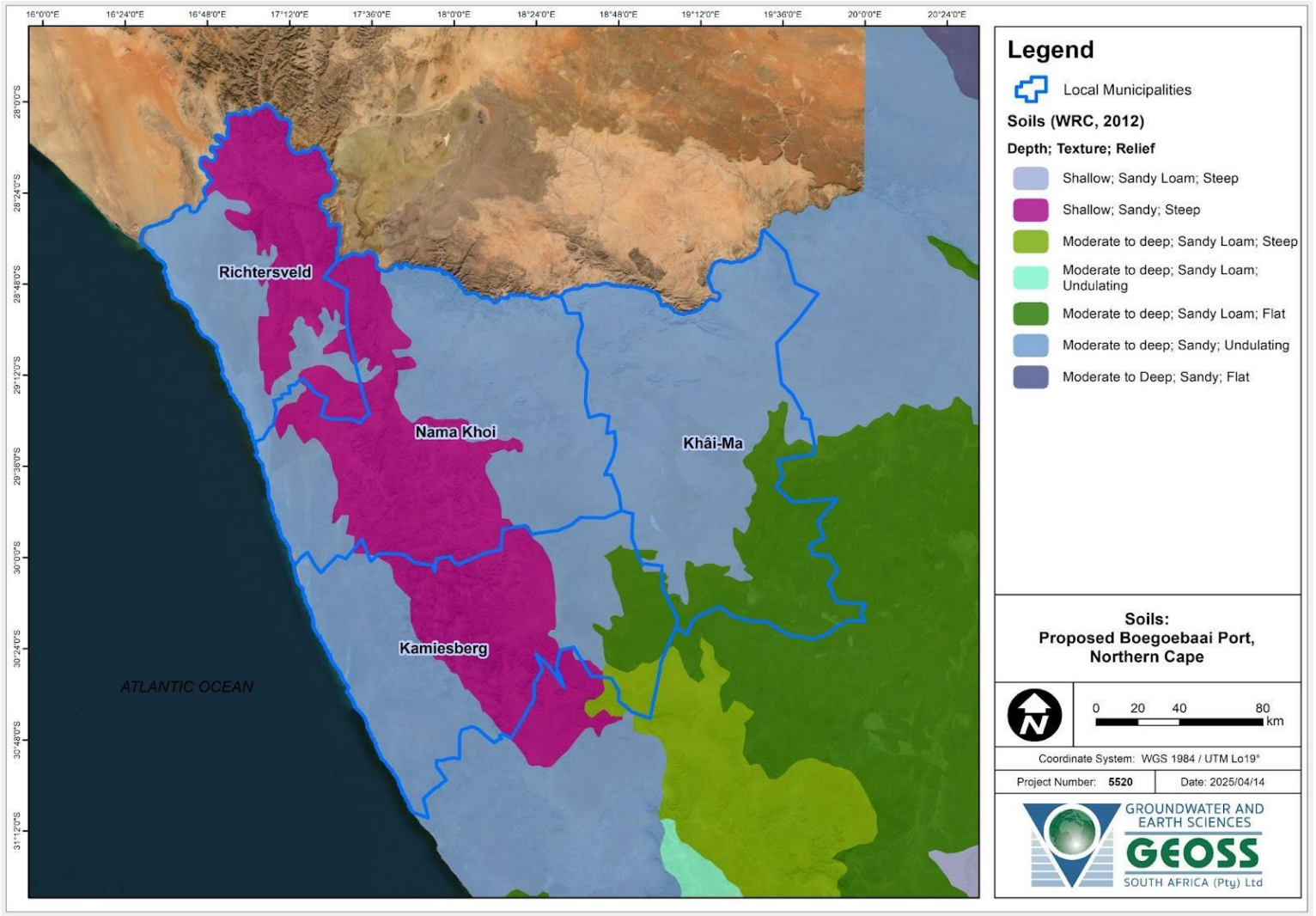


Figure B4: Soil types of the study area, proposed Boegoebaai Port, Northern Cape (WRC 2012; Herold and Bailey 2016).

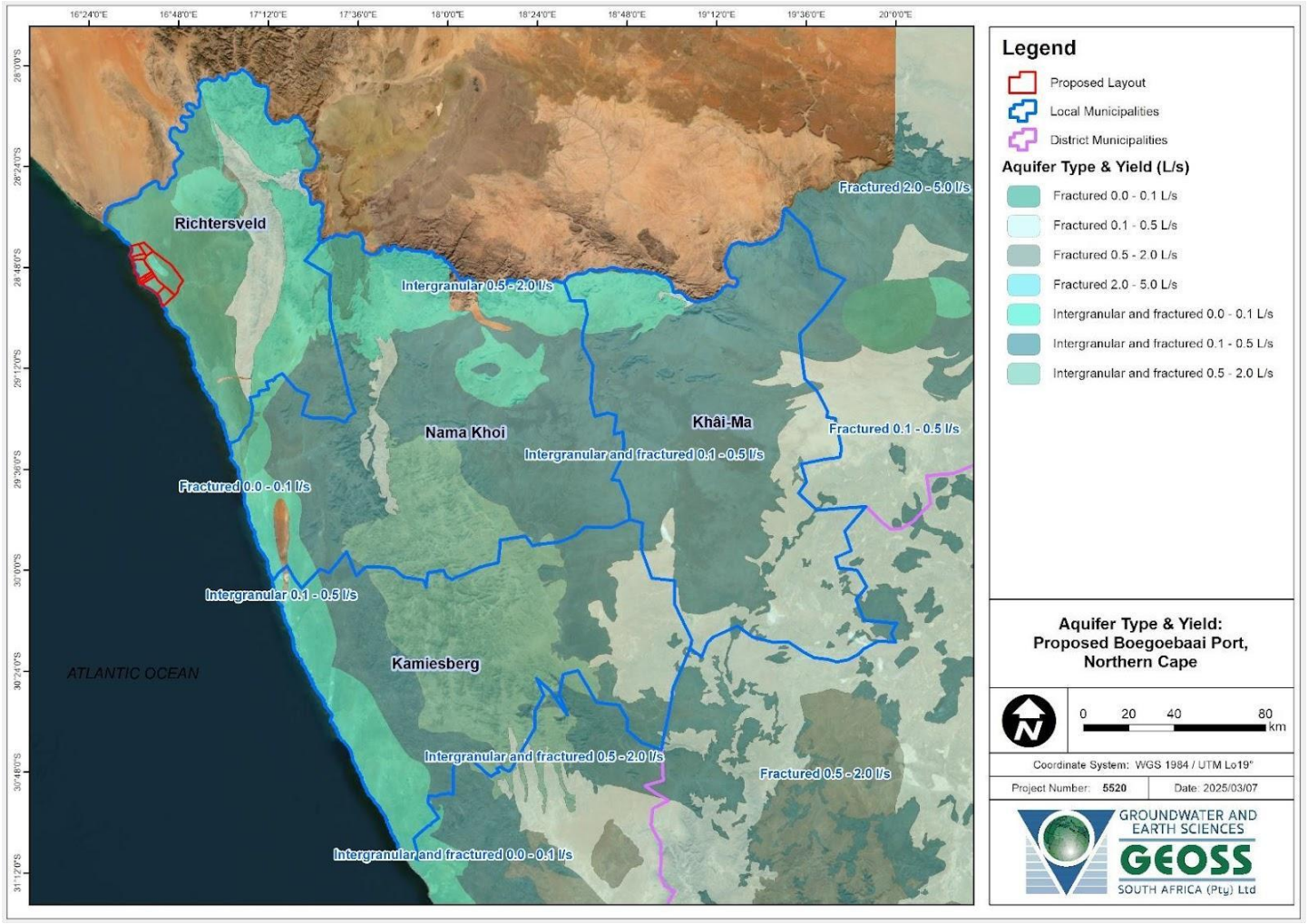


Figure B5: Regional aquifer yield (L/s) (DWAF 2001).

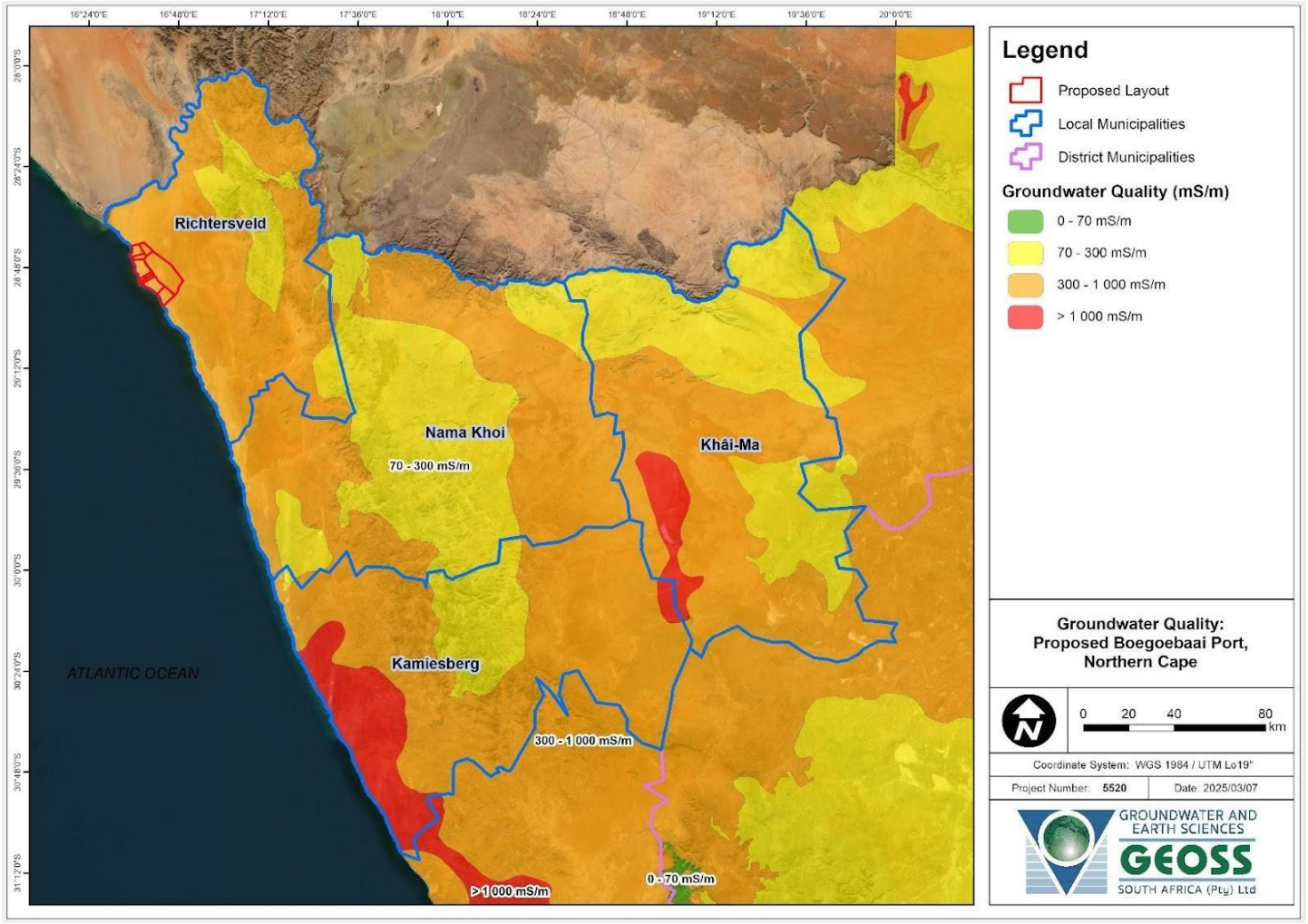


Figure B6: Regional groundwater quality (EC in mS/m) from DWAF (2002).

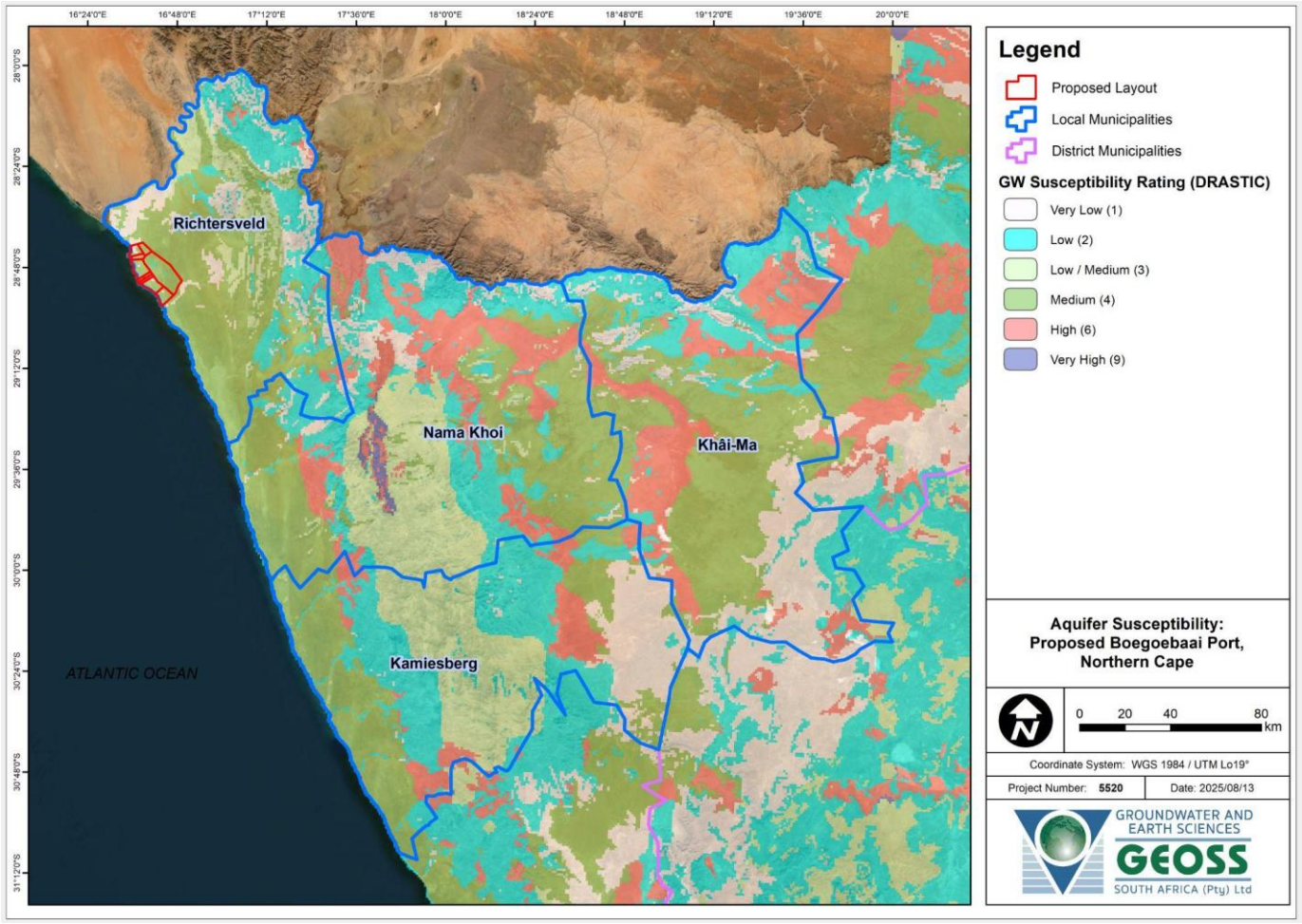


Figure B7: Susceptibility rating (DWAF 2005) and groundwater depths (mbgl).

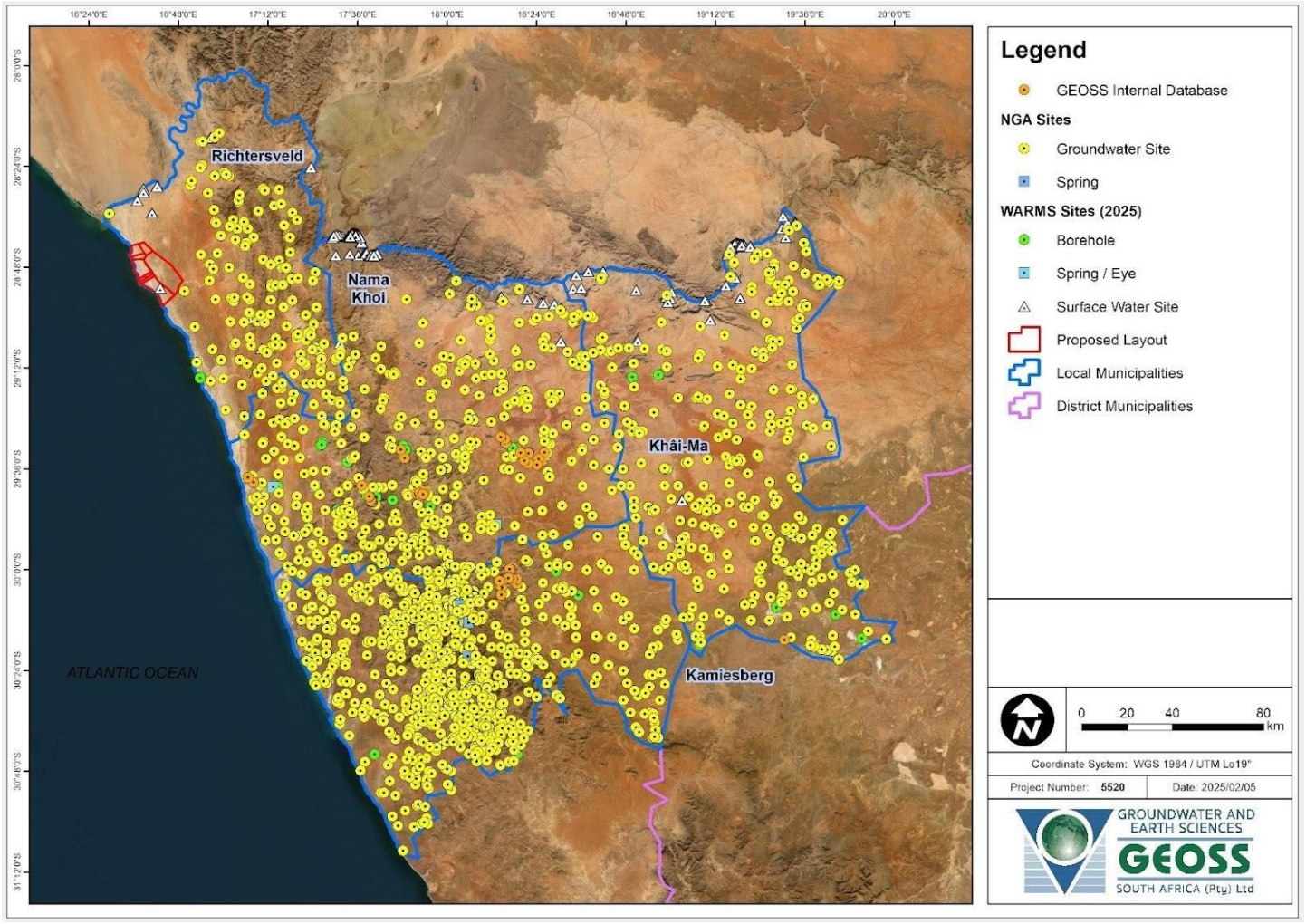
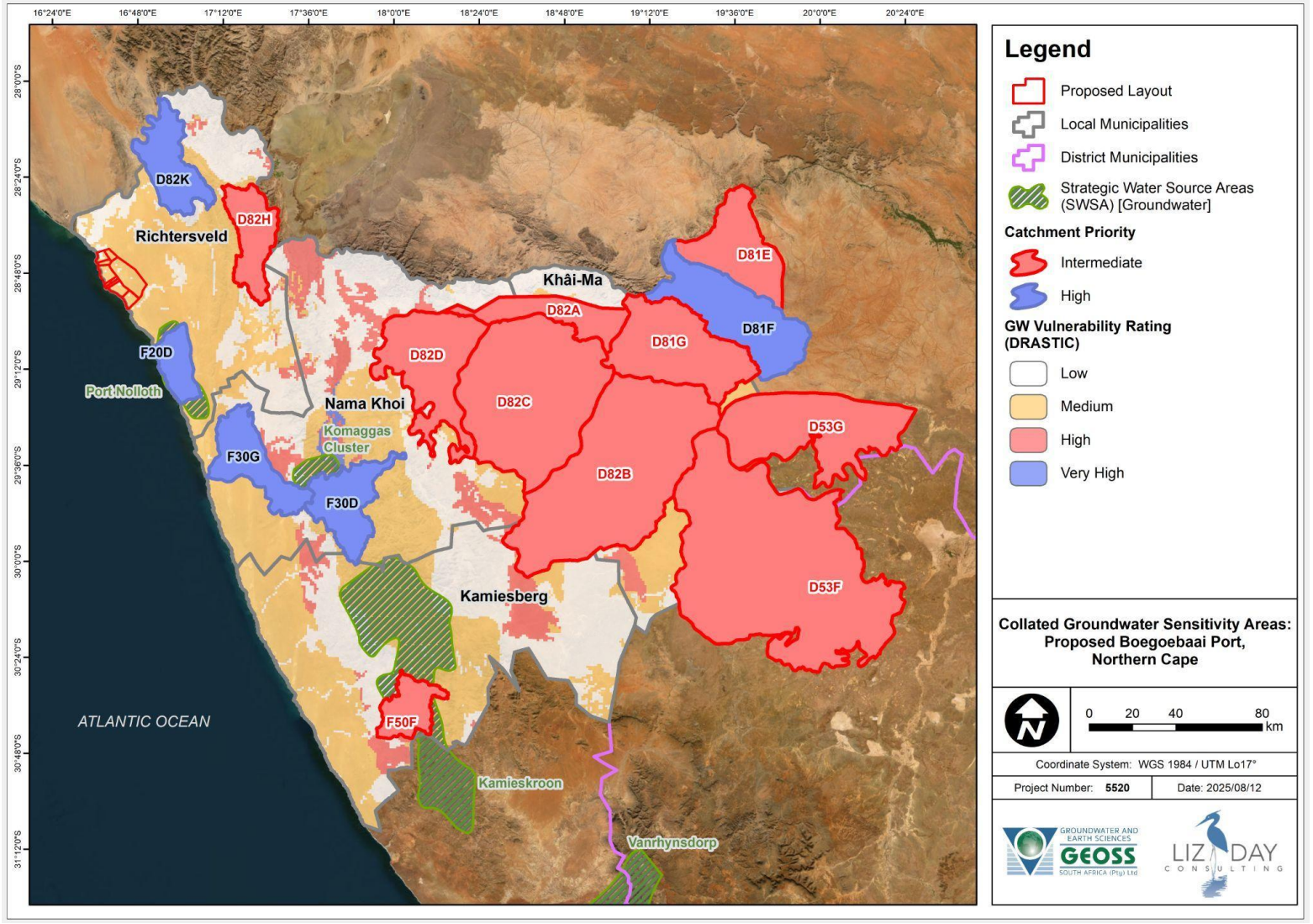


Figure B8: Registered groundwater users in the greater Namakwa Region, Northern Cape.



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Appendix C1: Meteorological Trends

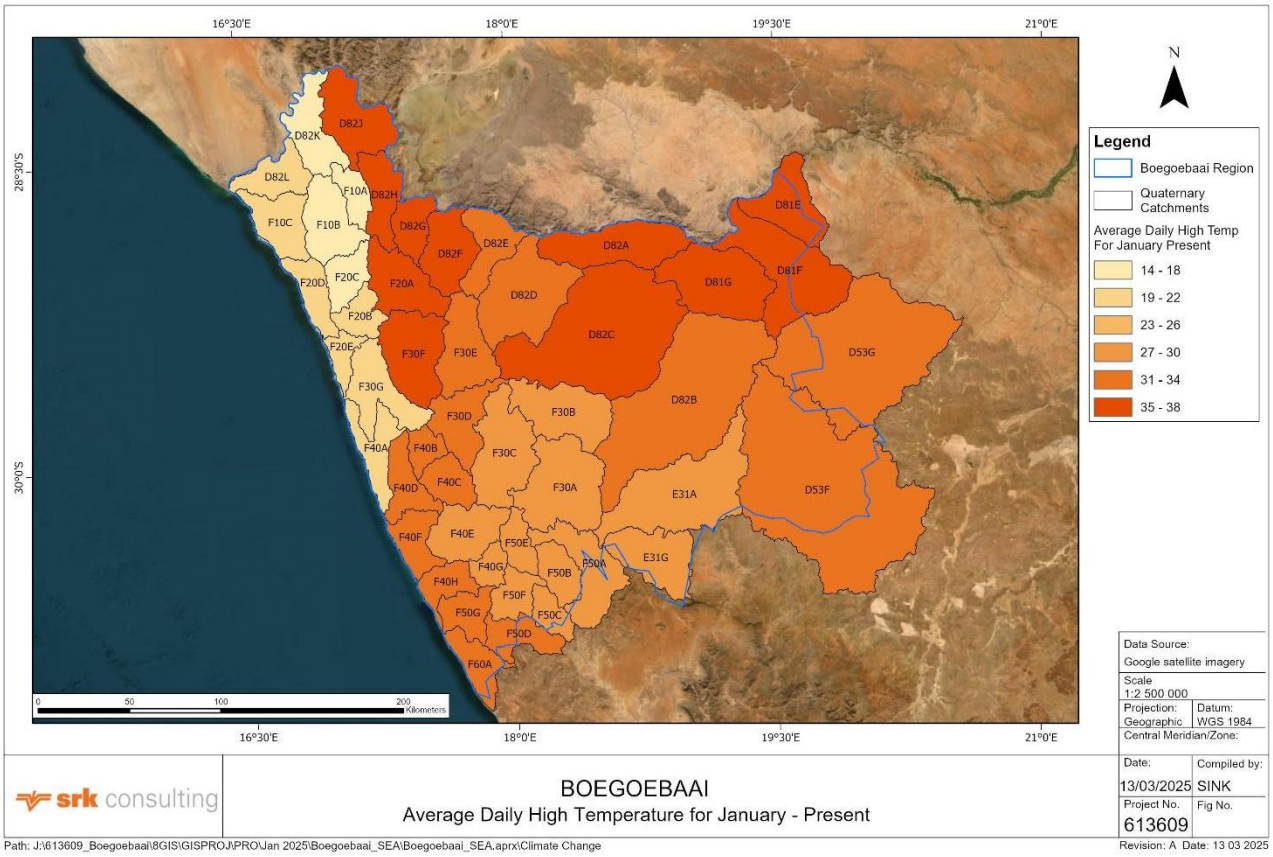


Figure C1.1: Average Daily High Temperature for January – Present (from Schütte *et al*. 2023)

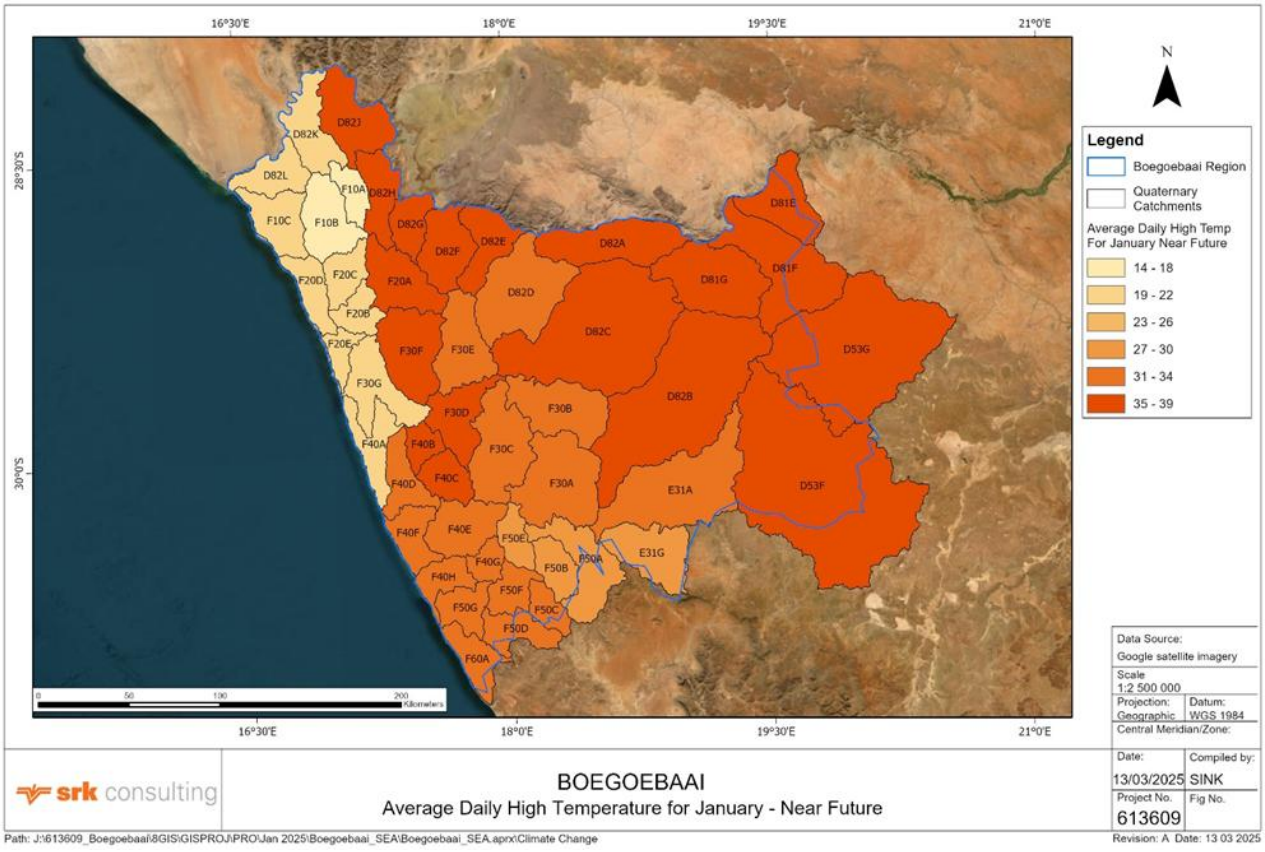


Figure C1.2 Average Daily High Temperature for January – Near-Future (from Schütte *et al*. 2023)

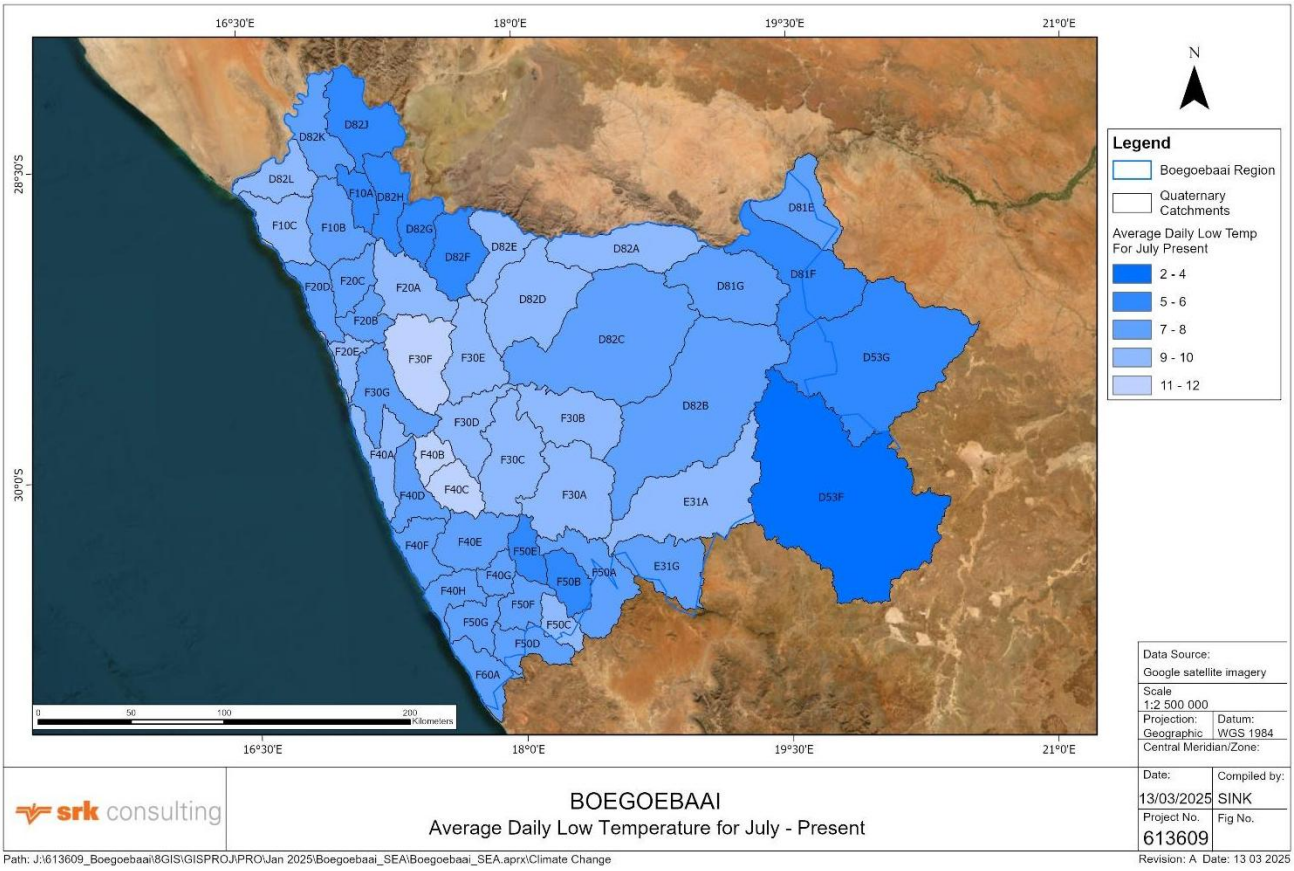


Figure C1.3 Average Daily Low Temperature for July – Present (from Schütte *et al*. 2023)

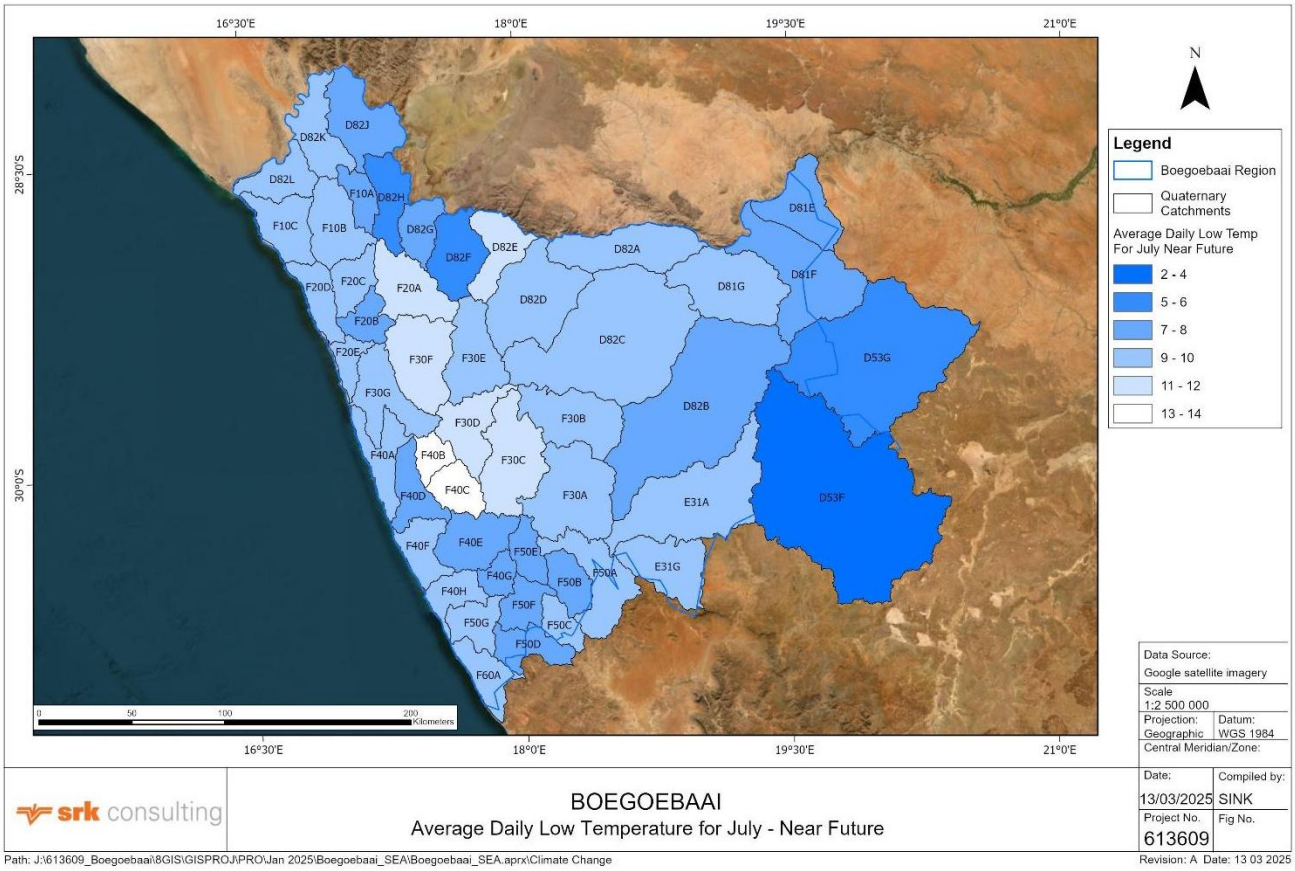


Figure C1.4: Average Daily Low Temperature for July – Near Future (from Schütte et al. 2023)

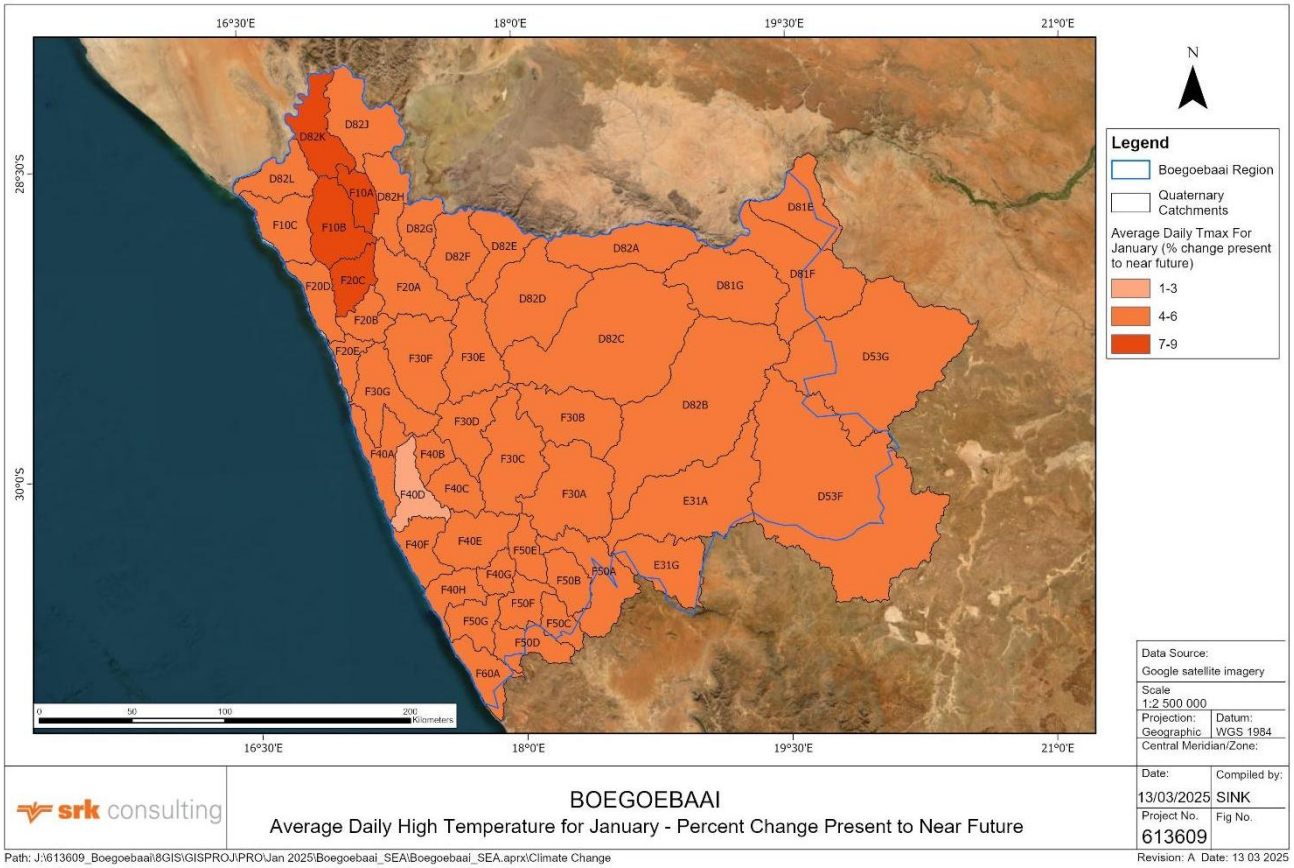


Figure C1.5: Average January Daily High Temperature – % Change from Present to Near Future

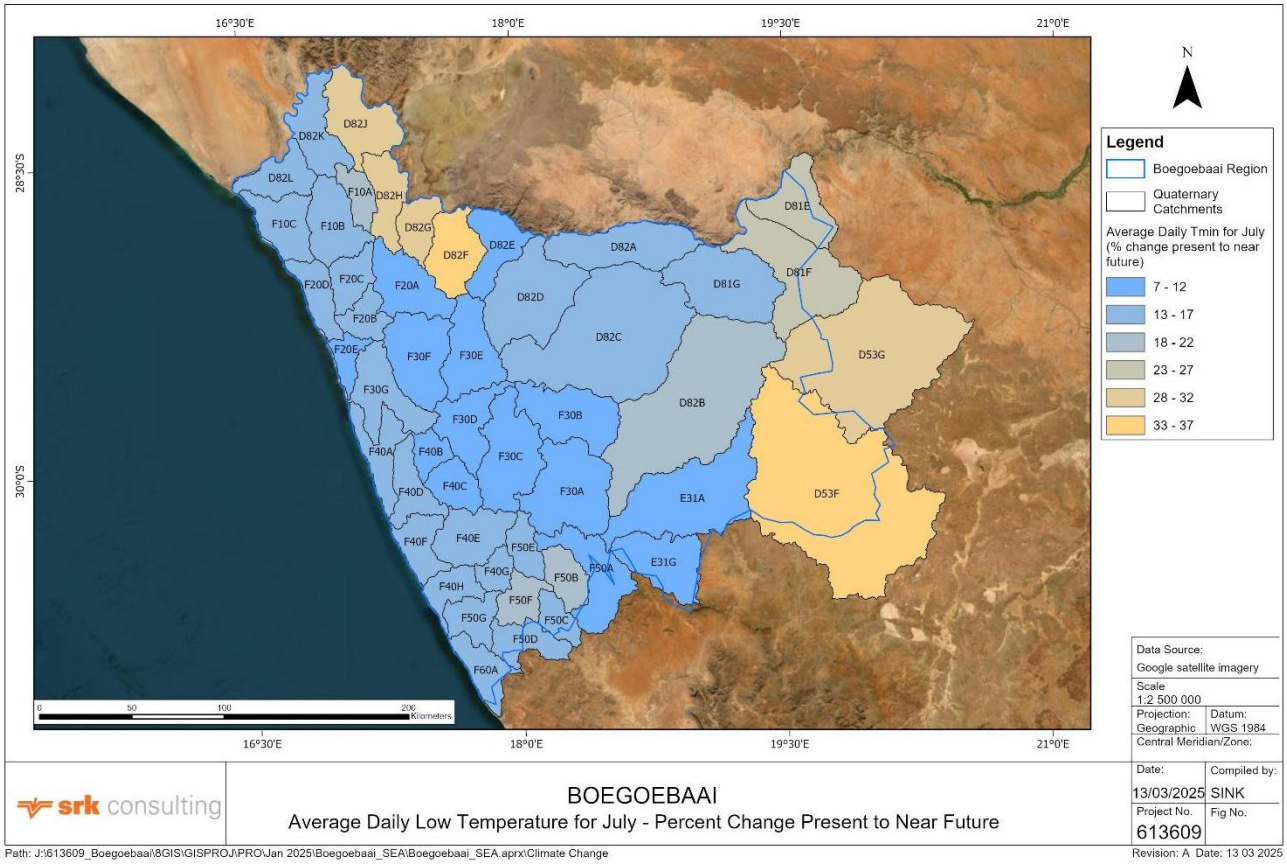


Figure C1.6: Average July Daily Low Temperature – % Change from Present to Near Future

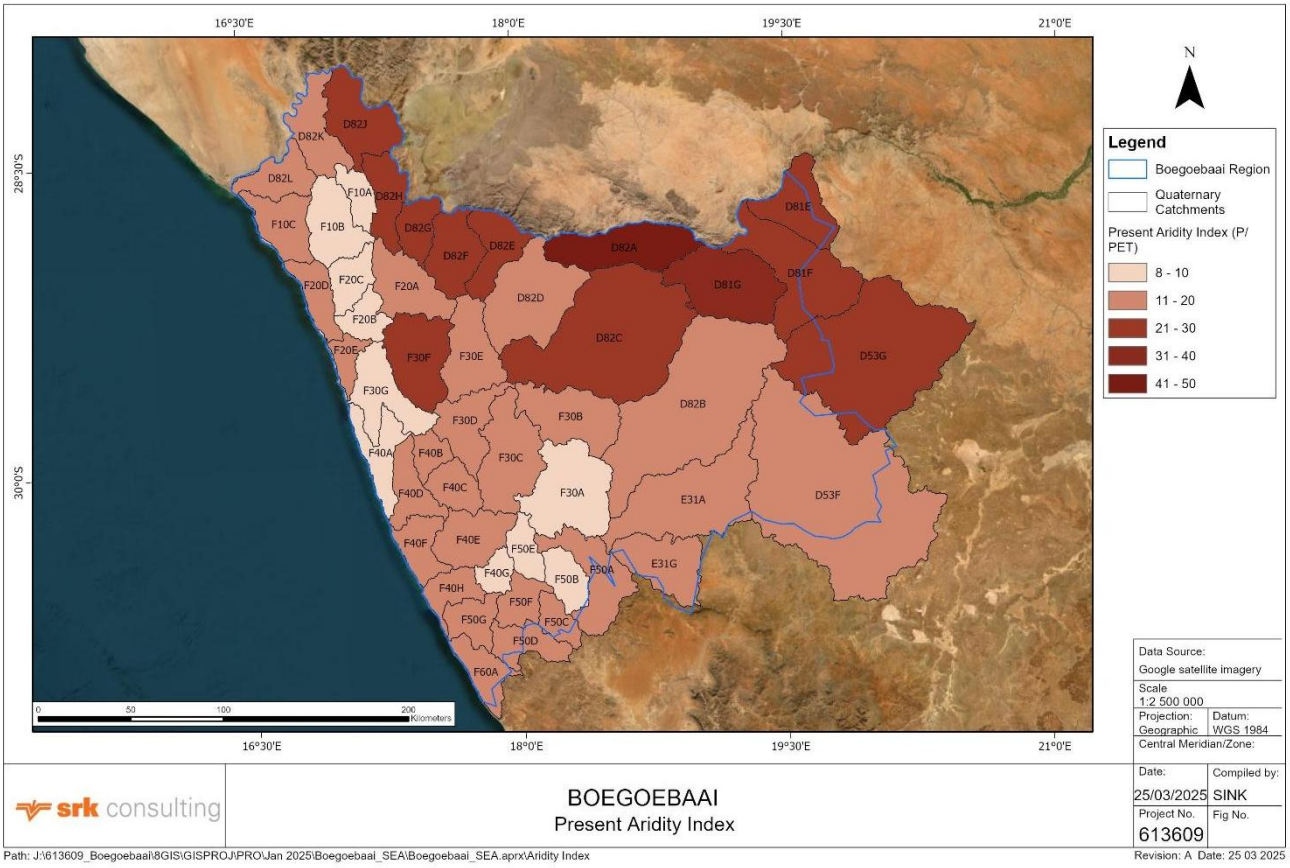


Figure C1.7: Distribution of Aridity Index: Present Climate (Average of 6 GCMs).

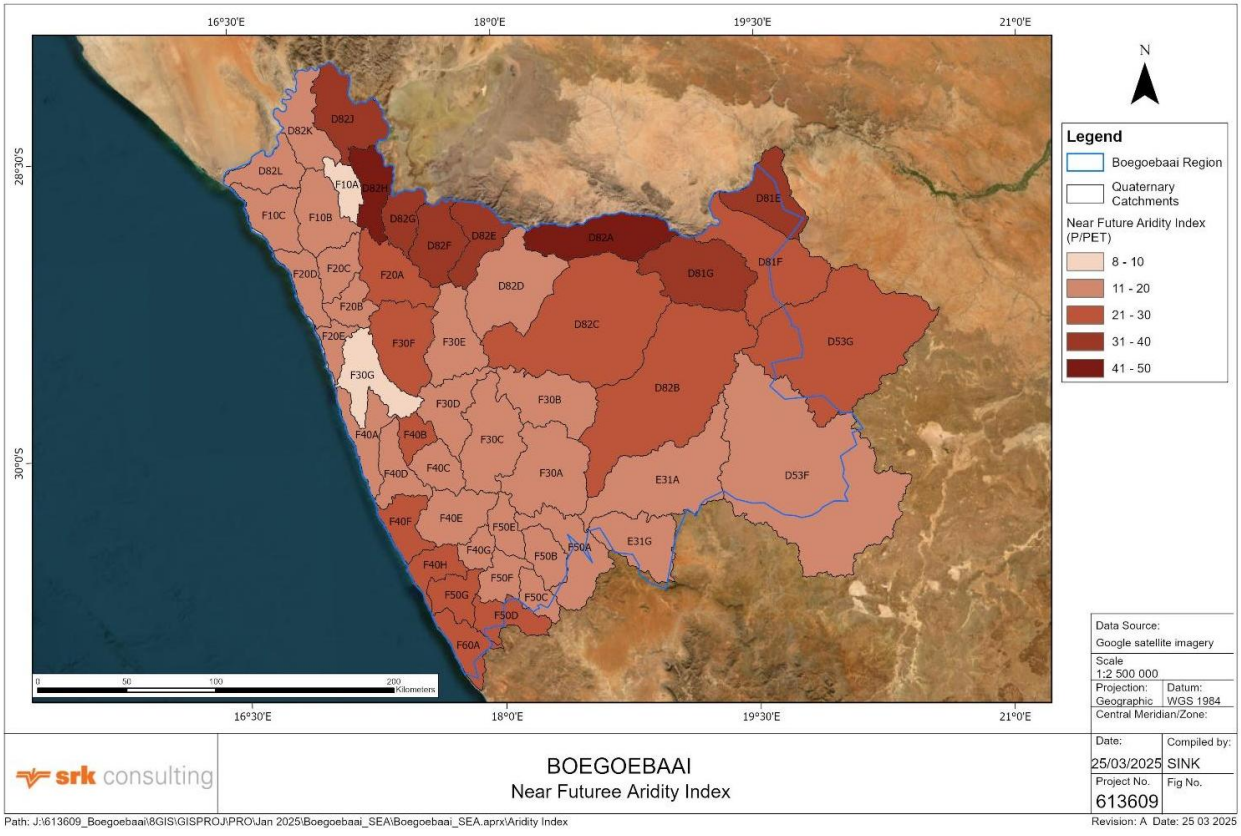


Figure C1.8: Distribution of Aridity Index: Near Future Climate (Average of 6 GCMs).

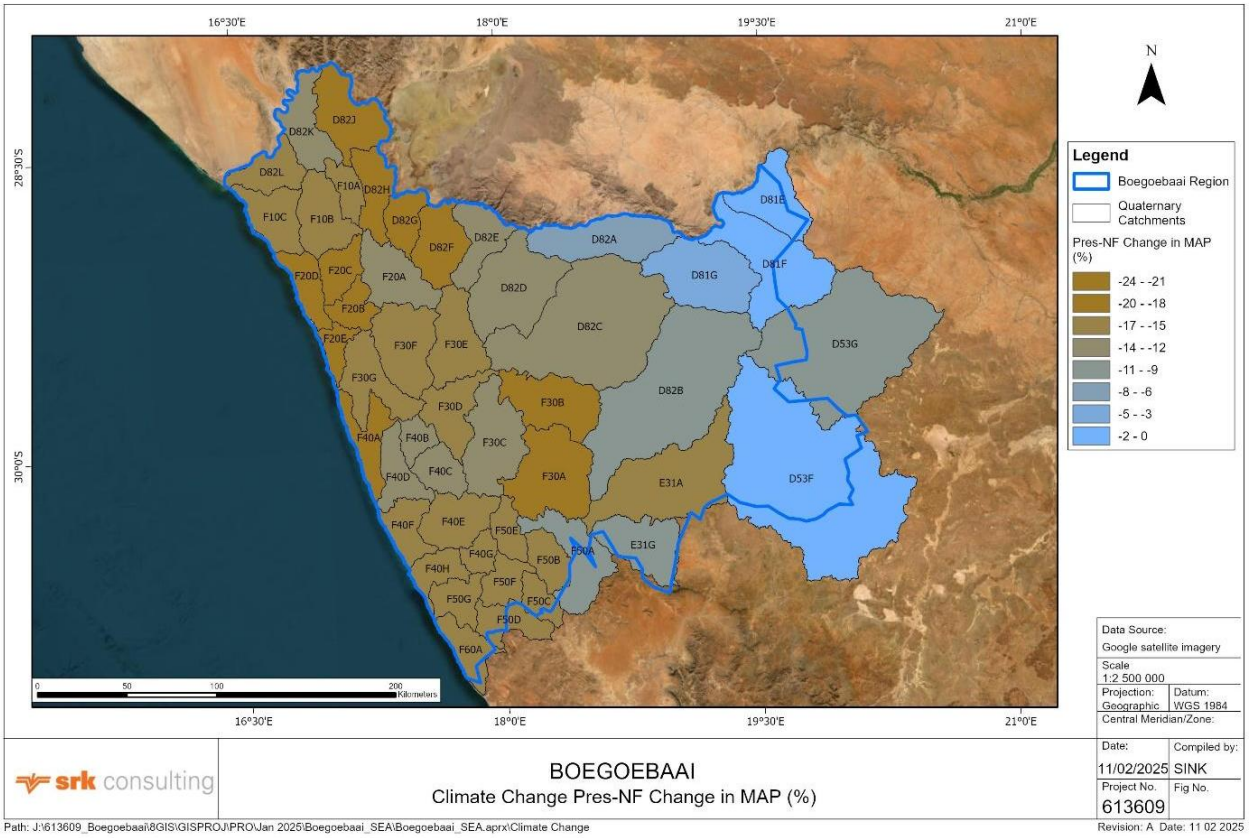


Figure C1.9: Estimated % Change in MAP for Near Future (Average of 6 GCMs, Extracted from Schütte, et al. 2023)

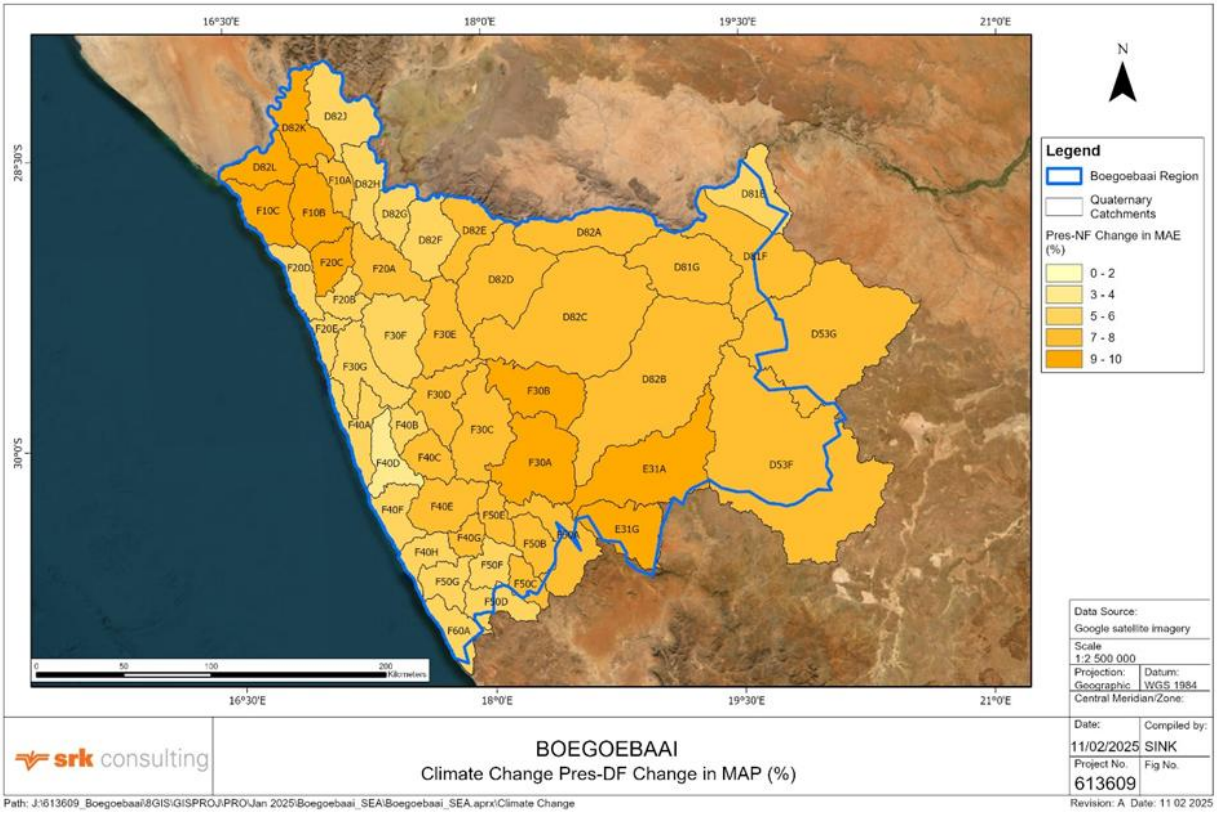


Figure C1.10: Estimated % Change in MAPE for Near-Future (average of 6 GCMs, Extracted from Schütte, et al. 2023)

Appendix C2: Quaternary Catchment Runoff

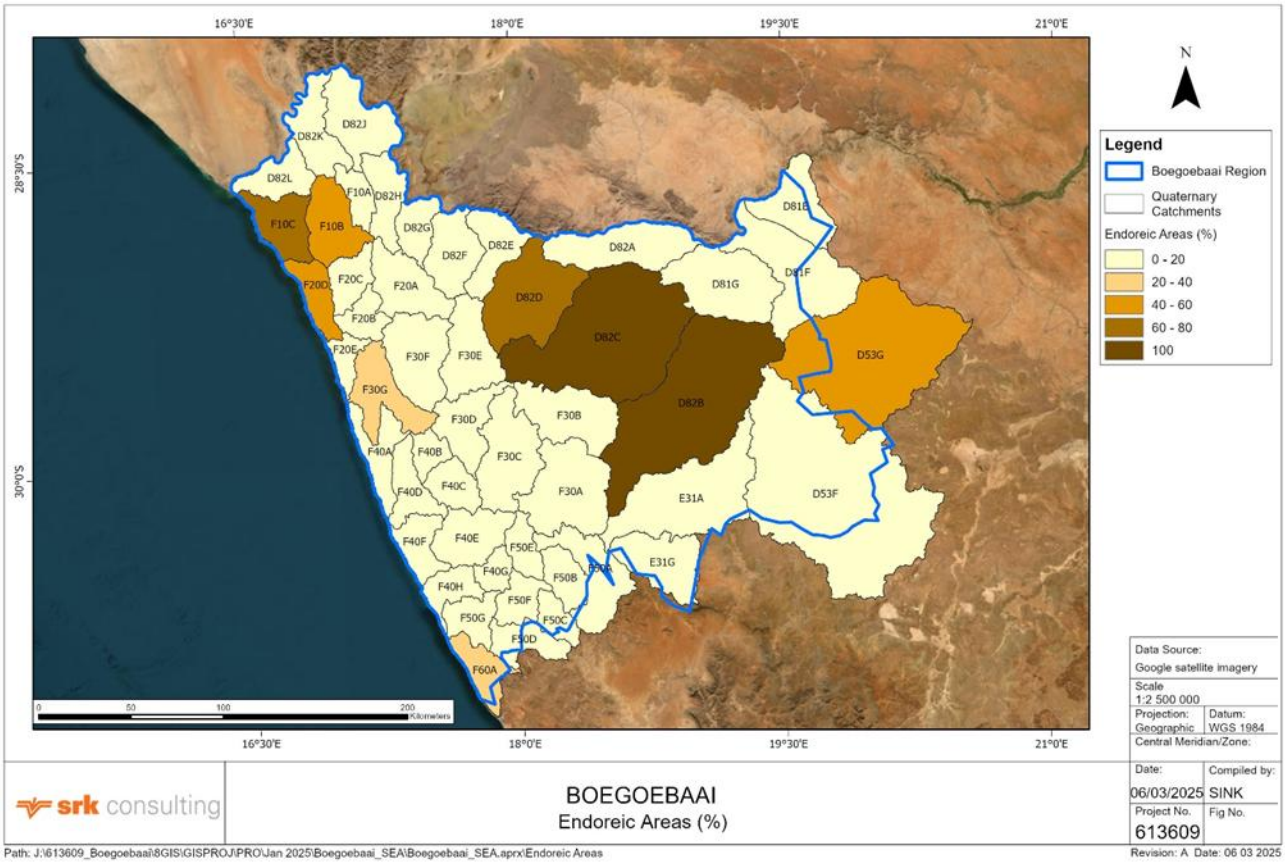


Figure C2.1: Distribution of endoreic areas (WR2012, Herold and Bailey, 2016)

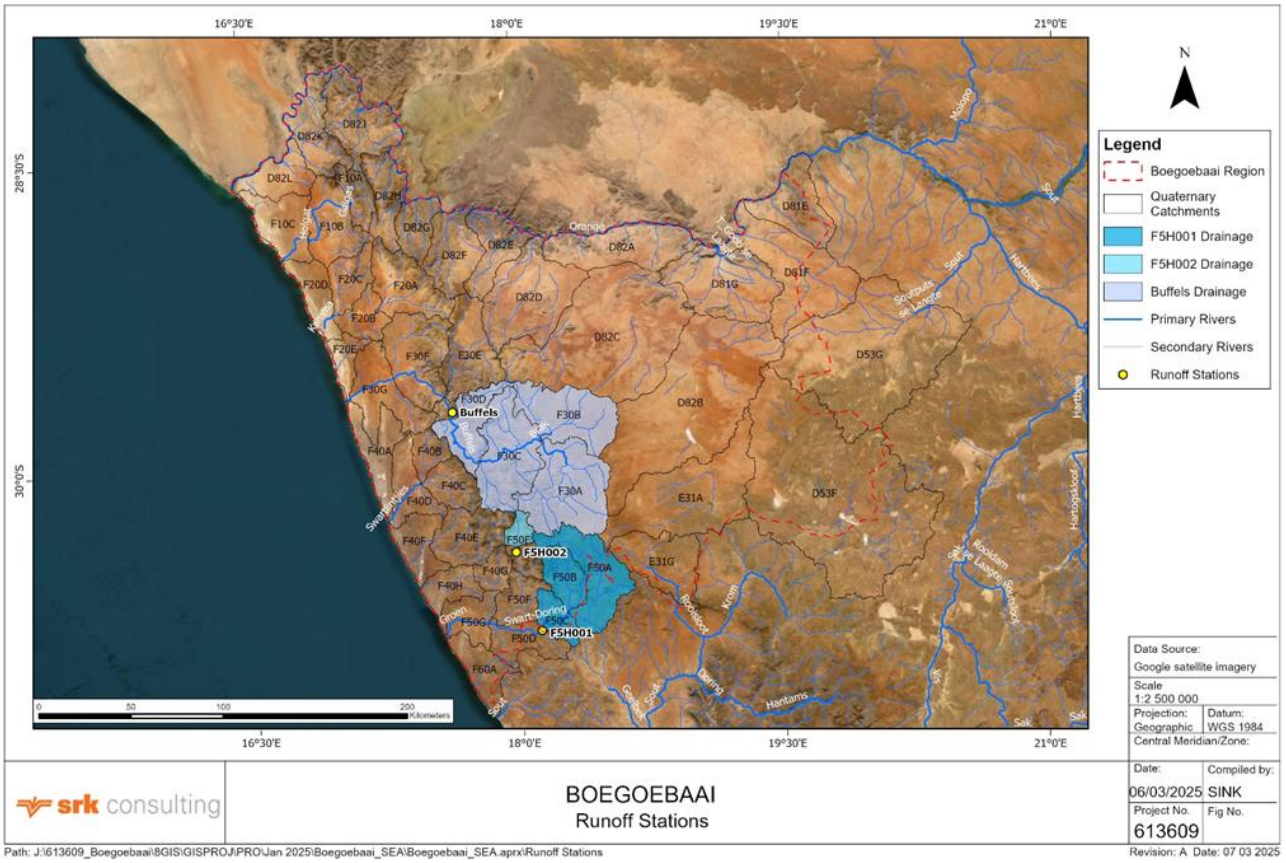


Figure C2.2: Location of River Monitoring Stations (DWS and Benito et al. 2011)

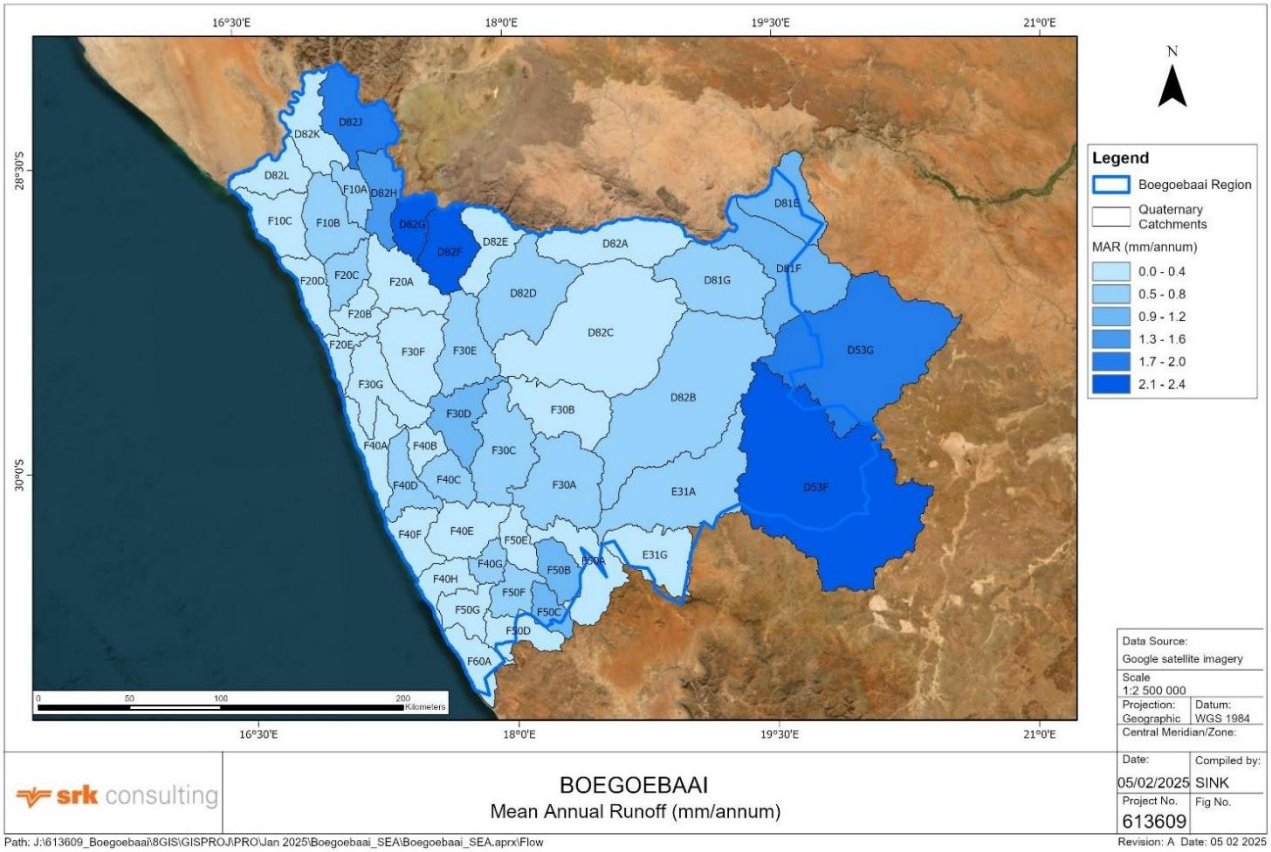


Figure C2.3: Distribution of Mean Annual Runoff, MAR (mm/annum), in the study area.

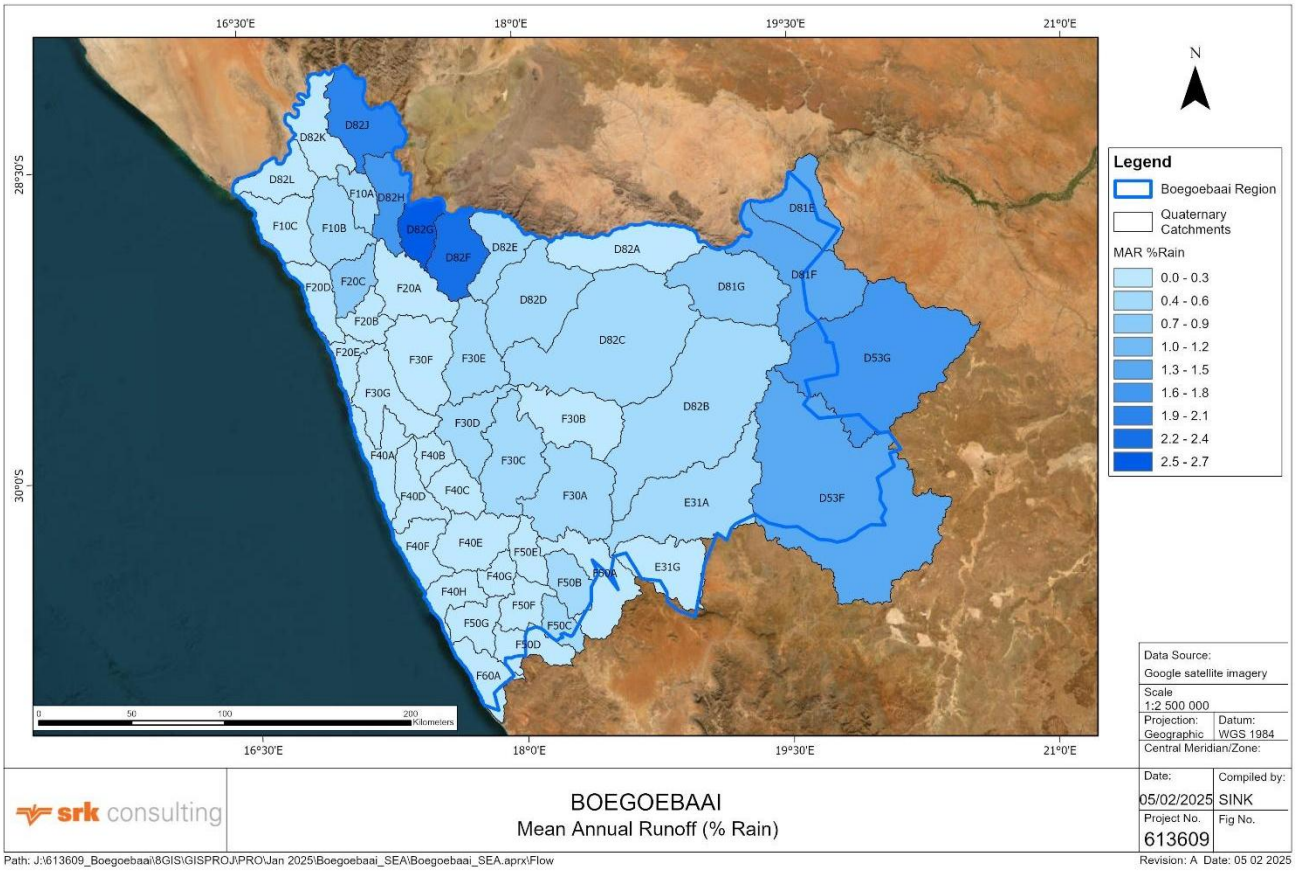


Figure C2.4: Distribution of the Quaternary MARs as a percent of rainfall.

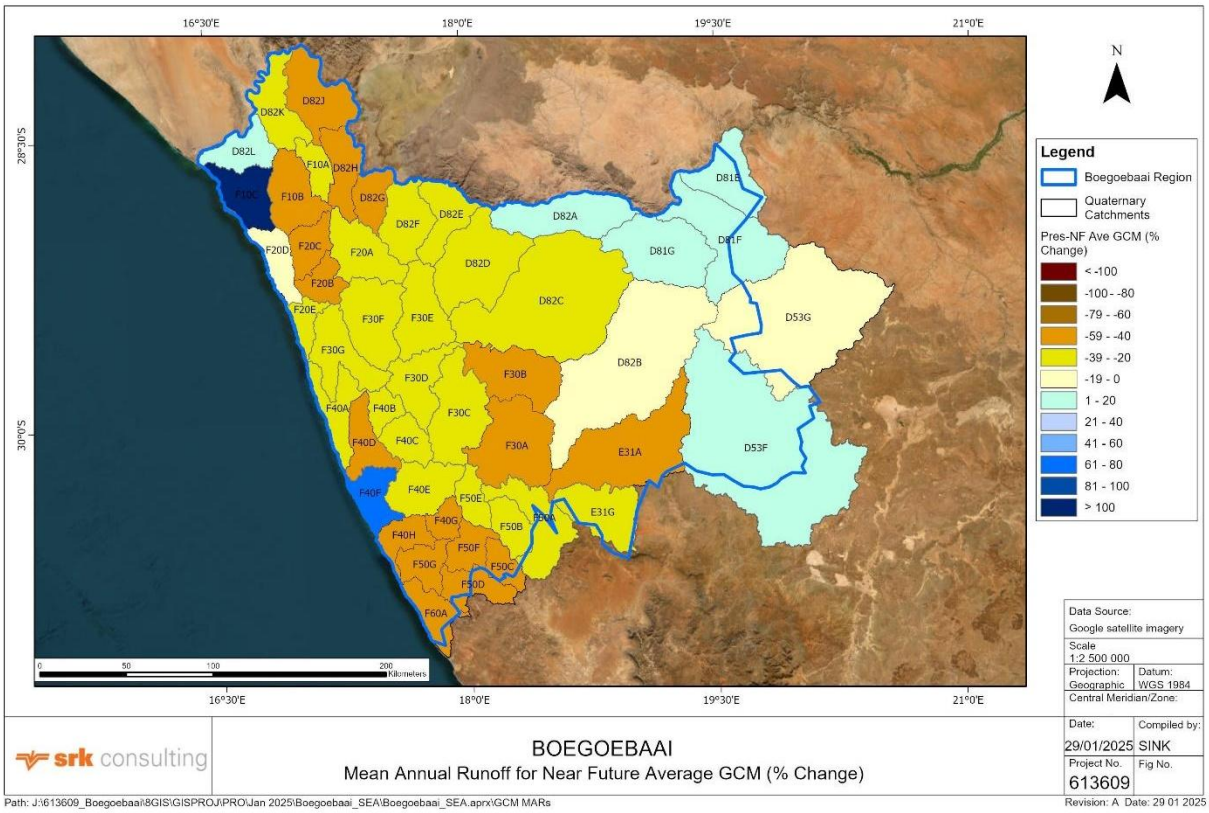


Figure C2.5: Percent Change in Near Future Mean Annual Runoff (average of 6 GCMs)

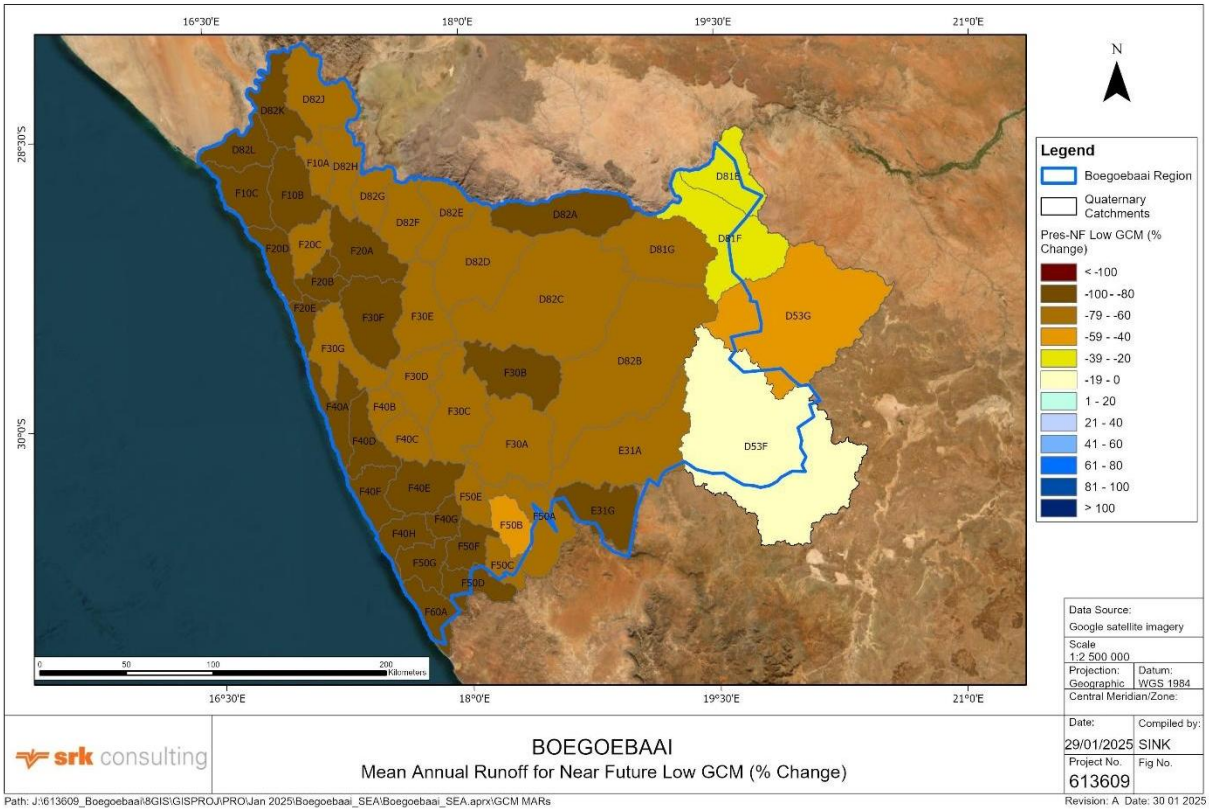


Figure C2.6: Percent Change in Near Future Mean Annual Runoff (lowest of 6 GCMs)

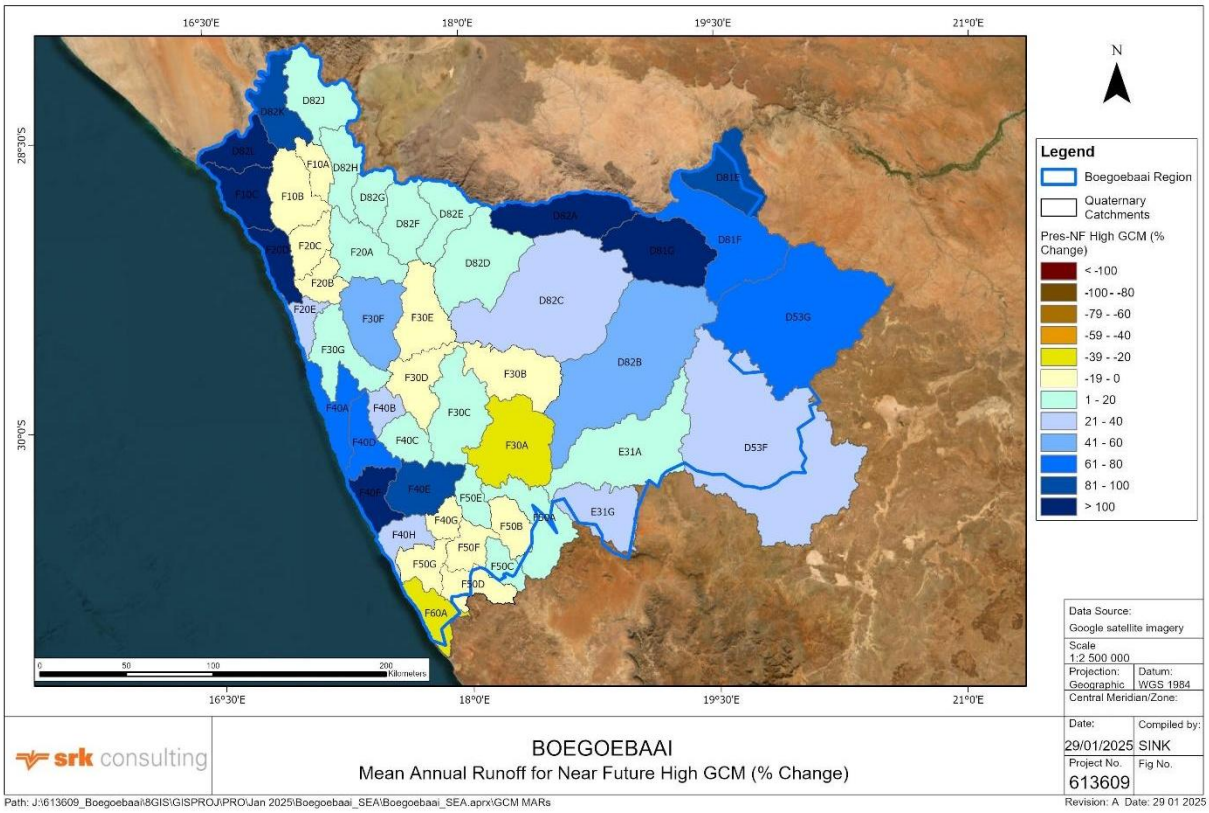


Figure C2.7: Percent Change in Near Future Mean Annual Runoff (highest of 6 GCMs)

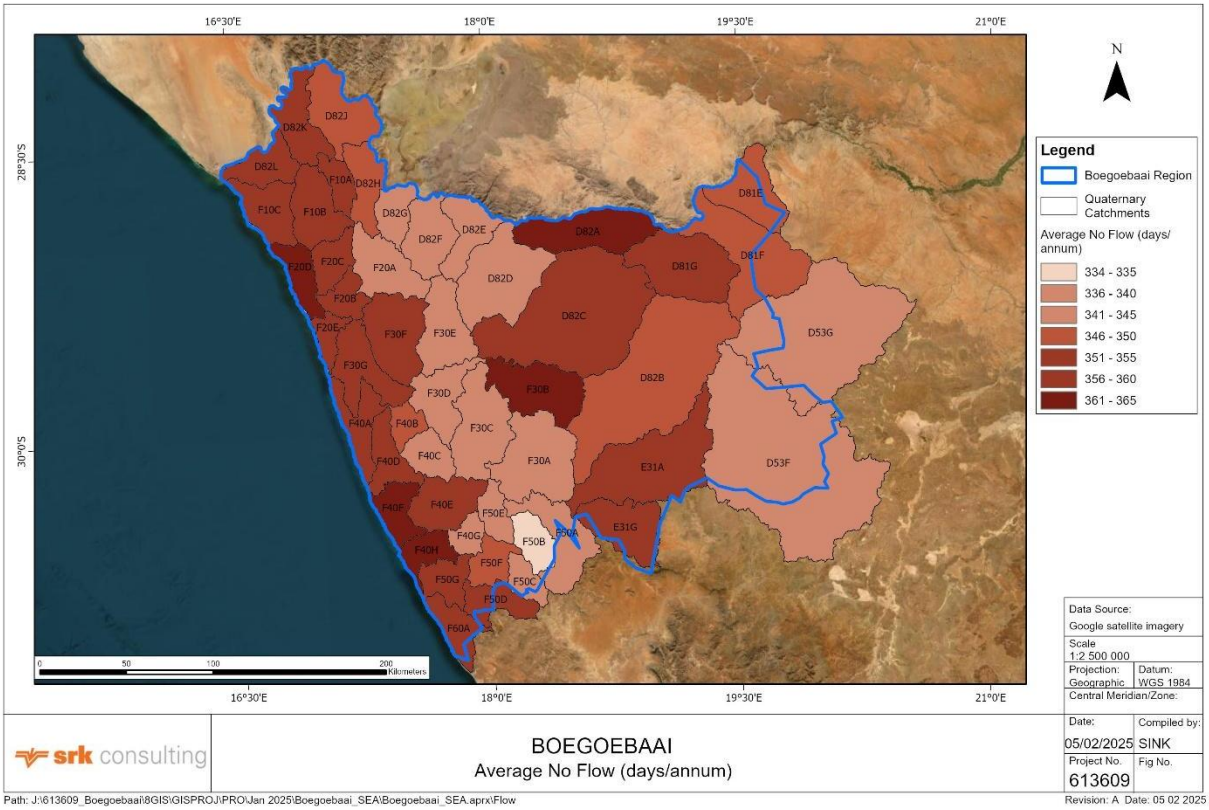


Figure C2.8: Distribution of Average Days of No-Flow (extracted from Schütte, et al. 2023)

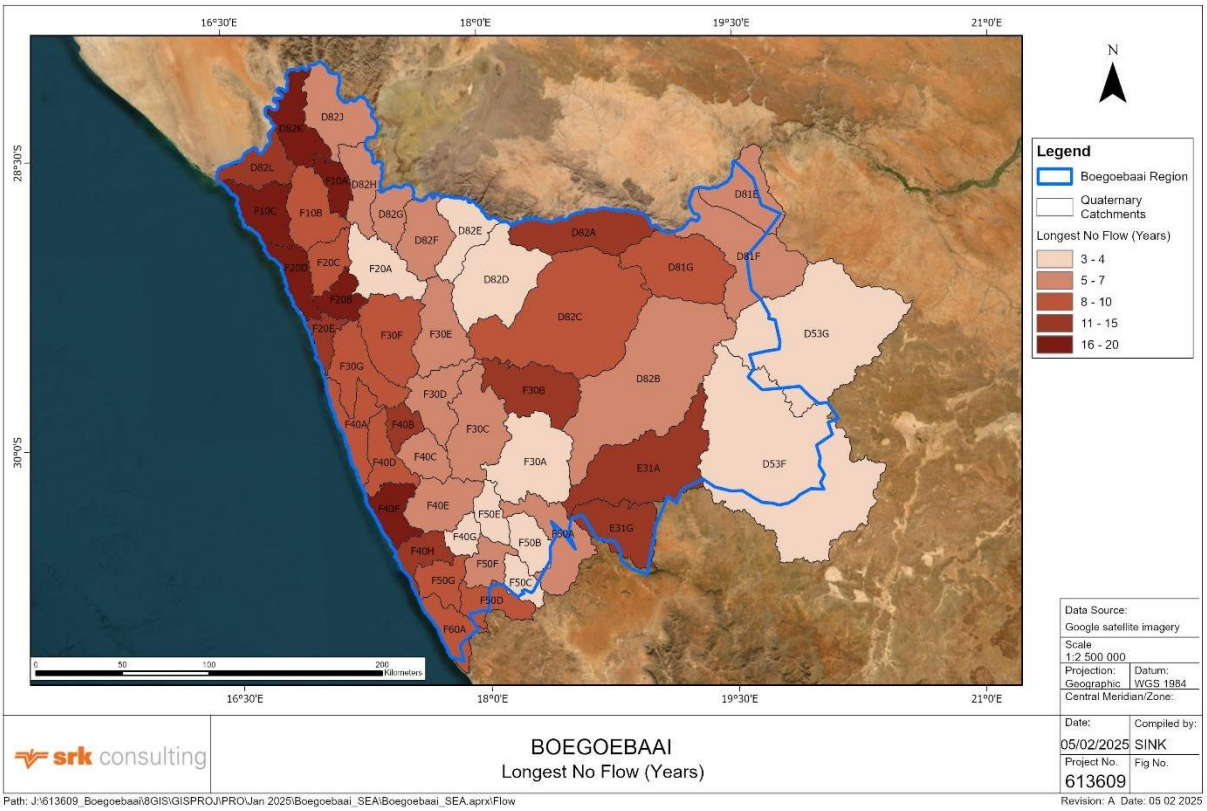


Figure C2.9: Distribution of Maximum Period of No-Flow (from Schütte, et al. 2023)

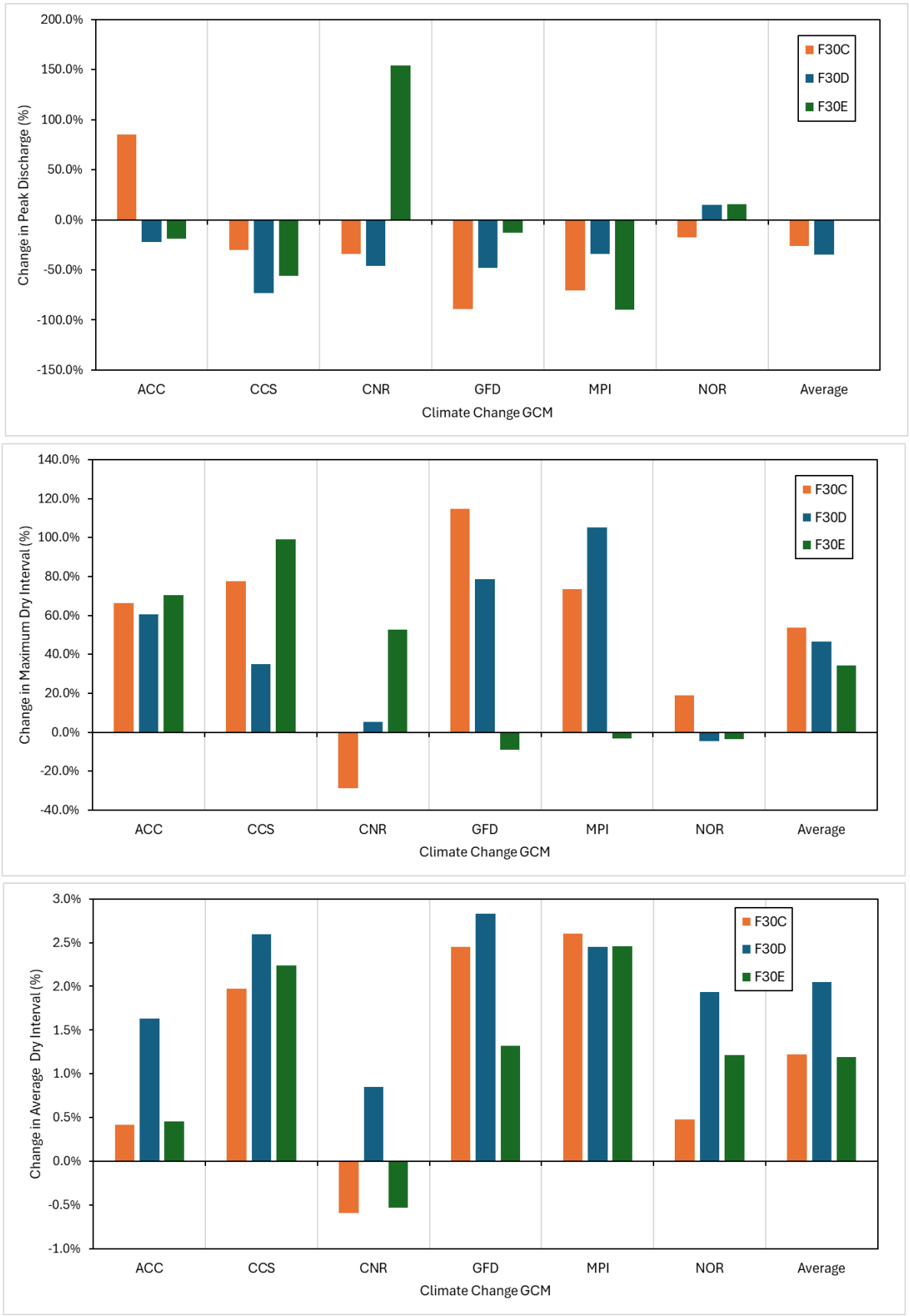


Figure C2.10: Percent Change in Peak Discharge and Dry Periods for Quaternaries F30C, F30D and F30E (6 GCMs, Schutte et al. 2023)

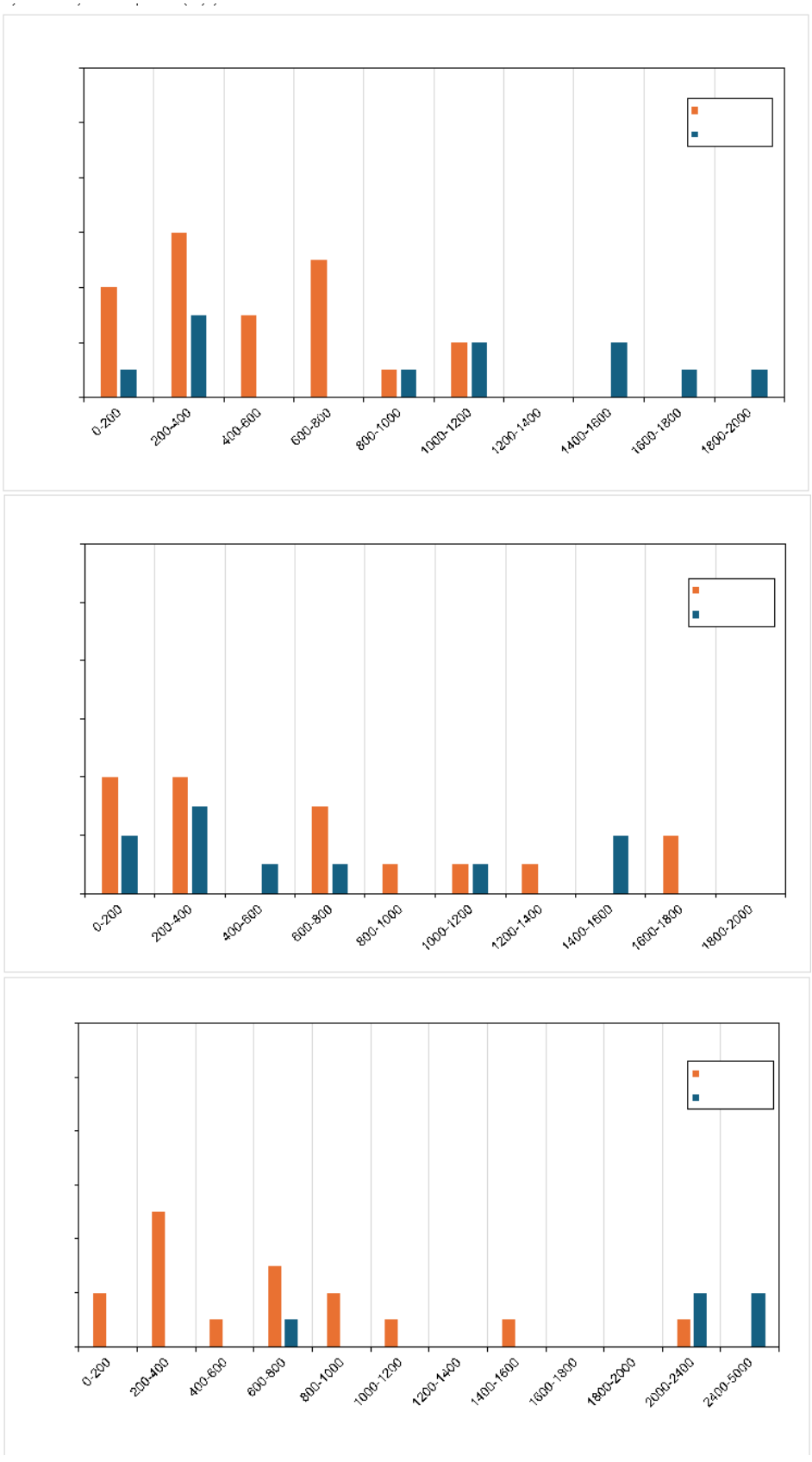


Figure C2.11: Dry period changes from Present to Near Future Climate F30C (3 GCMs)

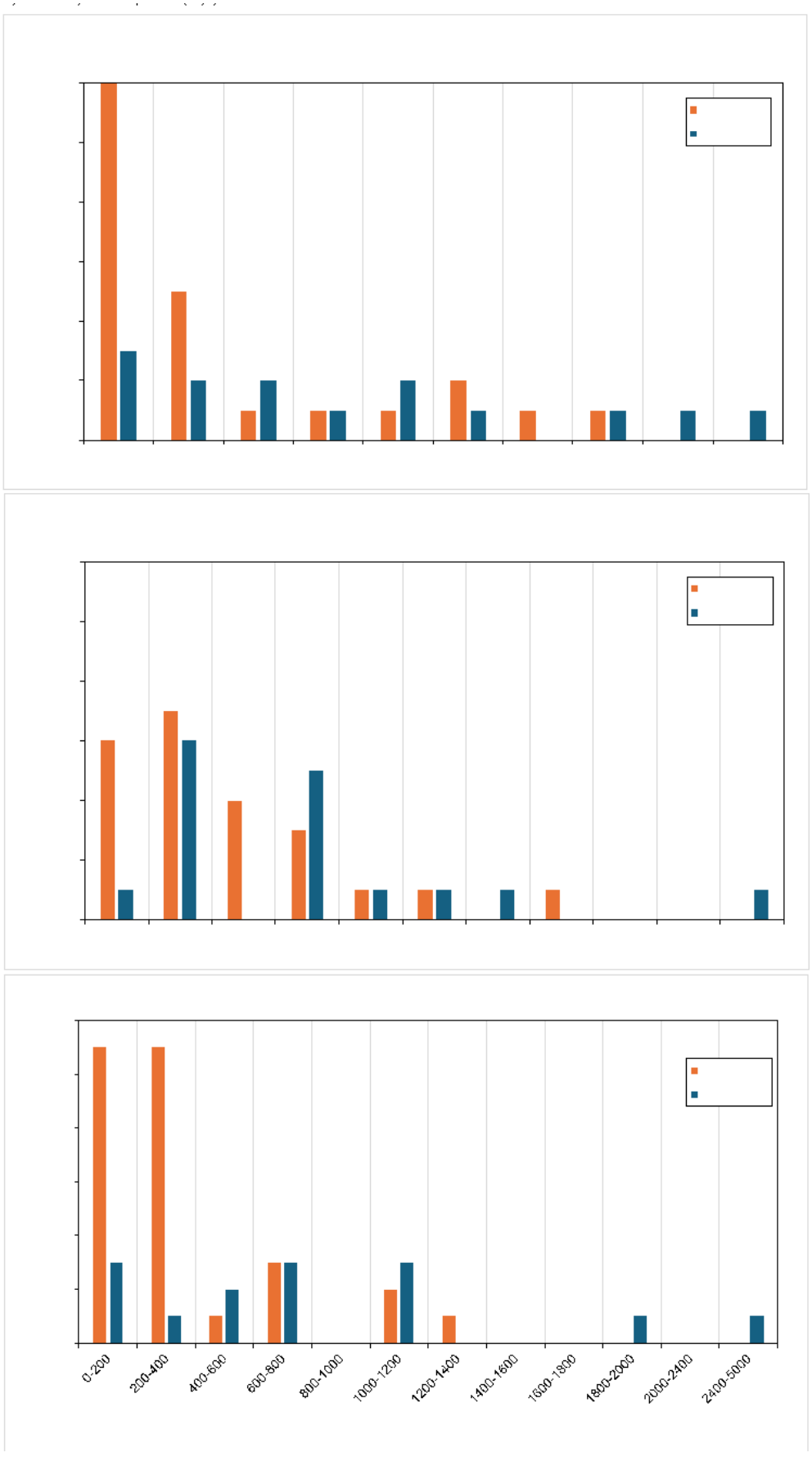


Figure C2.12: Dry period changes from Present to Near Future Climate F30D (3 GCMs)

Figure C2.13: Dry period changes from Present to Near Future Climate F30E (3 GCMs)

Appendix C3: Orange River Yield

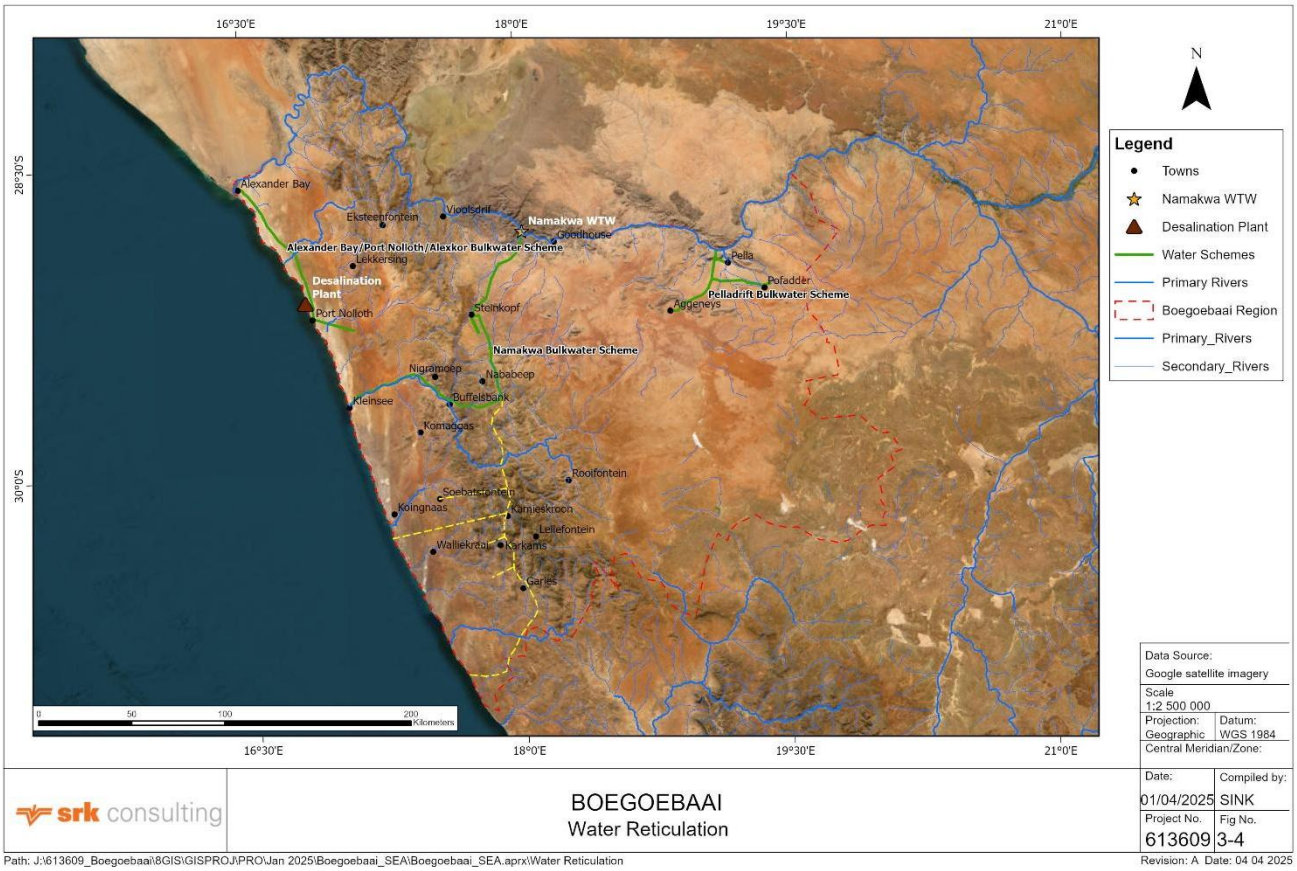


Figure C3.1: Orange River Water Supply Reticulation

APPENDIX D: WATER QUALITY

Table D1

Summary water quality data for DWS monitoring sites along the Orange River, between Onseepkans and Alexander Bay. Data extracted from DWS (2024a)

Site	Location and dataset	Electrical conductivity (mS/m)		Orthophosphate (PO_4-P) (mg P/L)		Total Oxidised Nitrogen (TON) (NO_2+NO_3)-N (mg N/L)		Total ammonia (NH_4-N) (mg N/L)	
		Median	Range	Median	Range	Median	Range	Median	Range
D8H4	Onseepkans 1971-2023	30.9	11.3-106	0.018	0.013-0.592	0.055	0.02-1.24	0.02	0.02-0.52
D8H8	Orange River at Pella Mission 1980-2023	39.7	18.5-75.2	0.02	0-0.62	0.047	0-3.17	0.02	0-1.5
D82 182752	Orange River at Henkries Namaqua Water Board Abstraction 2002-2003 & 2022	36.4	21.9-57.6	0.02	0.012-0.051	0.045	0.02-0.599	0.02	0.02-1.5
D8H3	At Vioolsdrift on Orange River 1965-2023	34.3	19.1-120	0.019	0.003-0.5	0.04	0.005-3.09	0.02	0.015-1.96
D8H7	Orange River at Korridor Brand Kaross 1971-2023	33.4	18.1-88.0	0.013	0.003-0.097	0.04	0.005-2.41	0.025	0.02-0.13
D8H12	Orange River at Alexander Bay at Sir Ernest Oppenheimer Bridge 1995-2011	47.2	23.4-93.9	0.026	0.005-0.422	0.041	0.005-2.13	0.02	0.02-0.545

Table D2

Interpretation of CRR scores, with colour coding as per 2023 Green Drop Report (DWS 2023)

Low	Medium	High	Critical
<50%	50%<70%	70% - <90%	90% - 100%

Table D3

CRR scores for WWTWs in the present study area, colour coded as per Table D2.

Data taken from Green Drop Report (DWS 2023)

WWTW	Municipality	CRR(%)(2011)	(CRR) 2013	(CRR) 2022	(CRR) 2023
Alexander Bay	Richtersveld	47.1	94.1	82.4	100
Port Nolloth	Richtersveld	47.1	94.1	82.4	100
Nababeep	Nama Khoi	82.4	82.4	94.1	88.2
Carolusberg	Nama Khoi	64.7	94.1	88.2	93.3
Springbok	Nama Khoi	64.7	94.1	88.2	93.3
Concordia	Nama Khoi	70.6	82.4	94.1	100
Komaggas	Nama Khoi	82.4	82.4	94.1	93.3
Steinkopf	Nama Khoi	82.4	88.2	82.4	86.7
Bergsig	Nama Khoi	82.4	82.4	94.1	93.3
Okiep	Nama Khoi	92.4	88.2	88.2	93.3
Garies	Kamiesberg	100	100	100	100
Kamieskroon	Kamiesberg	88.2	100	100	100
Pofadder	Khai-Ma	35.3	88.2	88.2	100
Aggeneys	Khai-Ma	0	0	100	100
Onseepkans	Khai-Ma	0	0	100	100
Pella	Khai-Ma	0	0	100	100

APPENDIX E: AQUATIC ECOSYSTEMS

Figure E1: Ecoregional context of the study area, showing main (1:500 000) rivers, mapped estuaries and quaternary catchments within the study area. Ecoregion data from Kleynhans et al. (2005) 35

Figure E2: River FEPA context of the study area, showing main (1:500 000) rivers, mapped estuaries and quaternary catchments. FEPA data from Driver *et al.* (2011) 37

Figure E3: Endoreic Areas in the study area. Data courtesy SRK Consulting, derived from Schutte et al 2023 38

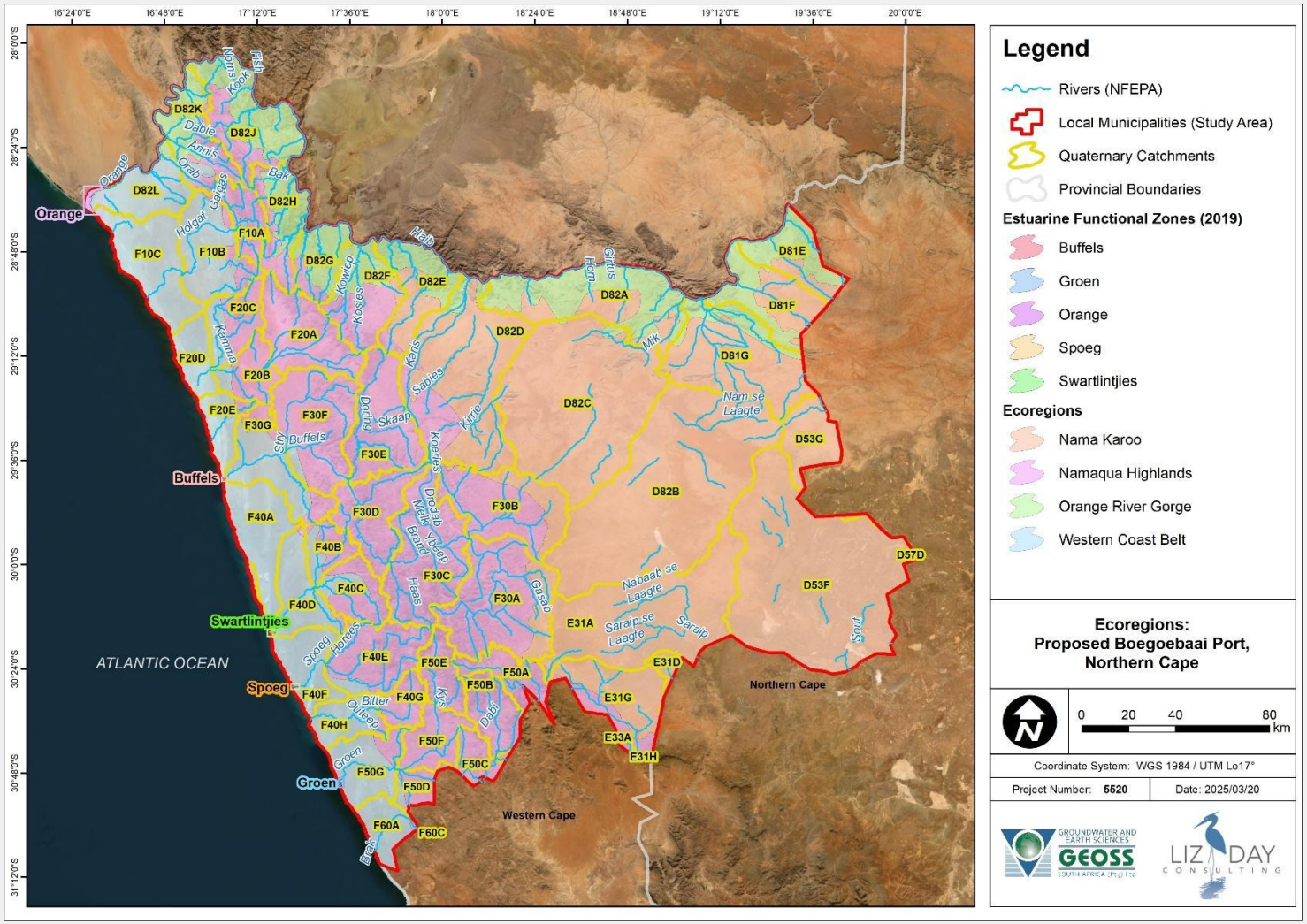
Figure E4: Study area in the context of the Northern Cape Biodiversity Planning dataset (Northern Cape Department of Environment and Nature Conservation 2018) for aquatic and terrestrial ecosystems 39

Figure E5: Bioregional context of the study area, showing wetlands from the NWM v5 (NBA 2018) coded in terms of wetland bioregions (zoom for detail). 40

Figure E6: Study area showing protected areas (nature reserves and other conservation areas) and landcover (2022 South Africa Land Cover data) 41

Figure E7: Study area showing modelled average no-flow days per quaternary catchment. Data courtesy SRK Consulting, derived from Schutte *et al.* 2023 42

Figure E8: Distribution of dry day intervals for the 30-year Present record versus the 30-year Near-Future record for Quaternaries F30C, F30D and F30E. “Dry” meaning no runoff, and presumably also no significant rain. Data supplied by SRK Consulting 43



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E1.1 National Freshwater Ecosystem (NFEPA) Programme Background

The National Freshwater Ecosystem (NFEPA) Programme (Driver *et al.,* 2011) includes rated Freshwater Ecosystem Priority Areas (FEPAs). These are strategic priority subcatchments that are needed for conserving freshwater ecosystems and supporting the sustainable use of water resources (Driver *et al.,* 2011). FEPAs have been determined for different river and wetland types throughout South Africa, on the basis of a number of criteria that included ensuring that there is an adequate extent of conservation of different river and wetland ecosystem types; that they represent sufficient habitats to support threatened fish species and their migration corridors; that free-flowing rivers (i.e. rivers without major dams) are prioritised as FEPAs; that water supply areas in high-water yielding sub-quaternary catchments are maintained; and that ecological connectivity between systems is maintained as far as possible.

FEPAs are often tributaries or rivers that support "hard working" rivers downstream (that is, rivers that are heavily utilised or impacted by agricultural, industrial or other human activities). They need to stay in (or get into) good condition to manage and conserve freshwater ecosystems and to protect downstream water resources for human use. Driver *et al.* (2011) stress however that FEPAs do not necessarily need to be protected from all human use. Rather, they should be supported by good planning, decision-making and management to ensure that human use does not impact on their condition or on the important resources they may protect downstream.

River FEPA ratings are important, because they assign different levels of conservation importance, associated with different requirements for the protection, rehabilitation and/or management of aquatic resources within these sub-catchments.

FEPA ratings include the following categories:

- River FEPA and associated sub-quaternary catchment (FEPA): River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources;

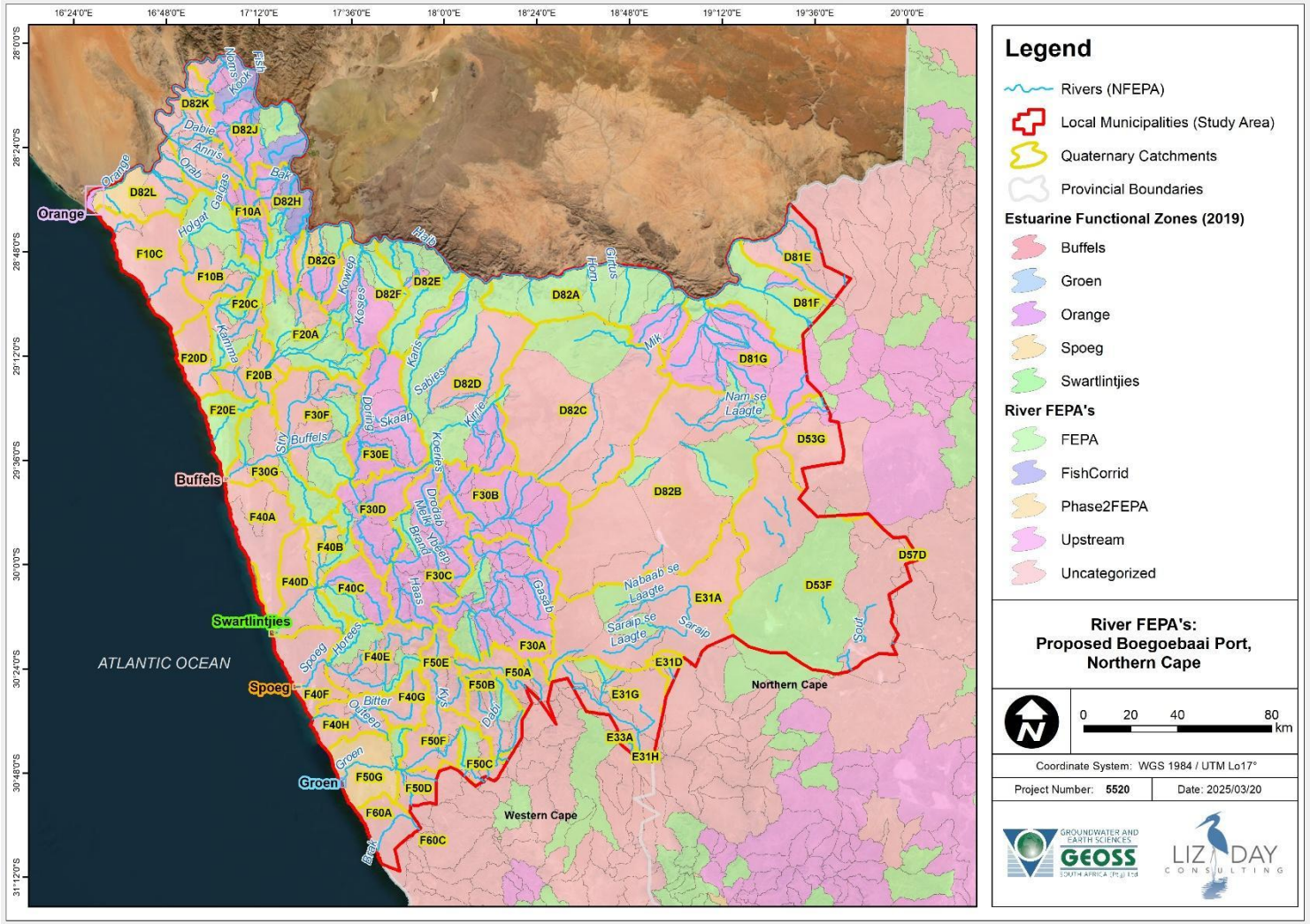
- Fish sanctuary and associated sub-quaternary catchment (FishFEPA): Fish sanctuaries are rivers that are essential for protecting threatened indigenous freshwater fish. They comprise rivers in a good condition (A or B ecological category) and their whole associated sub-quaternary catchment;

- Fish Support Area and associated sub-quaternary catchment (FishFSA): Fish sanctuaries in lower than an A or B ecological condition are rated as Fish Support Areas – they include sub-quaternary catchments that are important for the migration of threatened fish species;

- Upstream Management Areas: These are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas;

- Phase 2 FEPA: Phase 2 FEPAs are rivers that should not be degraded further, as they may in future be considered for rehabilitation once FEPAs in good condition (A or B ecological category) have been fully rehabilitated and are well managed;

- Free-flowing river: Free-flowing rivers are rivers without dams.



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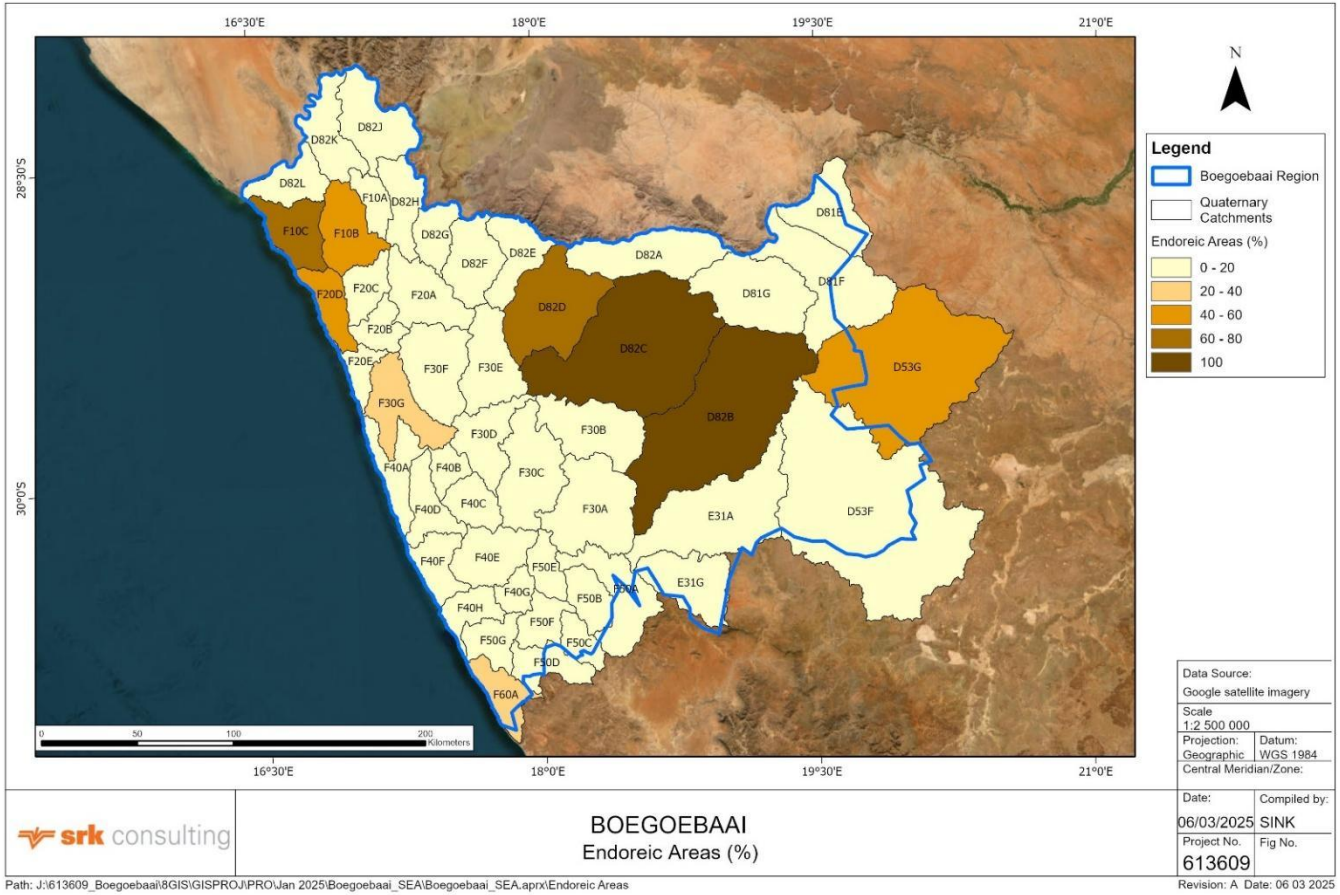

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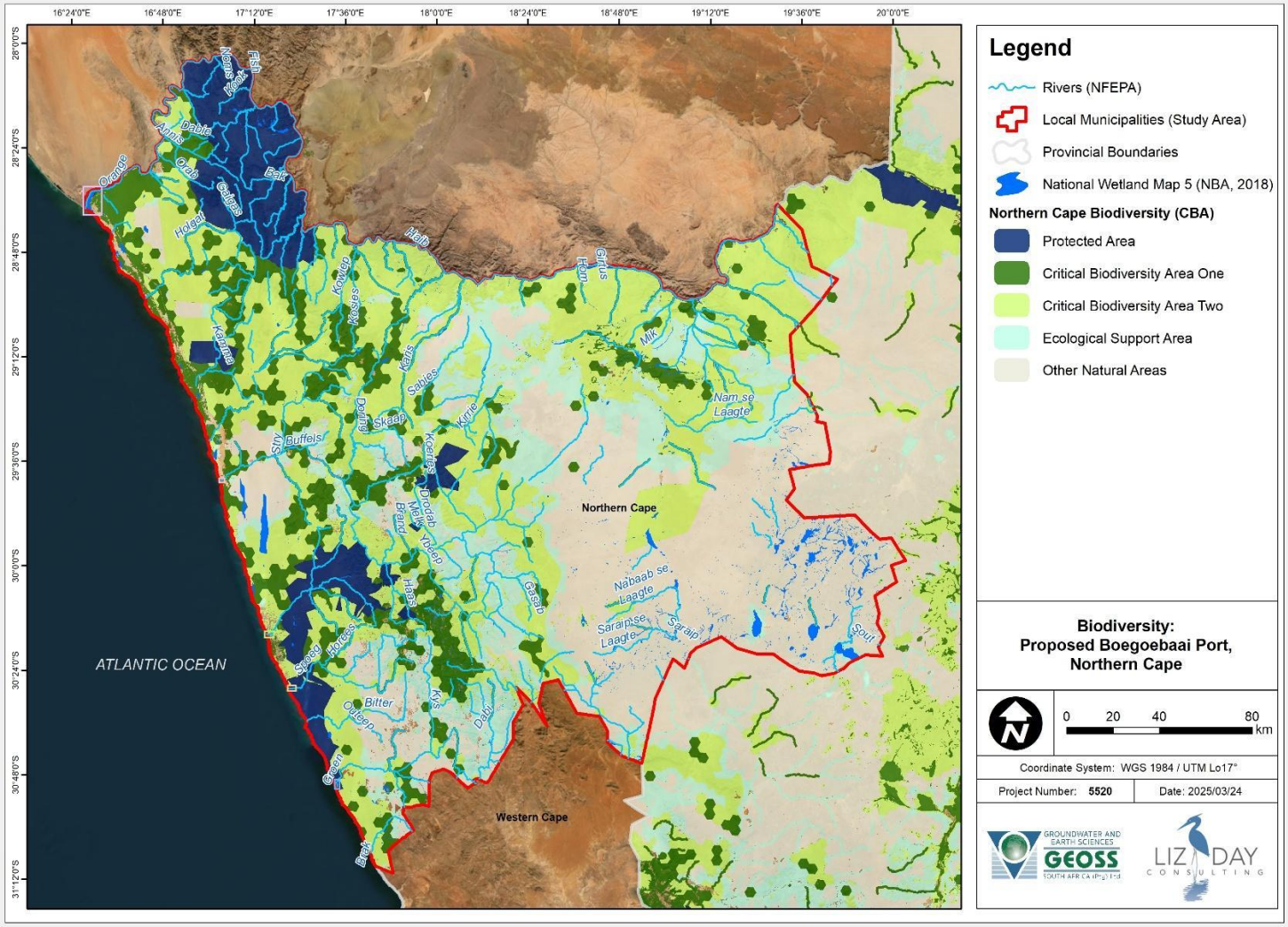
Data courtesy SRK Consulting, derived from Schutte et al 2023



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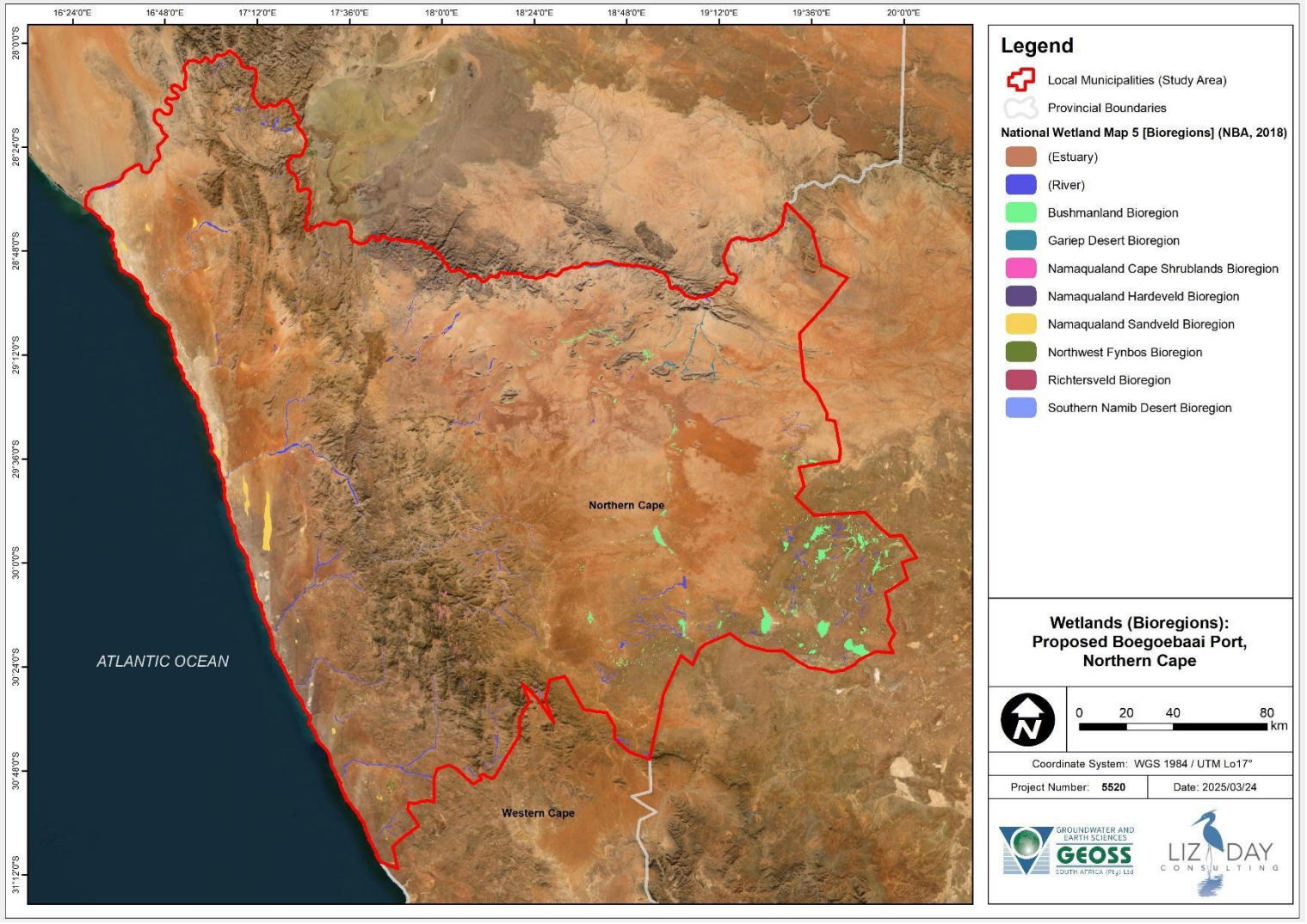

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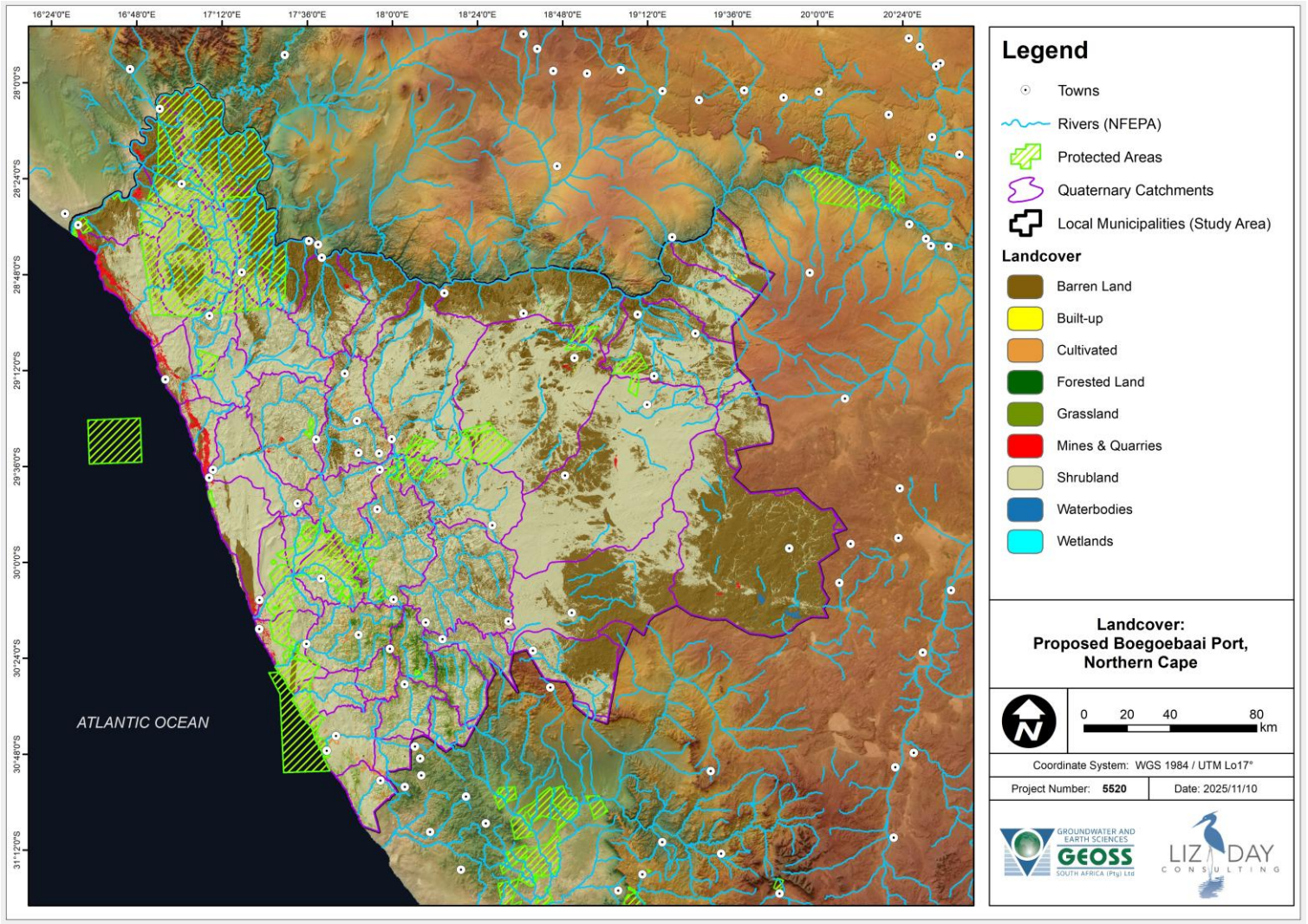

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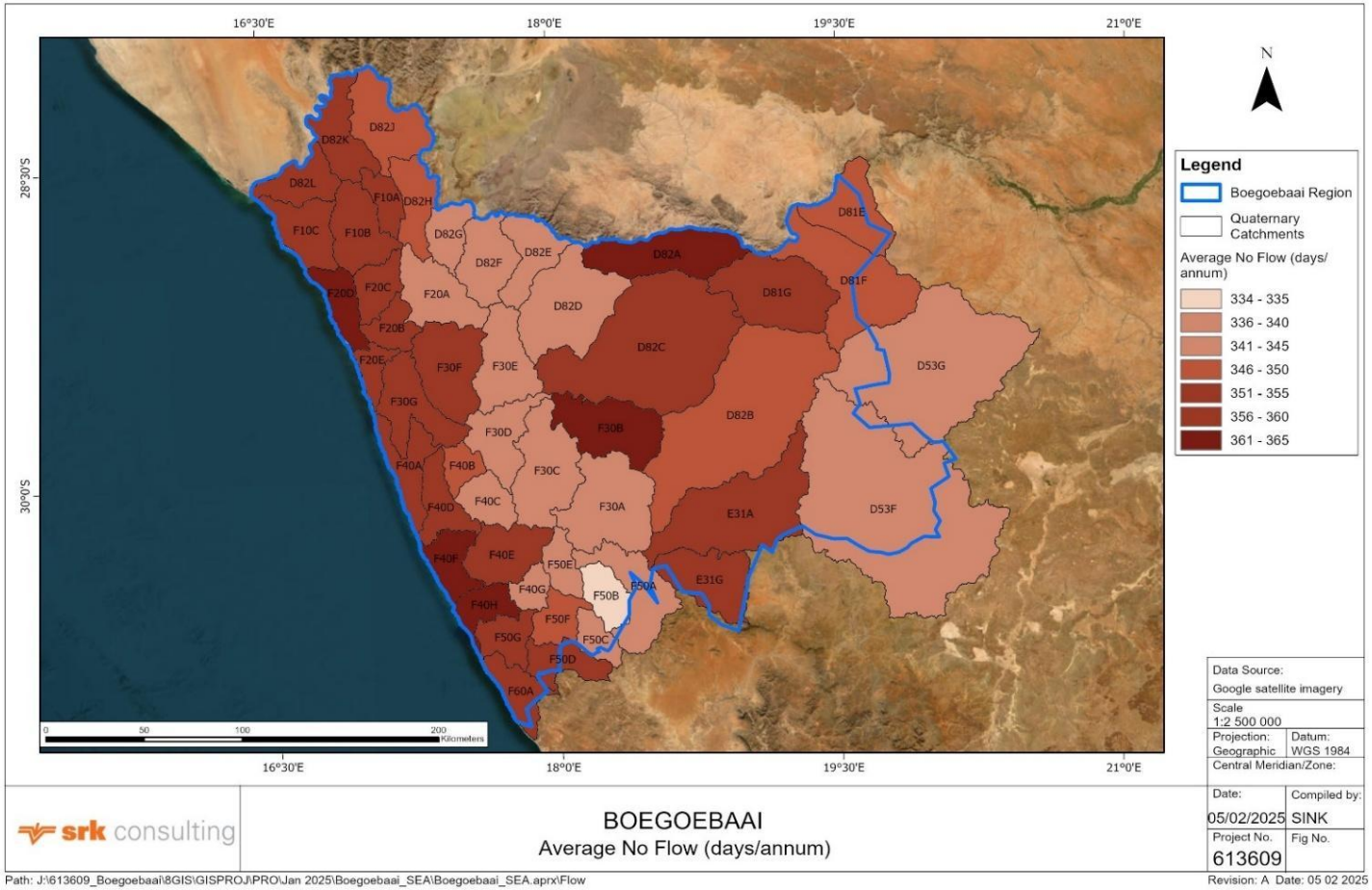
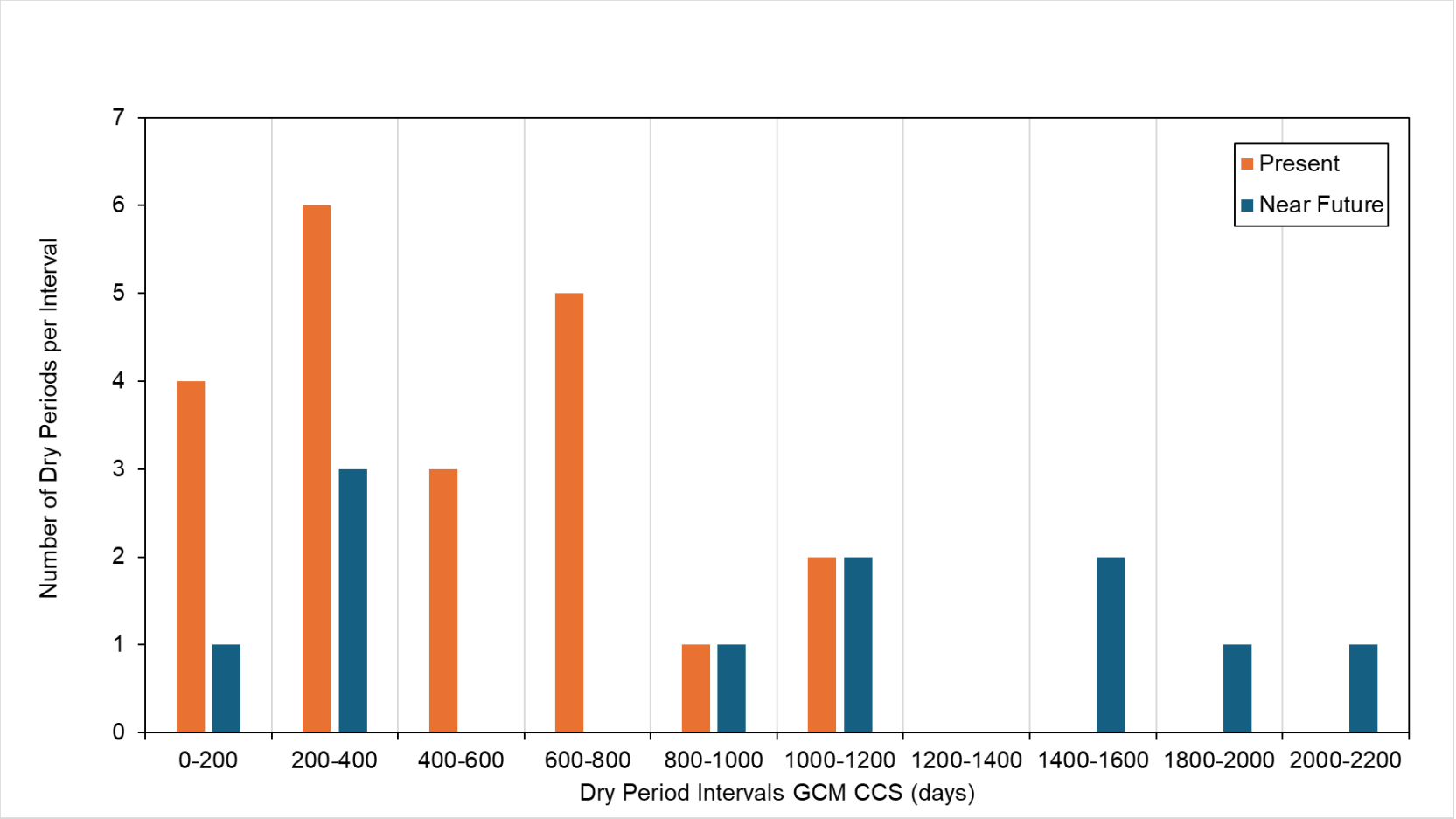


Figure E7: Study area showing modelled average no-flow days per quaternary catchment. Data courtesy SRK Consulting, derived from Schutte *et al.* 2023



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APPENDIX F: SPECIALIST HYDROLOGICAL REPORT

The findings of the attached report have been included in the main body of this chapter.

Boegoebaai Strategic Environmental Assessment WP2 – Surface Water

Report Prepared for

Liz Day Consulting

Report Number 613609

Report Prepared by

srk consulting

April 2025

Boegoebaai Strategic Environmental Assessment WP2 – Surface Water

Report to: Liz Day Consulting

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April 2025

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Authors:

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Executive Summary

Key Systems

The Boegeobaai area is classified mostly as Arid, with 24% of the area classified as Hyper-Arid, resulting in very limited surface water resources in the interior. Most drainage features drain westwards with a few eastward draining channels in the east of the area. However, large areas in the central region are endoreic. Runoff in the drainage network is very scarce, with discharge events only occurring during infrequent heavy rains, and lasting only a few days. Runoff is limited to less than 10% of the time with long dry periods between events. The Orange River bounds the region in the north, flowing westwards to discharge at Alexander Bay. Abstractions from the Orange River sustain much of the communities and industry in the north of the region.

Current Trajectory and Anticipated Scenario 1 and Impacts

The region is predicted to become warmer and drier in the near future, with some 18% of the area likely to change from Arid to Hyper-Arid, offering less opportunities outside the Orange River supply network. Planned augmentation of the Orange River abstraction infrastructure and reticulation is aimed at supplying anticipated needs for GH_2 Scenario 1. However, with the current system consistently yielding less than the design demand, future schemes will require improved operation and maintenance, requiring adequate funding and capacity to operate the scheme. It is also likely that continued and augmented groundwater supply to communities will require desalination planet, also requiring capacity for operating the sophisticated technology.

Main Sensitivities

The current abstractions from the Orange River and reticulation into the interior of the region are ageing and often do not yield their design demand, which continues to increase. Proposed new and augmented abstraction works and reticulated networks, are considered extremely sensitive to poor management and maintenance, since they have been assessed as being the only viable source for sustaining water supply to the region. These systems may be supplemented by coastal desalination works, but there is some concern over the local operators' capacity to cope with the more sophisticated technology.

With the very low occurrence of runoff events and long periods without runoff, all rivers and floodplains are considered fragile to disturbance, being dry most of the time and unable to resist disturbance. It is also considered that river networks would be unable to reconfigure from disturbance within periods of several decades

Key Recommendations

- Provide for Orange River abstractions and reticulation to the level of Scenario 1 demand, while providing for adequate operation and maintenance of the abstraction, treatment, reticulation and storage works.
- Provide for expertise to operate desalination plants at proposed coastal locations.
- Prevent all disturbances to river systems and floodplains, particularly at infrastructure crossings. Prevent any encroachment of structures or dwellings into the floodplain.

Disclaimer

The opinions expressed in this Report have been based on the information accessed by SRK Consulting (South Africa) (Pty) Ltd (SRK) by sources as specified. The opinions in this Report are provided in response to a specific request from Liz Day Consulting to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

List of Abbreviations

DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	electrical conductivity
ha	hectares
L/p/day	litres per person per day
m	metres
m^3	cubic metres
Mm^3	million cubic metres
mamsl	metres above mean sea level
MAP	mean annual precipitation
MAPE	mean annual potential evapotranspiration
mm/a	millimetres per annum
WR2012	Water Resources of South Africa, 2012 edition

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1: Introduction and Scope of Report

Liz Day Consulting (Pty) Ltd ("LDC") has been appointed by the CSIR to oversee and integrate the Water Resources and Aquatic Ecology Study for Work Package 2 of the above SEA. The study is aimed at assessing the state of resources in the region affected by the development of Green Hydrogen production in the area. The study is carried out as a collaborative project, working with surface and groundwater specialists as well as other aquatic ecology specialists, as necessary.

SRK Consulting SA (Pty) Ltd (SRK) were awarded the Surface Water study and this report presents the outcomes of the analyses, sensitivity determinations, risks and remediations for three scenarios related to Green Hydrogen development in the study region.

The work was intended as a desktop study, using available publications and data.

2: Major Water Resources Drivers

2.1 Climate

2.1.1 Rainfall

The rainfall in the study area is the lowest in the country, with Mean Annual Precipitation (MAP) varying from 60mm to 215mm as illustrated in Figure 2-1. Lowest rainfall areas include the north-east coastal region and along the Orange River. Rainfall increases towards the southern interior of the region, with highest values in the Kamiesberg mountains. Along the coastline, frequent fog occurs during winter due to the cold Benguela current, contributing to moisture levels.

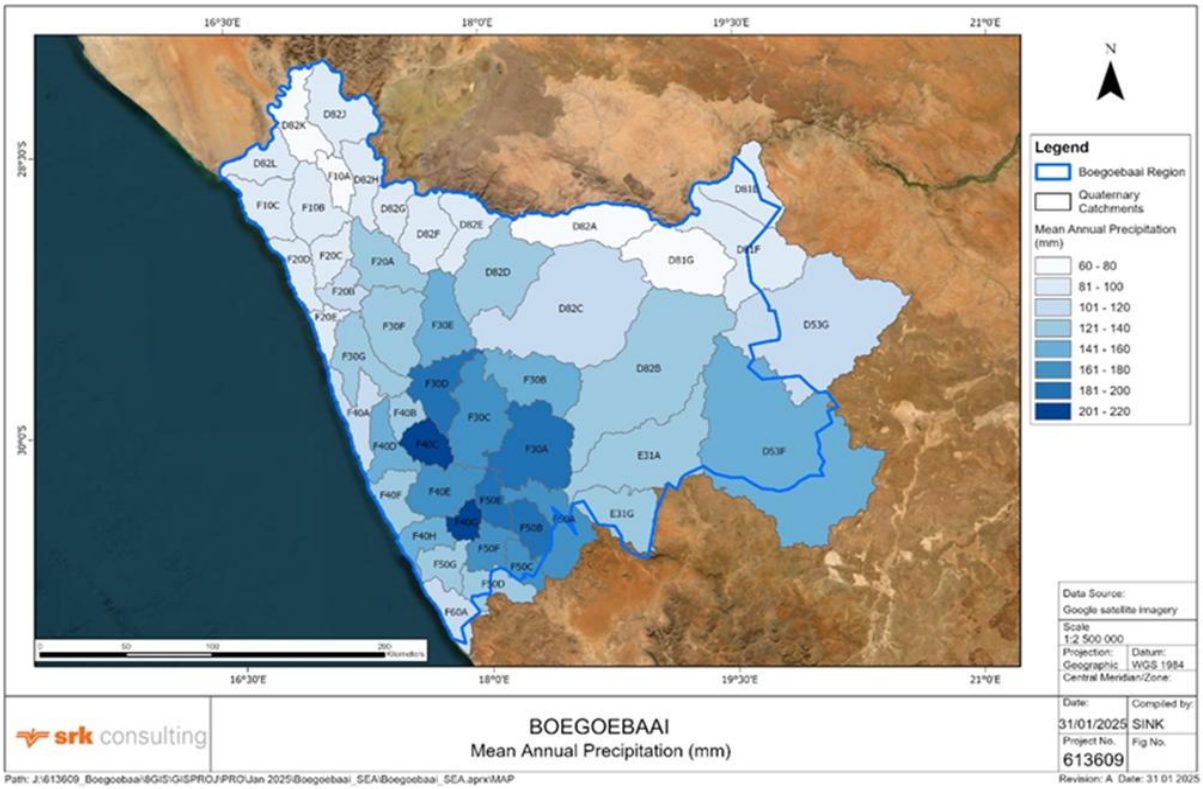

Figure 2-1: Distribution of the mean annual rainfall in the study area.

However, mean annual values are extremely deceptive, since the distribution of rainfall events is large, with some areas experiencing no rain for periods of years and rainfall often occurring in extreme events. This is reflected in the runoff analysis and particularly the number of dry days between runoff events.

Mean Annual Precipitation is predicted to decrease by 12% in the Near Future (2050). This result is derived from the average of six GCMs applied to the study area. The maximum change GCM predicts a 24% decrease and the minimum a 5% increase.

The distribution of estimated Near Future changes in MAP is illustrated for the Average of 6 GCMs in Appendix A

2.1.2 Temperature

The region has warm summers, with temperatures averaging around 30°C and occasionally peaking at 40°C, while winters are cooler, with daily averages ranging from 8 to 17°C. Observed average daily temperatures for Springbok are shown in Figure 2-2.

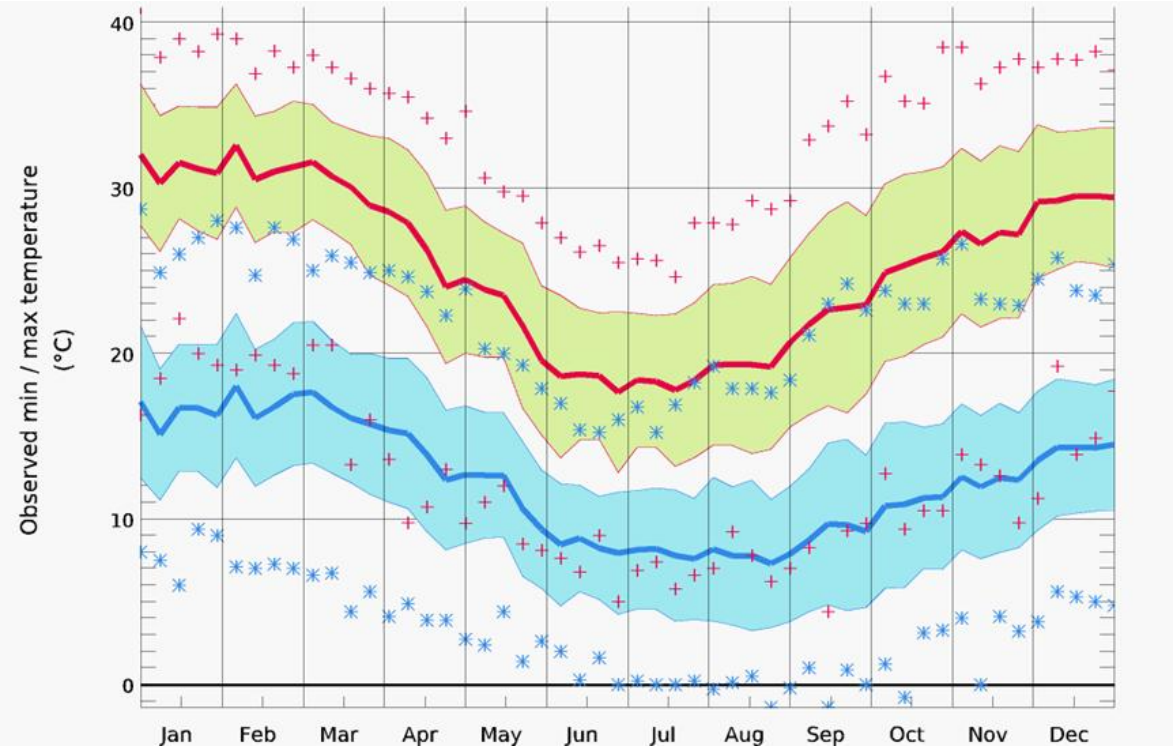

Figure 2-2: Mean daily maximum and minimum temperatures at Springbok.

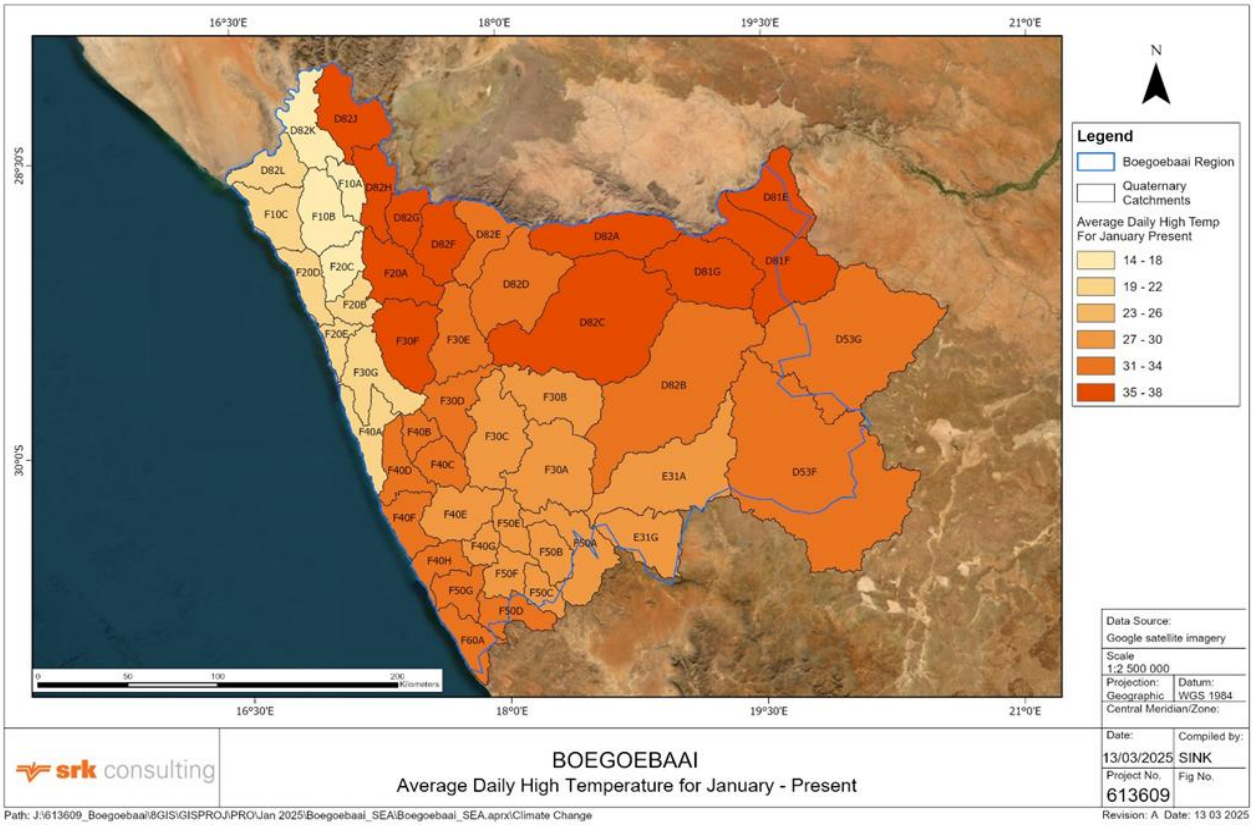

Figure 2-3: Distribution of average Temperatures for January.

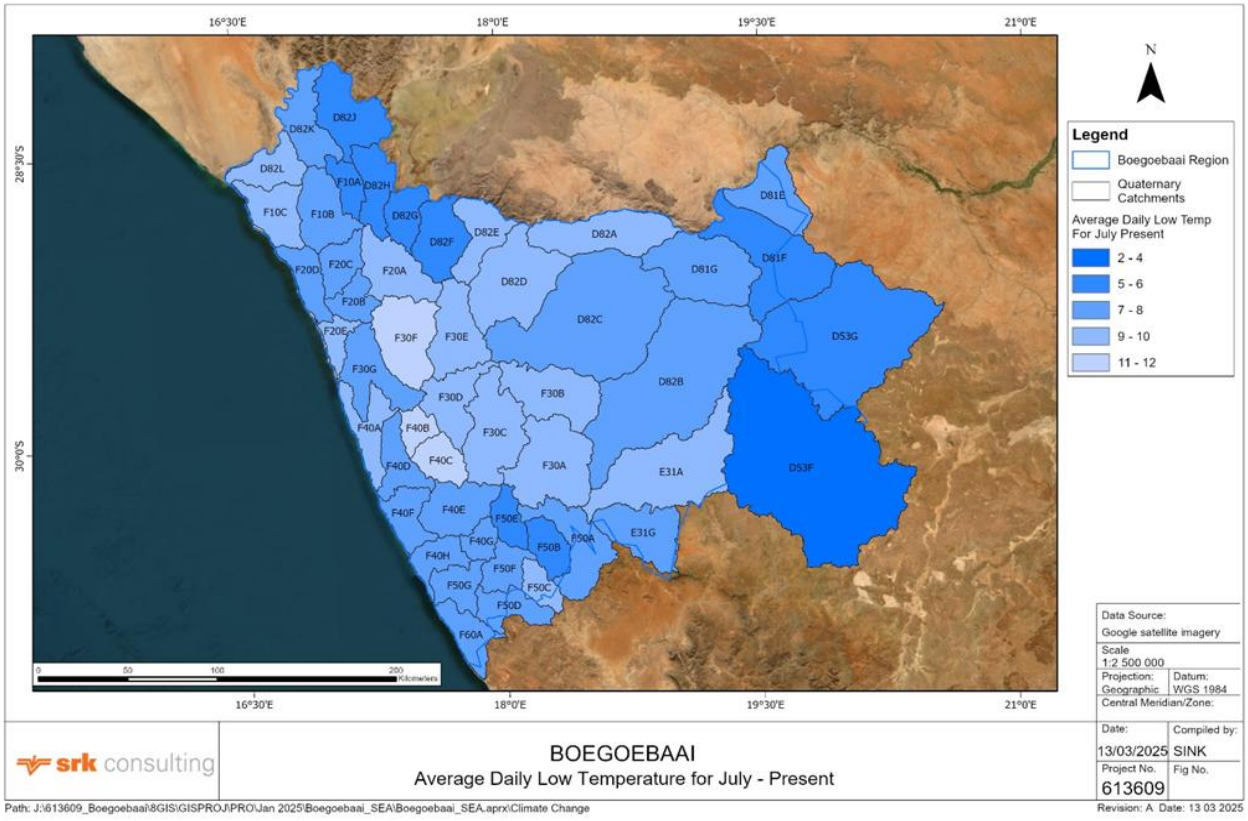

Figure 2-4: Distribution of Average Temperatures for July.

2.1.3 Mean Annual Potential Evaporation

The Mean Annual Potential Evaporation (MAPE) ranges between 611mm and 2 680 mm (Figure 2-2) and exceeds the MAP by between 8 to 44 times. Evaporation rates are lowest in the northwest coastal areas of the region and increase towards the east and south.

The Aridity Index, defined as the ratio MAPE/MAP, is greater than 20 over 24% of the quaternary catchments, classifying these as Hyper-Arid (Gunkel and Lange, 2017). The remainder are all classified as Arid, being less than 20, while 12% of the quaternaries have an Aridity Index less than 10. However, none of the quaternary catchments have an Aridity Index less than 5, which might classify these as Semi-Arid.

Mean Annual Potential Evaporation is predicted to increase by 7% in the Near Future (2050). This result is derived from the average of six GCMs applied to the study area. (WRC, 2023). With the predicted changes in MAP and MAPE, in the Near Future, some 18% of the quaternary catchments are likely to change from Arid to Hyper-Arid. (estimated from Schutte et al., 2024; Gunkel and Lange, 2017)

The distribution of estimated Near Future changes in MAE is illustrated for the Average of GCMs in Appendix A. The Present and Near-Future distributions of Aridity Index are also presented in Appendix A.

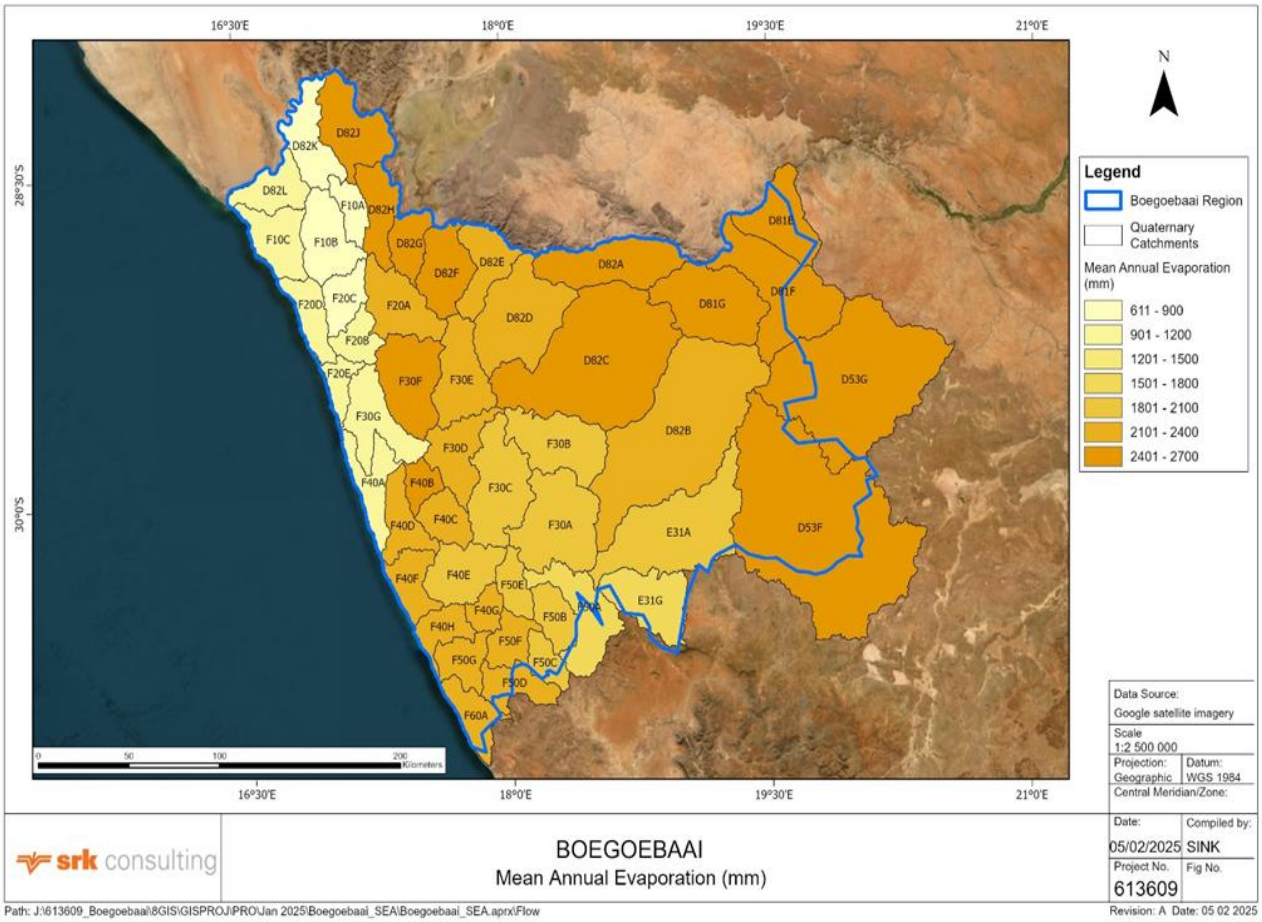

Figure 2-5: Distribution of Mean Annual Potential Evaporation.

2.1.4 Geology and Soils

Geology and Soils are described in the Groundwater section.

2.1.5 Land Use

The Land Cover 2022 is shown in Figure 2-6, while the number of small dams per quaternary are shown in in Figure 2-7.

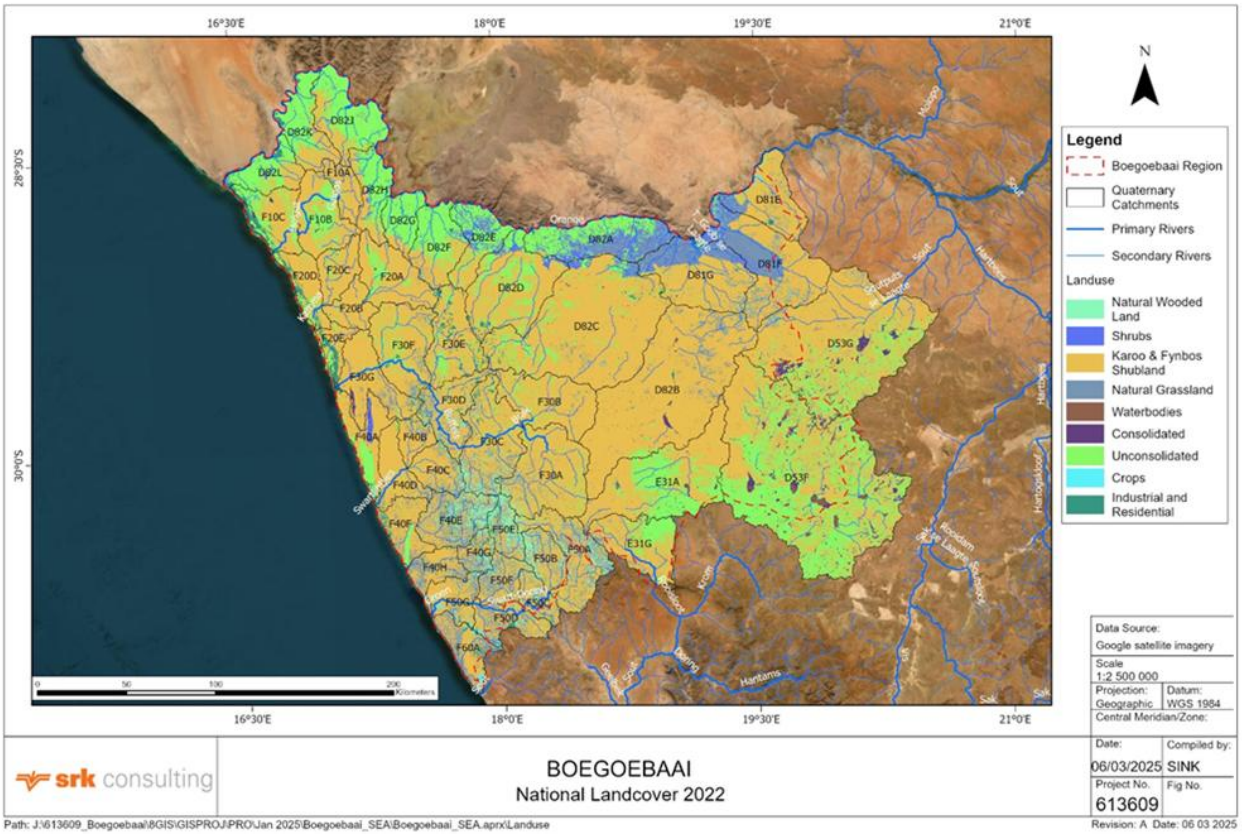

Figure 2-6: Distribution of Land-Use in the study area (SA Land-Use, 2022).

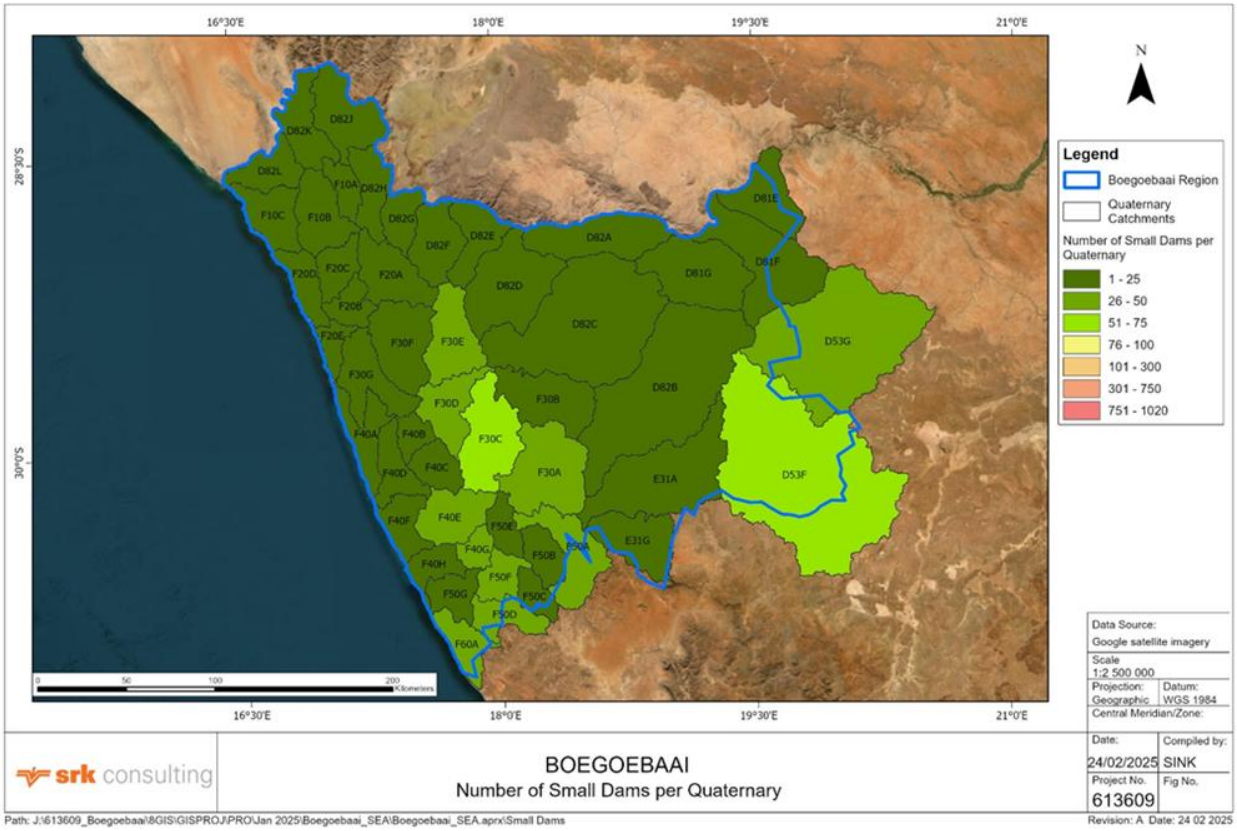

Figure 2-7: Distribution of the number of small dams per quaternary.

3: Surface Water Resources

3.1 Catchment Context – Major Rivers, Quaternaries

Major rivers and quaternary catchments are illustrated in Figure 3-1.

3.2 Surface Water Hydrology

The entire study area is classified as either Hyper-Arid or Arid, with no Semi-Arid catchments. The surface water resources are therefore very limited, with ephemeral streams and sporadic runoff events, mostly lasting for only a few days, with long dry periods in between events. The surface water runoff has been assessed on a Quaternary catchment basis.

3.3 Quaternary Runoff

Endoreic Areas

Two large Quaternary catchments (D82B and D82C) are completely endoreic as illustrated in Figure 3-2. This means that no surface runoff or stream discharge leaves these catchments, and all internal surface runoff terminates in internal pans or groundwater recharge zones. A few other Quaternaries have a portion of their area defined as endoreic, but otherwise most have drainage features that leave the Quaternary (Figure 3-2).

Figure 3-1: Quaternary catchments and river drainage in the study area.

The Mean Annual Runoff (MAR) for the Quaternary catchments in the study area have been estimated in WR2012, (Herold and Bailey, 2016). These estimates reveal mean annual quaternary runoff varying from a minimum of 0 (completely endoreic) to a maximum of 1.24% of the average annual rainfall, with the average of all Quaternaries without endoreic areas reporting MAR of 0.57% of MAP. However, average annual estimates of runoff are misleading in areas with such sporadic runoff regimes. An effort was therefore made to estimate the distribution and magnitude of runoff events and dry periods between these.

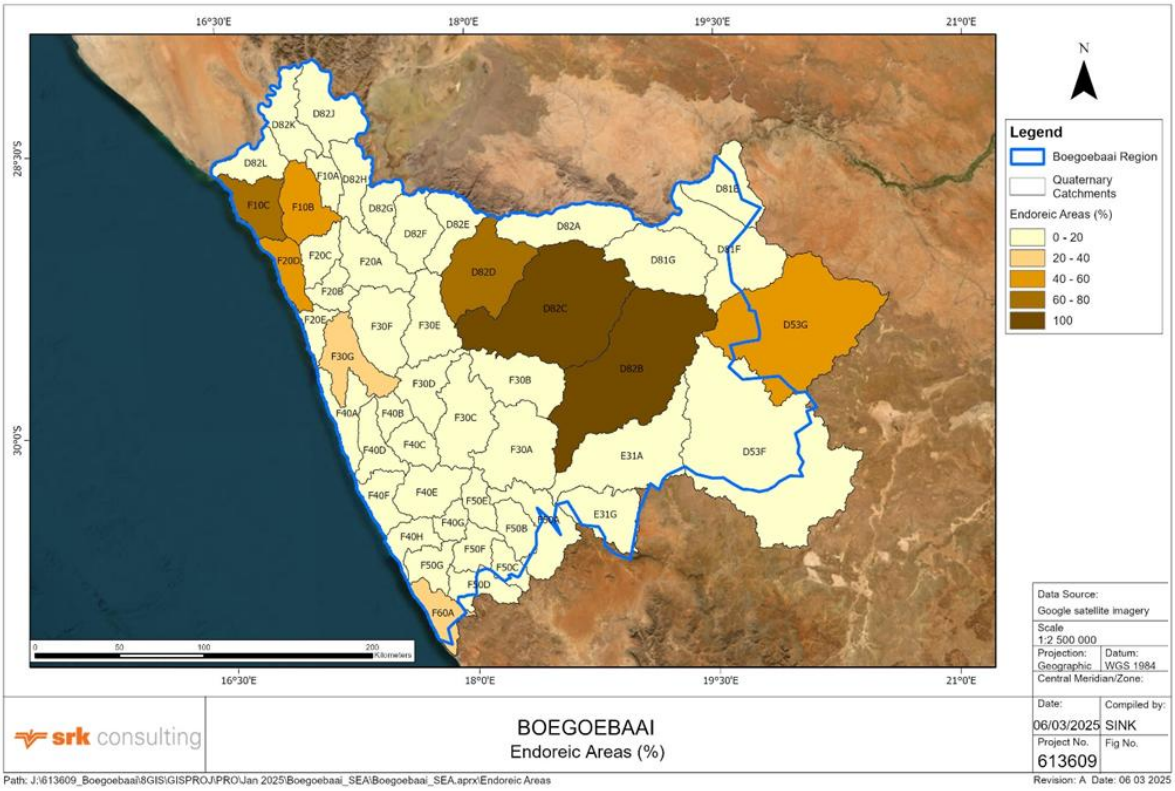

Figure 3-2: Distribution of endoreic areas (Mantel and Hughes, 2023).

Simulations of the quinary catchments making up the quaternaries in the study area had been modelled using the ACRU agro-hydrological model, with daily meteorological inputs (Schütte *et al.,* 2023). These simulations were calibrated using observed daily runoff data from two stations, F5H001 and F5H002 as well as a daily runoff record derived from a study on the Buffels river (Benito *et al*., 2011). The stations and contributing catchments are illustrated in Appendix B, Figure B-2.

The simulated and observed flow regimes for the Buffels river catchment indicate the sporadic nature of runoff, with all discharge events occurring over less than 10% of the time (Figure 3-3).

The simulated runoff for all quaternaries resulted in similar flow regimes and very low annual runoff. The MAR is predominantly less than 2 mm per annum, with lowest MAR along the coast, increasing towards the east, particularly in the high lying interior, decreasing again, eastwards on the leeward side of the mountains and finally increasing again in the far east of the region and far north along the Orange River (Figure B-3). The Quaternary MARs are generally less than 1% of the MAP, except in the far east and north, where the Quaternary MARs are some 2% of MAP (Figure B-4).

Mean Annual Runoff is predicted to decrease by 20-40% over most of the region in the Near Future (2050). A few Quaternaries in the coastal north and in the far east of the region are predicted to increase (up to 20%) in the Near Future. (Figure B-5). This result is derived from the average of six GCMs applied to the study area. (Schütte, *et al.*, 2023). The highest of the GCMs predicts mostly increasing MAR, while the lowest GCM predicts decreasing MAR everywhere (Figures B-6 and B-7).

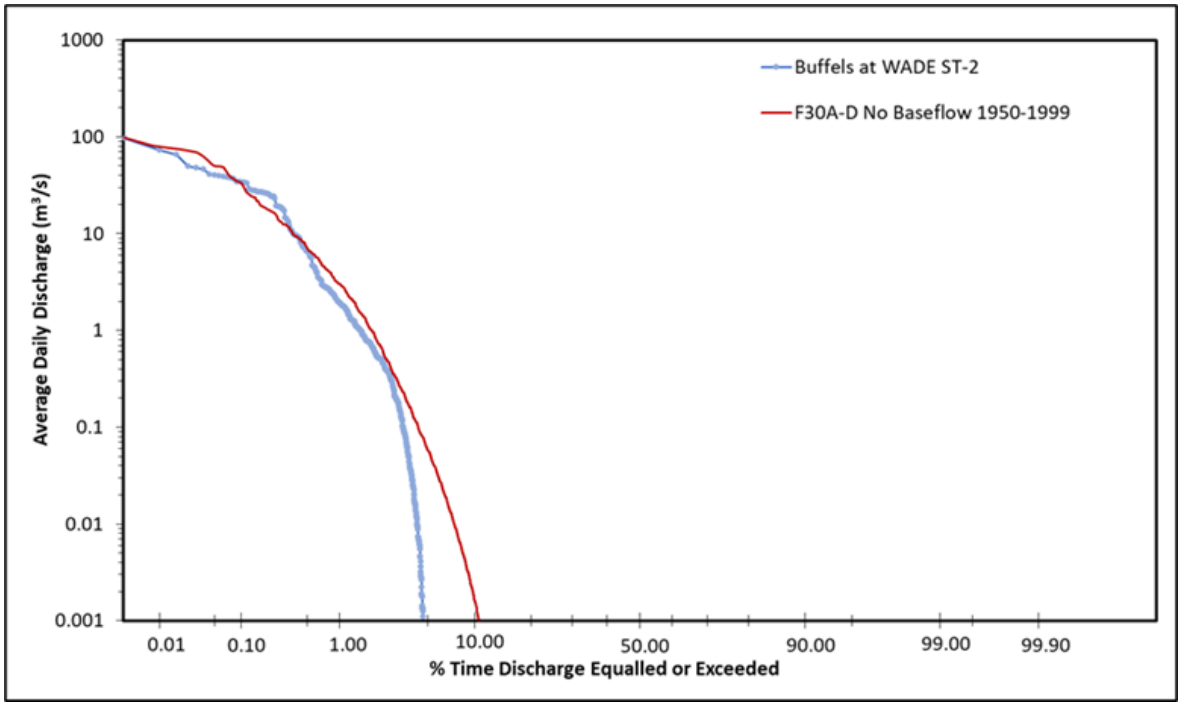

Figure 3-3: Comparison of simulated and observed flow regimes for the Buffels river WADE station 2 (Figure B-2).

Long periods without any flow occurring (No-Flow periods) are particularly prevalent throughout the region. The average duration of No-Flow periods ranges from 334 to 365 days, (Figure B-7), while the longest period of No-Flow in the 50-year simulated record, ranges from 3 to 7 years over most of the region, with maximum No-Flow durations reaching 16 years in the north coastal region (Figure B-8).

No-Flow periods are predicted to decrease in number but increase in duration in the Near Future (2050). (Figures B9 to Figure B-11).

3.4 Orange River Yield

The Mean Annual Runoff in the Orange River, without abstractions, has been simulated as 24 400 Mm^3/annum (Schutte *et al*., 2023). The current Urban, Industrial and Mining abstractions from the Orange River, overall are estimated to be 360 Mm^3/annum, while future abstractions (2040) could reach 479 Mm^3/annum (DWS 2012). Average annual river losses from the Vanderkloof dam to the mouth are estimated at 615 Mm^3/annum.

3.5 Water Yield/Demand

The Water Yield is provided by abstraction schemes as illustrated in Figure 3-4.

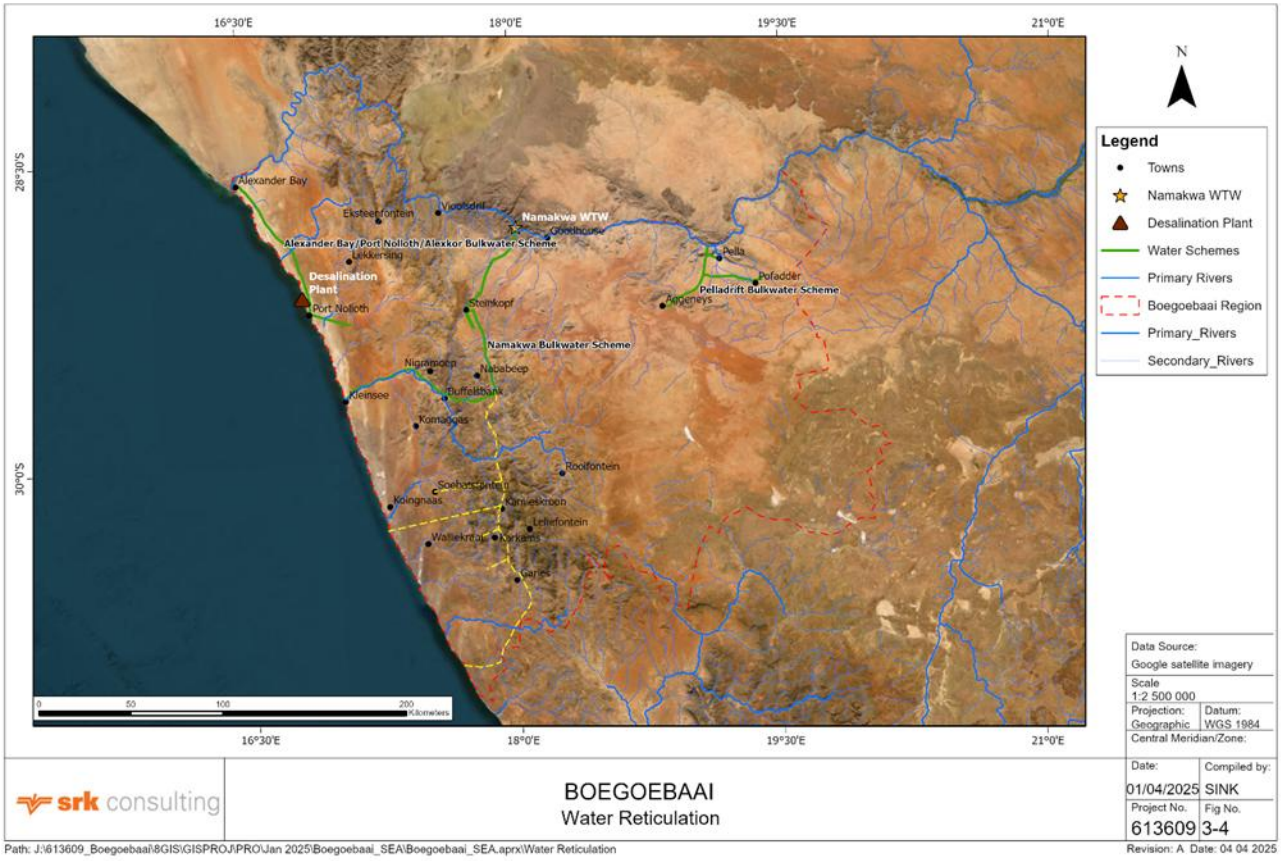

Figure 3-4: Water supply reticulation from the Orange River and desalination plants.

4: Surface Water Sensitivity Classification

Surface water sensitivity has been assessed for linear and distributed criteria. Linear features subject to impact are the drainage network (river system) and the Orange River abstraction and reticulation network. Distributed features include aridity levels and the density of farm dams.

4.1 Stream Networks

Although surface water discharge only occurs occasionally in the drainage network, the responses are generally brief and can be intense, when they do occur. The drainage networks are particularly sensitive to disturbance (road crossings, bridges, encroachment into the flood plain) and the alluvial flood plains are critical for groundwater recharge, which occurs mainly during flood events.

Disturbances and restrictions in the stream network could give rise to extensive upstream flooding and, if breaches occur, downstream damage. Restrictions in the streams could also give rise to increased velocities and scour damage to stream banks and bed. Where riverbeds comprise mostly sands and floodplains mostly silts, disturbances are likely to cause significant changes in sediment transport and scour.

With the very low occurrence of runoff events and long periods without runoff, all rivers and floodplains are considered fragile to disturbance, being dry most of the time and unable to resist disturbance. It is also considered that river networks would be unable to reconfigure from disturbance within periods of several decades (Fryirs, 2017).

4.2 Water Supply Reticulation

The extensive use of groundwater in the area has stretched the resource to a limit and further groundwater exploitation in the region is limited. The current abstractions from the Orange River and reticulation into the interior of the region are also ageing and often do not yield their design demand, which continues to increase (DWS 2012; BVI, 2023a). These abstraction works and reticulated networks, including planned extensions and improvements are considered extremely sensitive, since they have been assessed as being the only viable source for sustaining water supply to the region.

These systems may be supplemented by coastal desalination works, but there is some concern over the local operators' capacity to cope with the more sophisticated technology.

4.3 Aridity

All quaternary catchments in the study area are categorised as either arid or hyper-arid. It is considered that hyper-arid areas would be insensitive to water supply impacts as the yield is negligible. These areas are considered unsuitable for crops or grazing. In arid regions, some grazing systems may be supported, but co crops would be viable without irrigation. Aridity indices (defined as the ratio between average annual evapotranspiration to precipitation) above 20 are classed as hyper-arid and those between 5 and 20 as arid. It is deemed that the quaternaries with low aridity indices (5 to 10) would be highly sensitive to disturbance, since these would be the most suited to cattle farming. Quaternaries with aridity indices between 11 and 20 would be considered having medium sensitivity.

4.4 Farm Dams

In a similar way to the aridity indices, areas with small farm dams are also considered sensitive. Disturbances in these areas which might restrict replenishment of the dams would impact on the capacity to water cattle.

4.5 Sensitivity Classification

The linear and areal sensitivity criteria are summarised in Table 1.

Sensitivity	Sensitivity Feature	Motivation
Very High	• Orange River and buffer area. • Water supply reticulation pipeline from the Orange River and desalination plants, including towns they supply. • All river systems and buffers.	DWS current and future supply schemes (Figure 4-9). River systems (Figure 4.1)
High	• Areas with more than 50 farm dams per quaternary or • Areas classified as Arid, but with Aridity index less than 10.	Mantel and Hughes, 2023 Gunkel and Lange 2017.
Medium	• Areas with fewer than 50 farm dams per quaternary or • Aridity Index greater than 10, but in Arid classification (Aridity Index less than 20).	Mantel and Hughes, 2023 Gunkel and Lange 2017.
Low	• Areas classified as Hyper-Arid (Aridity Index greater than 20). • No surface water supply or storage	Schutte, *et al*., 2024; Gunkel and Lange 2017. (While these areas may be sensitive to hyper-arid ecosystems, they are not considered sensitive to surface water supply).

5: Projected Impacts on Surface Water

5.1 Baseline Scenario: Scenario 0

Both groundwater withdrawals and the reticulated supply from the Orange River are severely stressed in the region. Assessment studies point to augmenting the abstractions and reticulation of supply from the Orange River (BVI, 2023a; DWS, 2012). Desalination of ocean water and borehole water has been assessed as a supplementary option, but studies warn of the lack of current capacity to operate this sophisticated technology.

With expected growth remaining at 1.68% per annum in the Port Nolloth Bulk Water supply scheme, the current system will require augmentation to supply some 917 000 kL/annum (based on consumption of 125L/person/day plus losses and municipal use, making 145 L/person/day). The Alexander Bay pipeline is designed to deliver approximately 504 000 kL/annum, and even this is not systematically delivered. Groundwater may yield some 345 000 kL/annum, but this is increasingly subject to desalination prior to household consumption.

5.2 Further Development (Boegoebaai Port): Scenario 1 and 2

The predicted increase in population to include Boegoebaai SEZ in the Port Nolloth supply area amounts to some 76% by 2040, being a population increase from 7 078 to 12 503. Other areas may also see significant increase in population.

Combinations of Orange River abstractions from the Port Nolloth Bulk Water Supply scheme, Namakwa Supply scheme as well as desalination of borehole and ocean water will be required to meet the expected increase in demand in the region.

6: Risk Assessment

6.1 Surface Water Resources Drivers

Table 1: Surface Water Resources Drivers

Theme/Driver Surface Water resources	Trend	Explanation
Evapotranspiration		Projected increase in Mean Annual Potential Evapotranspiration (MAPE) of 6 to 10% (WRC 2023). Increased vegetation uptake will impact agriculture and ecosystems. Human comfort levels will deteriorate, and water demand will increase. Stored open water bodies will experience higher losses.
Rainfall		Mean Annual Precipitation (MAP) has reduced from 100 years ago, but past 50 years has been stable (Benito 2011). MAP is projected to decrease between 10-20% in most places, but some locations between 0 -10% (WRC 2024). Less local water in quaternary catchments.
Mean Runoff		Runoff has been dropping marginally over past 50 years in Namaqualand (Benito *et al*., 2011). Mean Annual Runoff (MAR) is projected to reduce by up to 50% in most quaternary catchments but may increase by up to 25% in a few places. The sporadic nature of runoff events offers very limited opportunity for useable storage. Some small farm dams are concentrated in the mountainous areas of the Buffels river and in the Salt pan areas of quaternaries D53F and D53G.
Runoff Extremes		Flood events are not likely to increase in intensity. (Present to Near-Future Climate change GCMs predict a 20% reduction in maximum discharge). Riparian areas will be subjected flood levels and crossings exposed to flood damage.
Dry Periods		Current average duration of runoff-free periods is 350 days, with some places reporting dry periods of several years (SRK Quaternary Runoff Analysis). These dry intervals are likely to increase (Climate change GCMs predict slight increase in average duration – 1%, but large increases in the maximum dry periods up to 45%). 9 of the quaternary catchments are likely to change classification from Arid to Hyper-Arid in the near future. Extended runoff-free dry periods will impact ecosystems and agriculture.
Water Demand		Increasing MAPE, reduction in average rainfall and decrease in rainfall frequency (WRC 2023) will intensify the pressure on existing and future water resources.
Water Scarcity		Within quaternary catchments, higher MAPE and lower MAP will increase water scarcity. Higher extreme runoff events are not likely to improve or lessen recharge to riparian aquifers, although salinity may increase due to the higher MAPE (Benito 2011). However, predicted increase in flows in the Orange River due to future MAP increase in Lesotho and eastern RSA may allow for increased abstractions, depending on upstream water use in the Orange-Vaal system.
Bulk Water Supply		Increase in demand will be met from Orange River abstractions due to projected increase in Orange River MAR at points of abstraction due to predicted Climate Change increases in runoff in Lesotho and eastern RSA (WRC, 2023). However, availability for abstraction will depend on upstream water use in the Orange-Vaal systems.

6.2 Consequence Definitions

Table 2: Negative and Positive Consequences related to Surface Water

	Consequence	Description
Negative	Slight	• Current flow regimes would largely remain constant. – Low rainfall-runoff intensity and duration of no-runoff increase at local extent and persist for medium term – Low rainfall-runoff intensity and duration of no-runoff increase at medium extent and persist for short term – Low to medium rainfall-runoff intensity and duration of no-runoff increase at local extent and persist for short term. • Slight change to discharge or access of Orange River abstractions.
	Moderate	• Moderate change to flow regimes. • Impacts to ecosystems, drainage crossings, access points manageable. • Moderate reduction in discharge or abstraction potential of Orange River flows.
	Substantial	• Substantial change to flow regimes. • Higher extreme events and longer dry periods result in substantial deterioration of ecosystems, drainage crossings and access points. • Substantial reduction in discharge or abstraction potential of Orange River flows.
	Severe	• Severe changes to flow regimes. • Increase in extreme events and longer dry periods between events lead to loss of income in agriculture and hardships in health, livelihoods and income. • Severe reduction in discharge or abstraction potential of Orange River flows.
	Extreme	• Extreme flow regime changes. • Increase in extreme events and extension of dry periods between events lead to irreversible, severe effects to income in agriculture and hardships in health, livelihoods and income for urban communities. • Extreme reduction in discharge or abstraction potential of Orange River flows.
Positive	Slight	• Perturbations to flow regimes would not impact ecosystem, agriculture and human demand. • No shortfall in Orange River discharge and access.
	Moderate	• Perturbations to flow regimes marginally improve supply to agriculture, ecosystems and human demand. Drainage systems remain intact and riparian system benefit. • Moderate improvement in discharge and abstraction potential of Orange River flows.
	Substantial	• Substantial improvement to flow regimes. • Lower extreme events and shorter dry periods result in substantial improvement to ecosystems, drainage crossings and access points. MAR increase. • Substantially improved discharge and abstraction potential in Orange River flows.
	Severe	• Severe improvements to flow regimes. • Decrease in extreme events and shorter dry periods between events lead to access of quaternary catchment water and improvement to agriculture productivity, health, livelihoods and income. • Severe increase in discharge and abstraction potential of Orange River flows.
	Extreme	• Extreme improvements in flow regimes. • Decrease in extreme events and reduction of dry periods between events lead to improvements to income in agriculture and, livelihoods and income for urban communities. Surface water storage become possible in quaternary catchments. • Extreme improvement in discharge and abstraction potential of Orange River flows satisfy all demands and provide excess for storage.

6.3 Potential Impacts

6.3.1 Impact identification

The Boegoebaai delimited area is classified as either arid or hyper-arid. Water scarcity for life and livelihoods is limited and is likely to become more so, without effective alternative water supplies. The potential impacts include:

- Limited water supply from the Orange River to increasing population due to inadequate system operation and maintenance, (current delivery is consistently below design yield), budget limits to expansion and lack of capacity to operate.
- Shortage of water to sustain life and livelihoods where areas change from arid to hyper-arid in future.

6.3.2 Mitigation Measures

Mitigation measures to water supply, particularly in the north-west of the delimited area will include:

- Appropriate estimation of future needs, design and implementation of new and augmented water supply schemes from the Orange River.
- Implementation of effective desalination plants for saline groundwater and seawater use.
- Effective capacity building and proper operation and maintenance of abstraction works reticulation and local water supply infrastructure.
- Prevention of pollution to the abstraction works, where Orange River water is drawn from riparian subsurface (to allow for abstraction of filtered Orange River yield).

6.3.3 Impact Assessment

Table 6.3 provides formal ratings of the above impacts, considering their application to areas of different surface water sensitivity (Very High to Low sensitivity, as defined in Section 4-5), for the Baseline Scenario (Sc0) and the two development scenarios (Sc1 and Sc2).

The ratings are carried out separately, with and without the recommended mitigation and management measures outlined above.

Table 3: Assessment of potential impacts on surface water resource availability, quality and security

Impact	Scenario	Spatial receiving environment or receptor	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Negative	S0: Baseline	Very High Sensitivity	Severe	More likely	Very High	Substantial	Less Likely	Moderate
	S1: Small GH2		Extreme	Likely	Very High	Substantial	Less Likely	Moderate
	S2: Big GH2		Extreme	Likely	Very High	Substantial	Less Likely	Moderate
	S0: Baseline	High Sensitivity	Substantial	More likely	High	Moderate	Unlikely	Low
	S1: Small GH2		Severe	Likely	High	Moderate	Unlikely	Low
	S2: Big GH2		Severe	Likely	High	Moderate	Unlikely	Low
	S0: Baseline	Medium Sensitivity	Moderate	More likely	Moderate	Moderate	Unlikely	Low
	S1: Small GH2		Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S2: Big GH2		Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S0: Baseline	Low Sensitivity	Slight	Likely	Low	Slight	Unlikely	Very Low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Unlikely	Very Low
	S2: Big GH2		Moderate	Unlikely	Low	Slight	Unlikely	Very Low

7: Recommended Strategic Management Actions

The following strategic management actions are recommended:

- Provide for Orange River abstractions and reticulation to the level of Scenario 1 demand. Provide for adequate maintenance of the abstraction, treatment, reticulation and storage works.
- Provide for protection of abstraction works and reticulation pipelines.
- Provide for expertise to operate desalination plants at proposed coastal locations.
- Prevent all disturbances to river systems and floodplains, particularly at infrastructure crossings. Prevent any encroachment of structures or dwellings into the floodplain.
- Assign protective measures to quaternary catchments with high sensitivity with regard to aridity and density of small farm dams.

8: Data accessed for the Water Resources Chapter

The surface water assessment drew on the following datasets:

- Catchment runoff, dry periods and meteorological data (Current and Near Future) extracted and interpreted from databases of Schütte et al., 2023, WRC Report 2833/1/22.
- Mean Annual Runoff, Precipitation and Evaporation from WR2012, (Herold and Bailey, 2016) used for comparative purposes.
- Daily runoff record for the Buffels river derived from published figure in Benito et al., 2011.
- Orange River abstractions, current and future water demands lifted from DWS 2012, DWS 2023, BVI 2023a and BVI 2023b.
- Farm dam density distribution lifted from Mantel and Hughes, 2023.
- Aridity definition and limits lifted from Gunkel and Lange, 2017.

9: References

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Prepared by

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Simon Lorentz

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Kivana Singh

Hydrologist

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

Appendices

Appendix A: Meteorological Trends

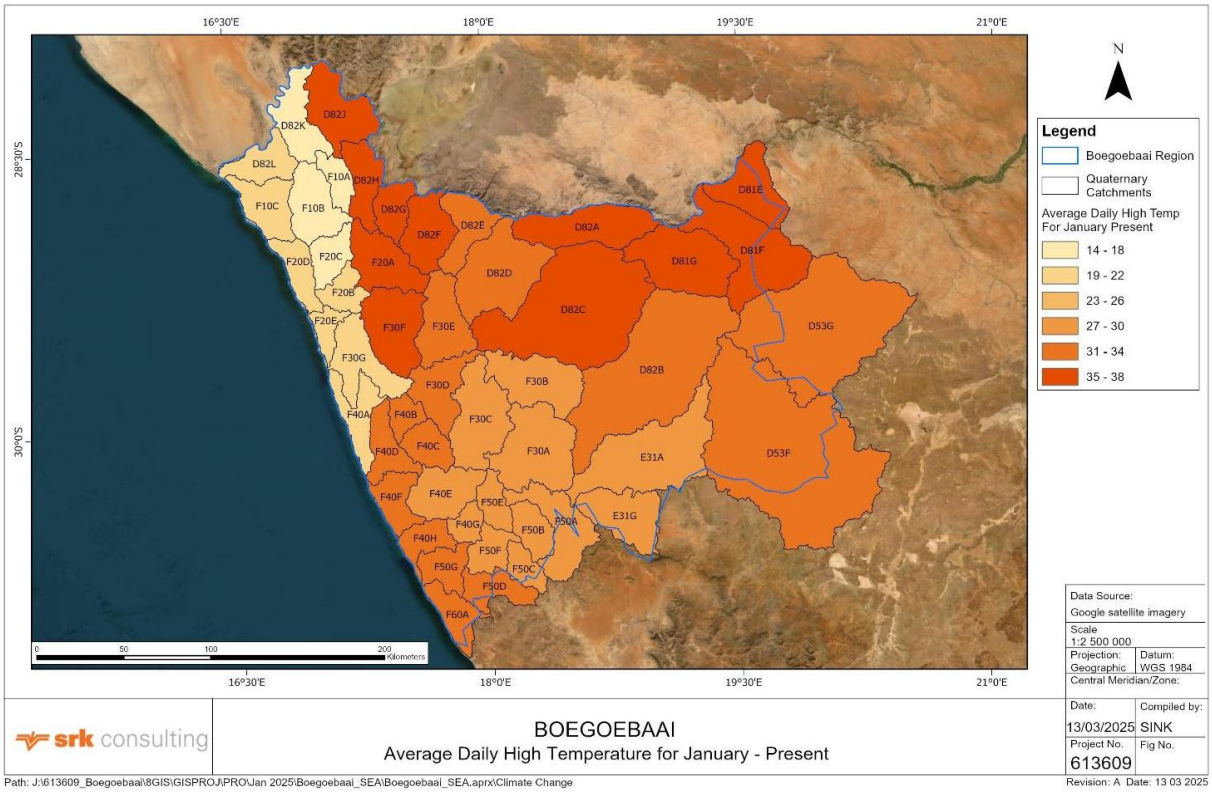

Figure A-1: Average Daily High Temperature for January – Present (from Schutte *et al*., 2023)

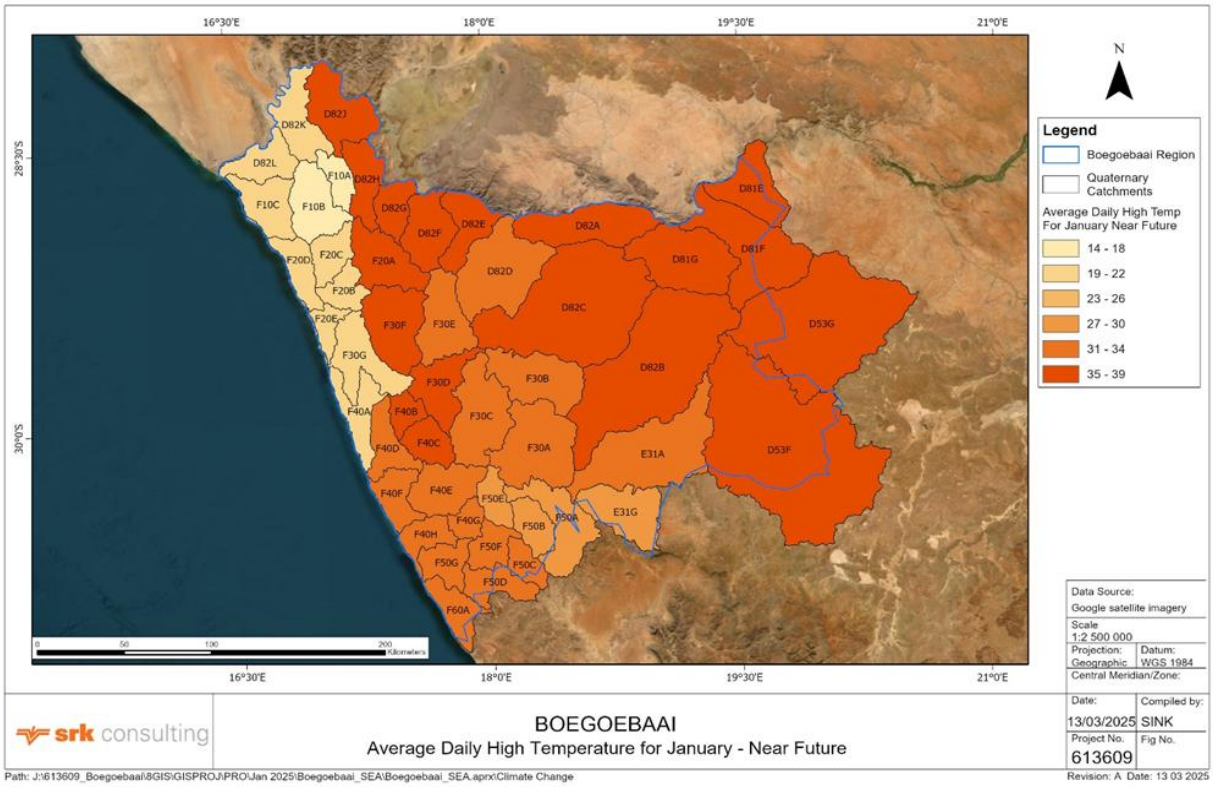

Figure A-2: Average Daily High Temperature for January – Near-Future (from Schutte *et al*., 2023)

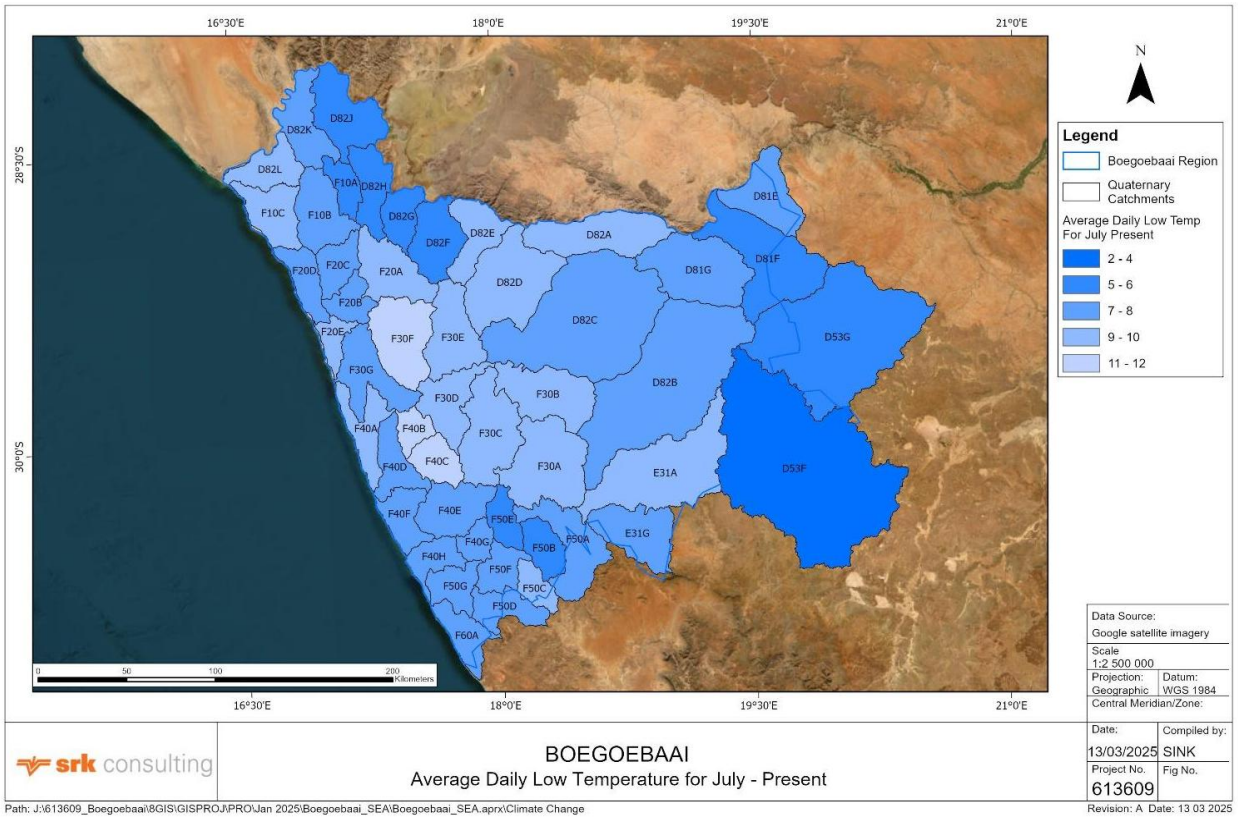

Figure A-3: Average Daily Low Temperature for July – Present (from Schutte *et al*., 2023)

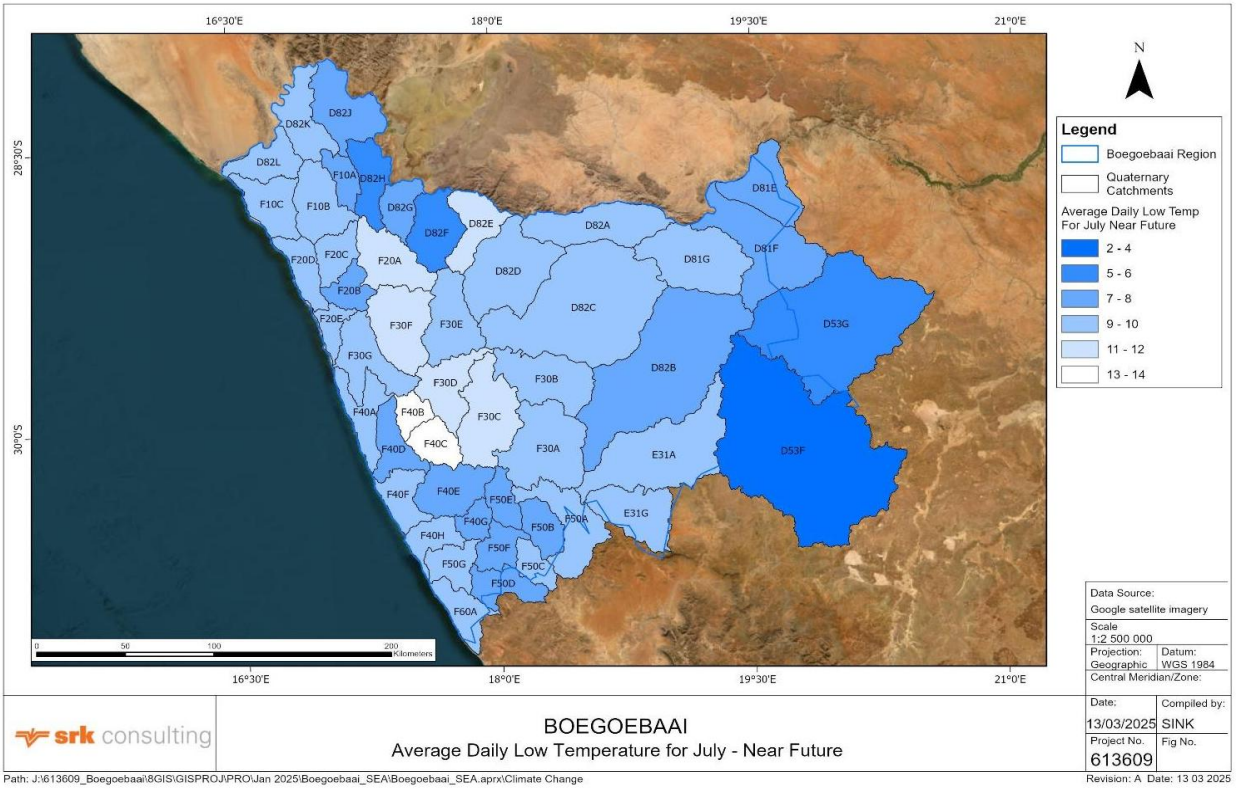

Figure A-4: Average Daily Low Temperature for July – Near Future (from Schutte et al., 2023)

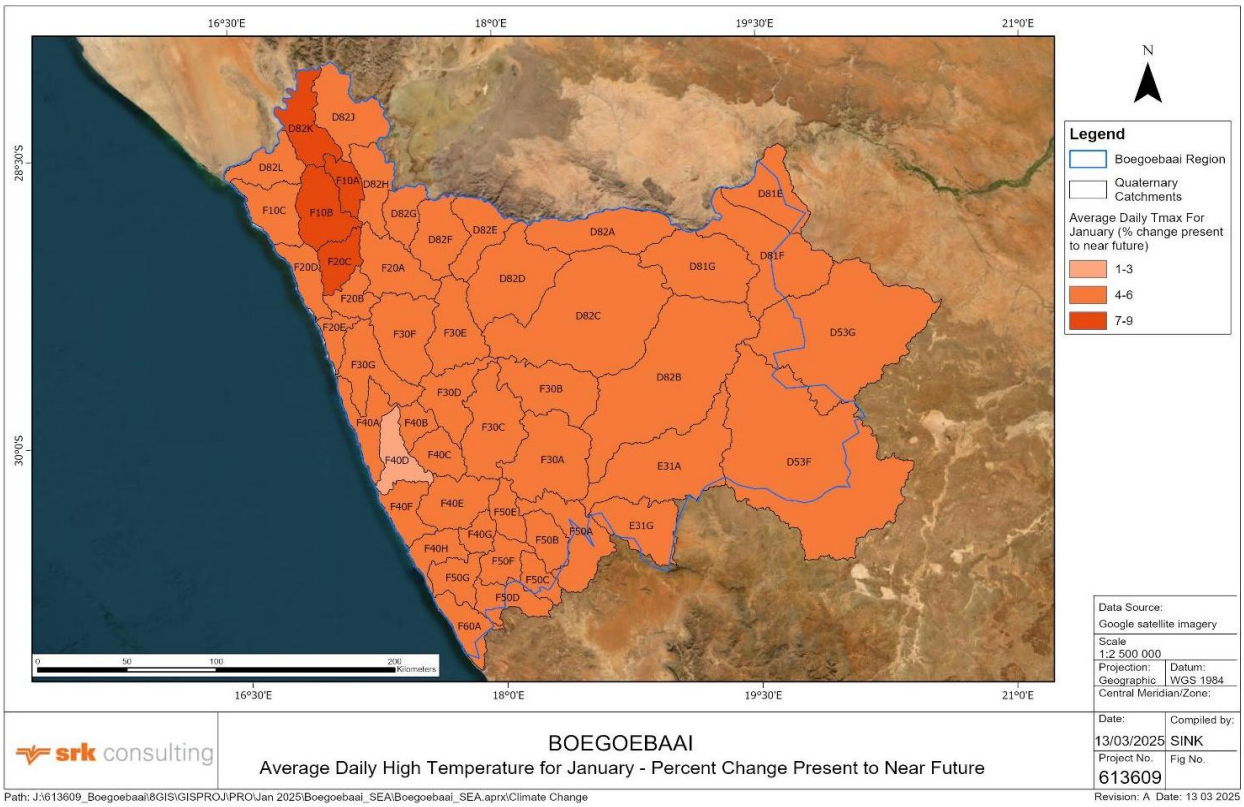

Figure A-5: Average January Daily High Temperature – % Change from Present to Near Future

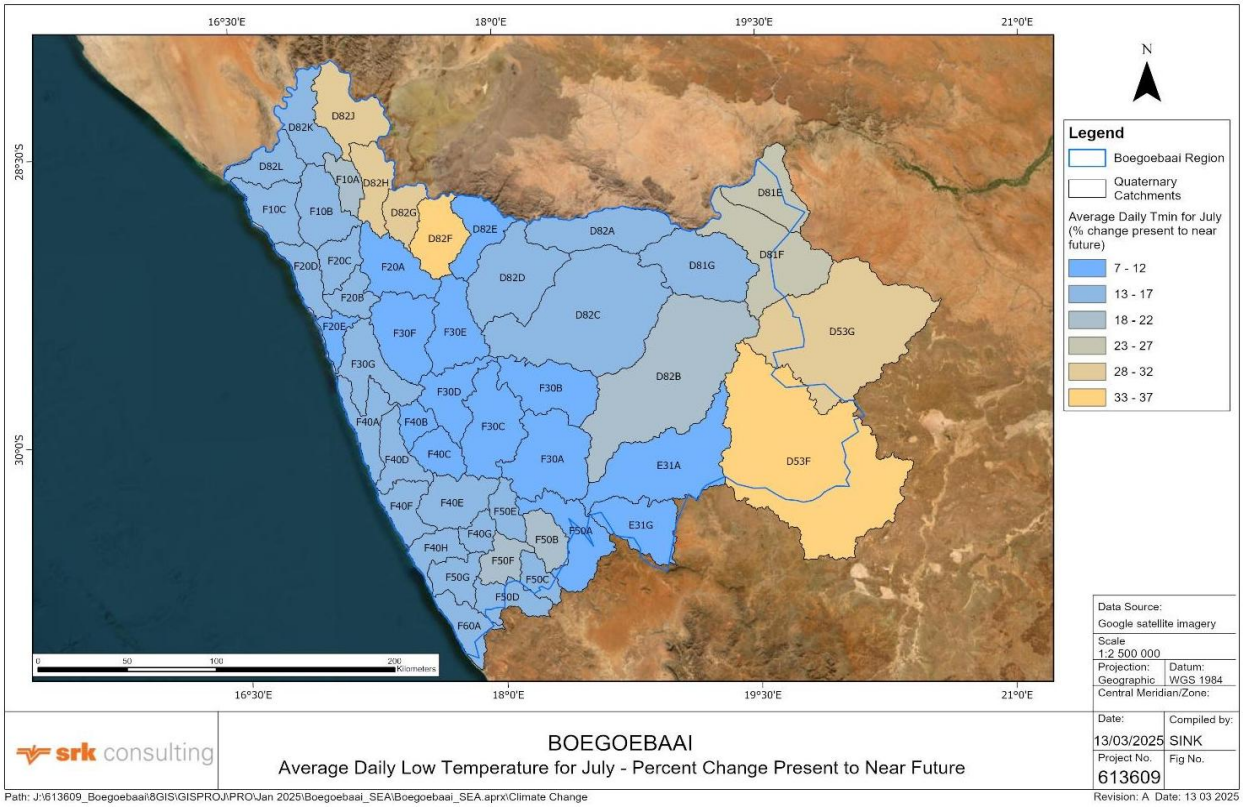

Figure A-6: Average July Daily Low Temperature – % Change from Present to Near Future

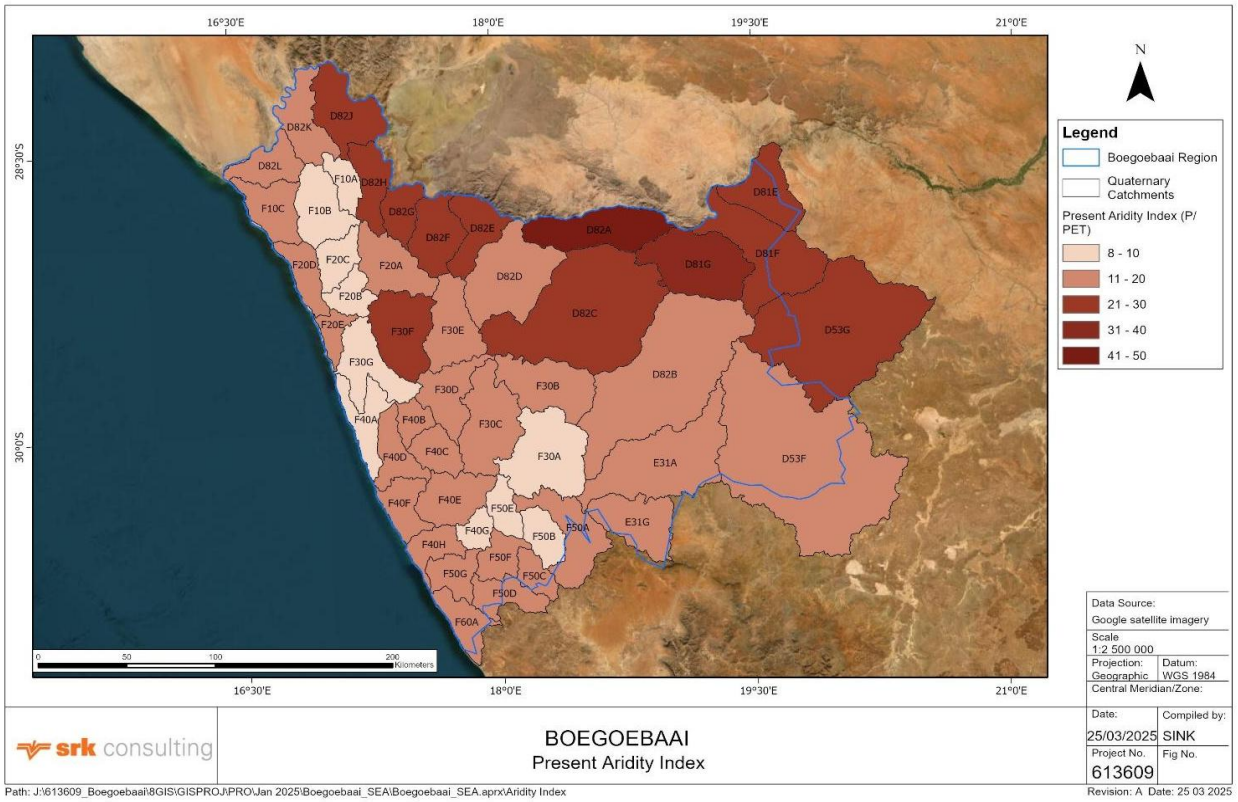

Figure A-7: Distribution of Aridity Index: Present Climate (Average of 6 GCMs).

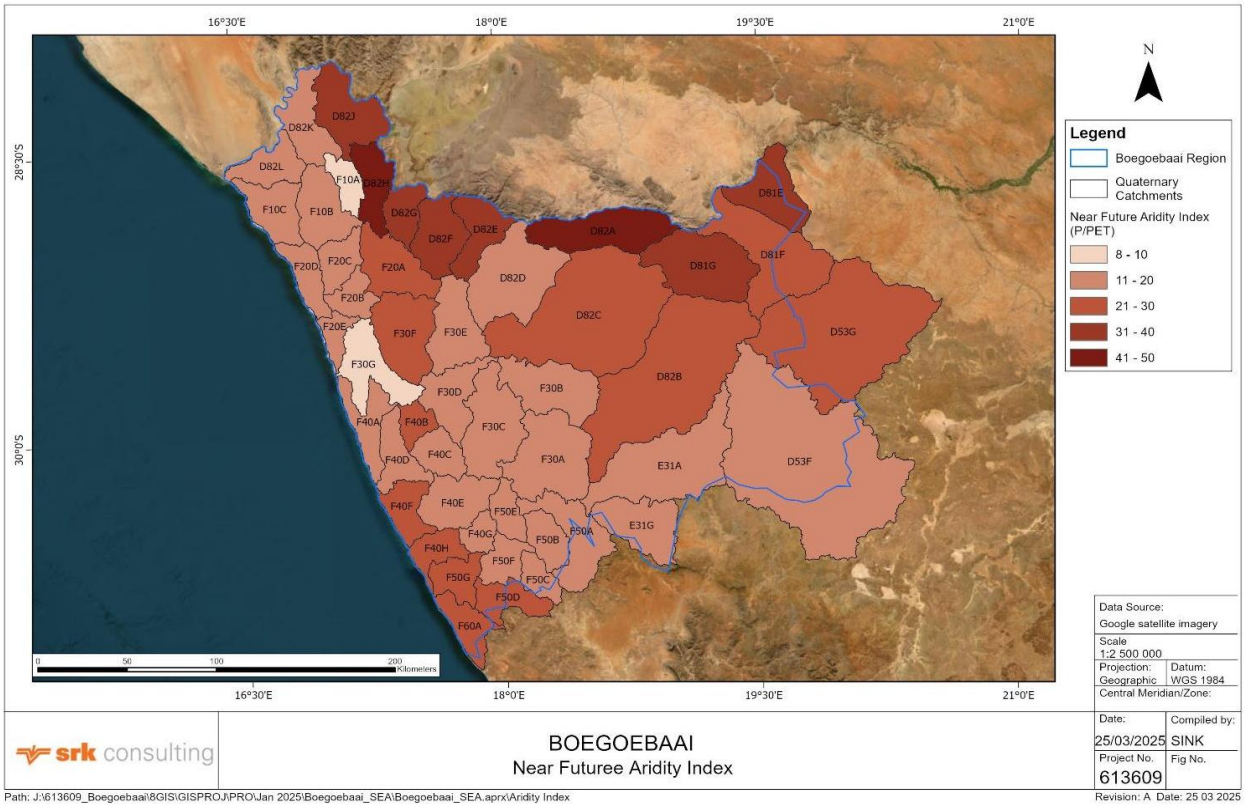

Figure A-8: Distribution of Aridity Index: Near Future Climate (Average of 6 GCMs).

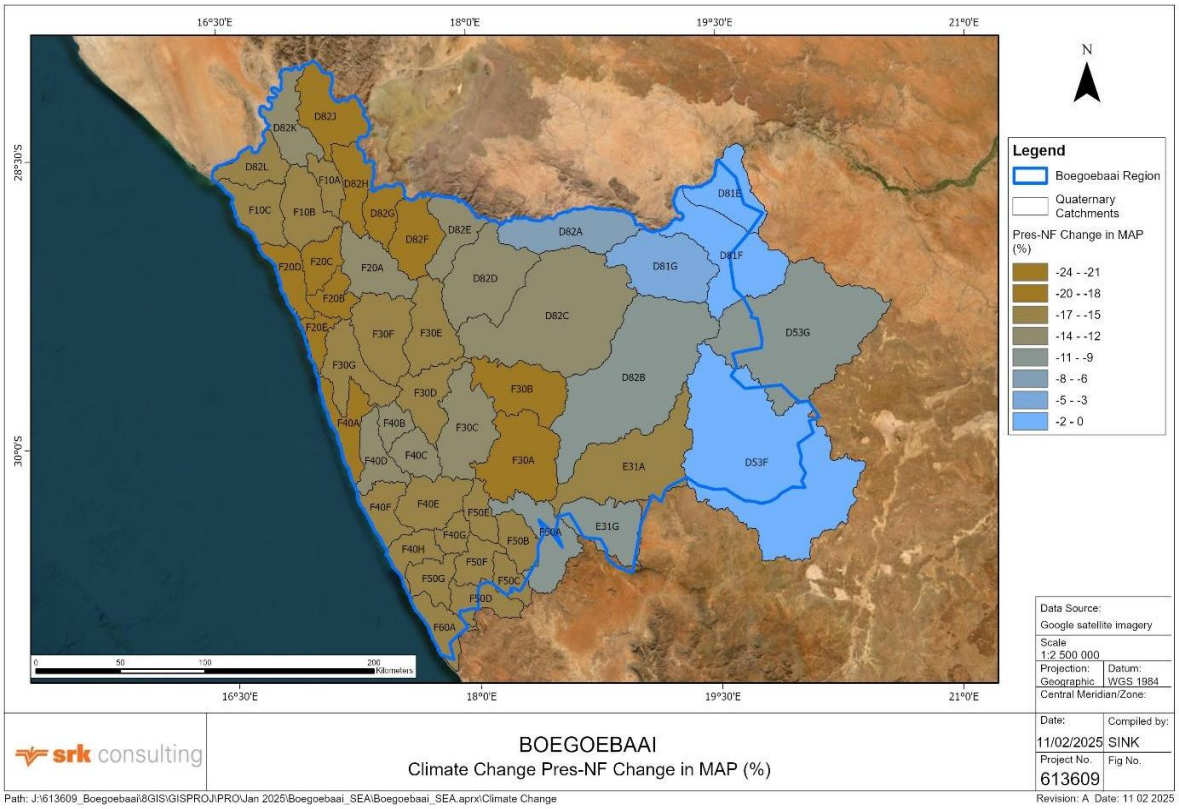

Figure A-9: Estimated % Change in MAP for Near Future (Average of 6 GCMs, Extracted from Schütte, et al., 2023)

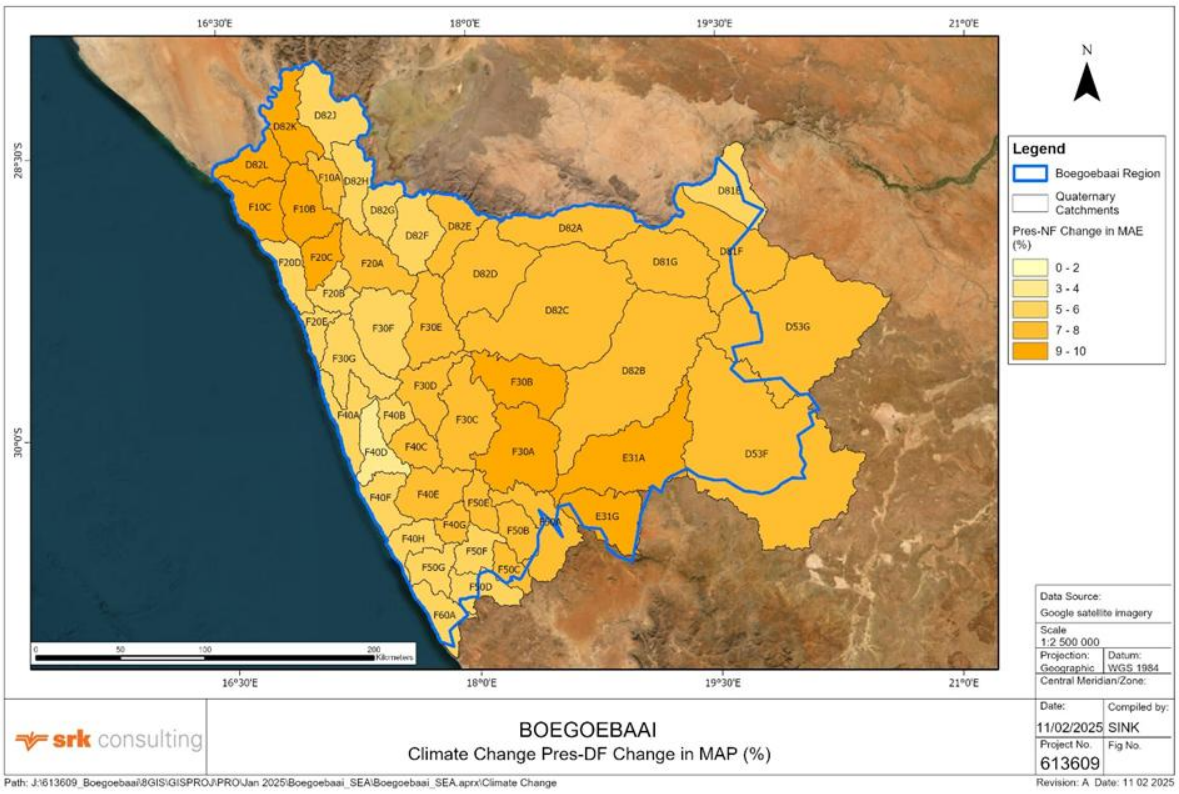

Figure A-10: Estimated % Change in MAPE for Near-Future (average of 6 GCMs, Extracted from Schütte, et al., 2023)

Appendix B: Quaternary Catchment Runoff

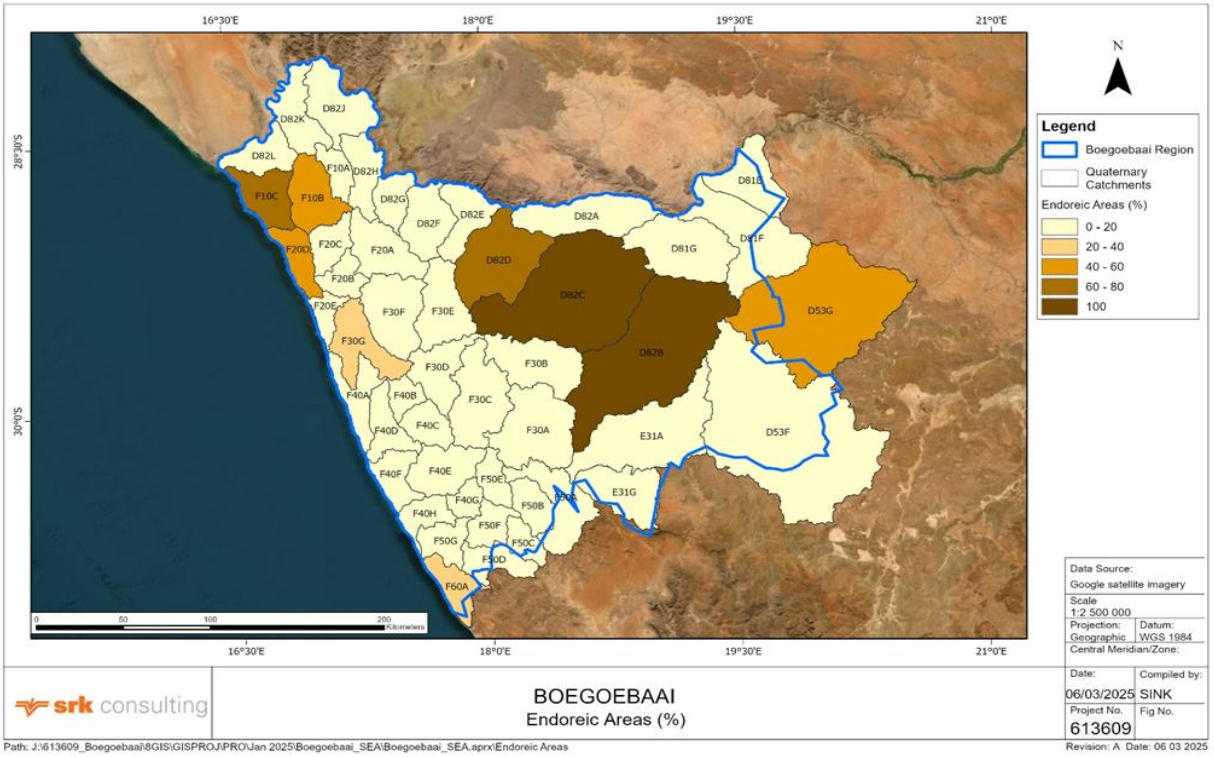

Figure B-1: Distribution of endoreic areas (WR2012)

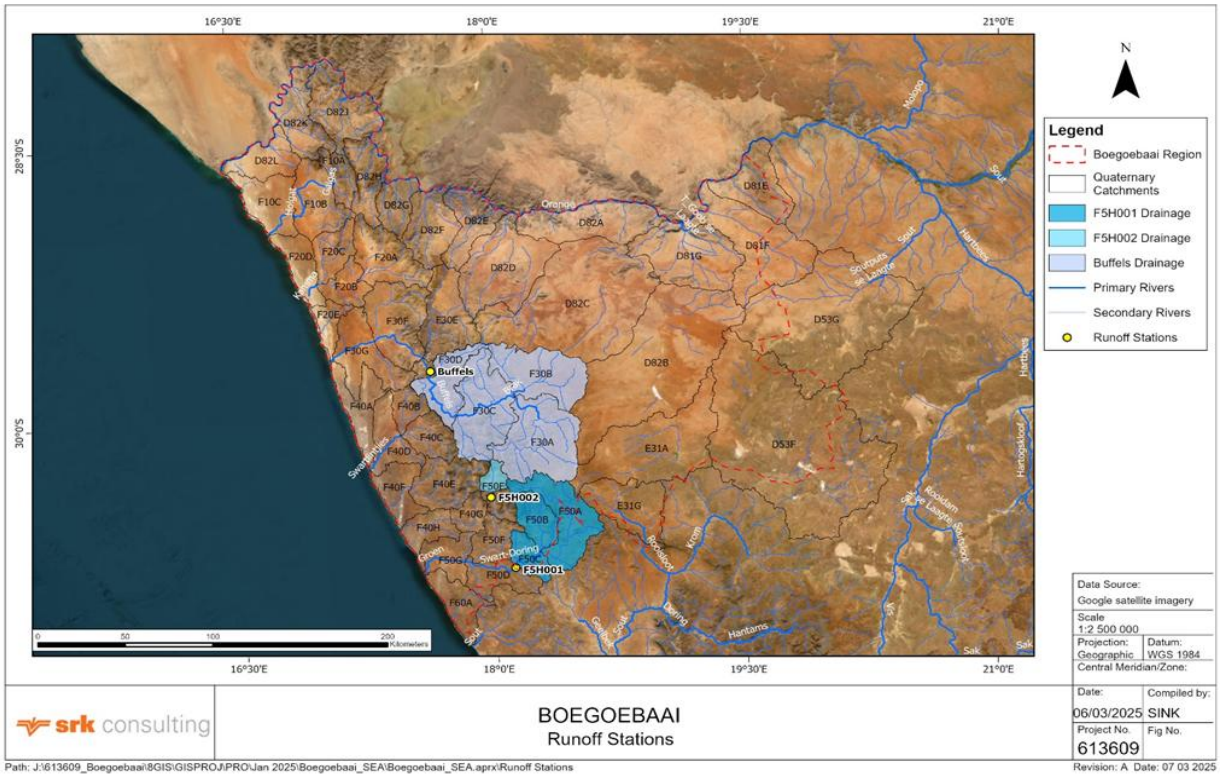

Figure B-2: Location of River Monitoring Stations (DWS and Benito et al., 2011)

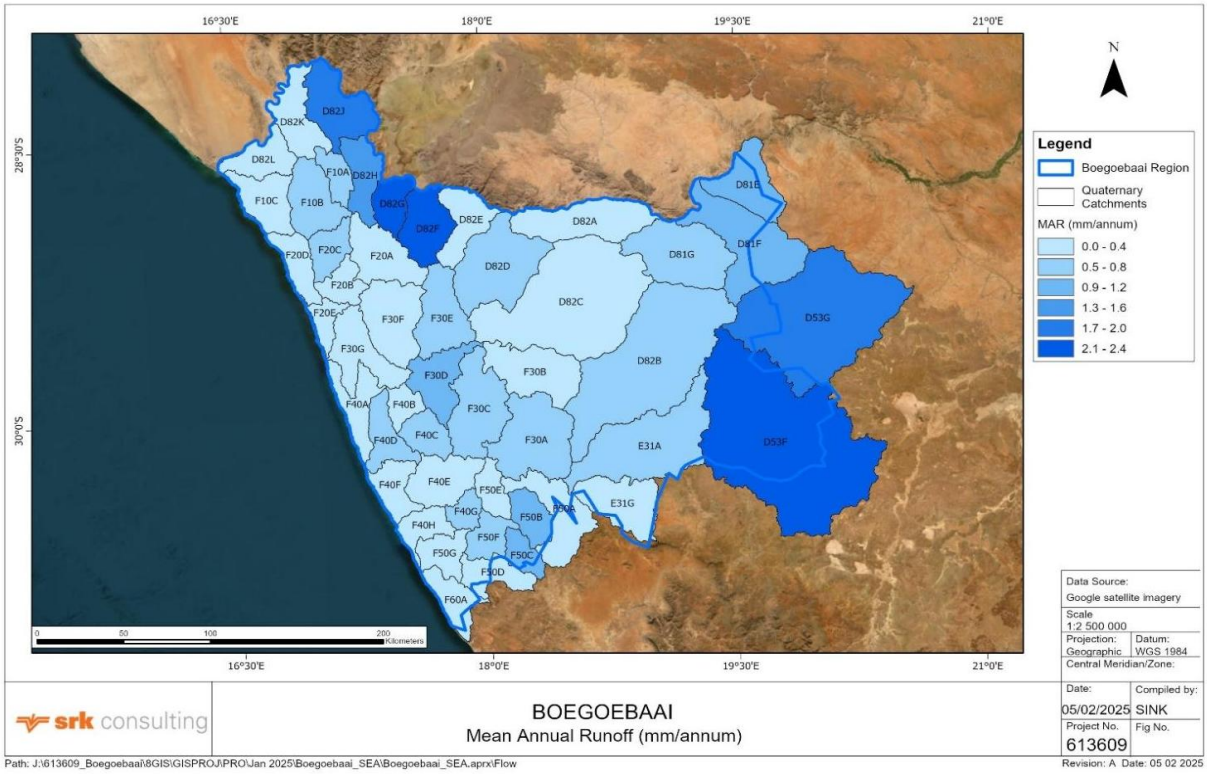

Figure B-3: Distribution of Mean Annual Runoff, MAR (mm/annum), in the study area.

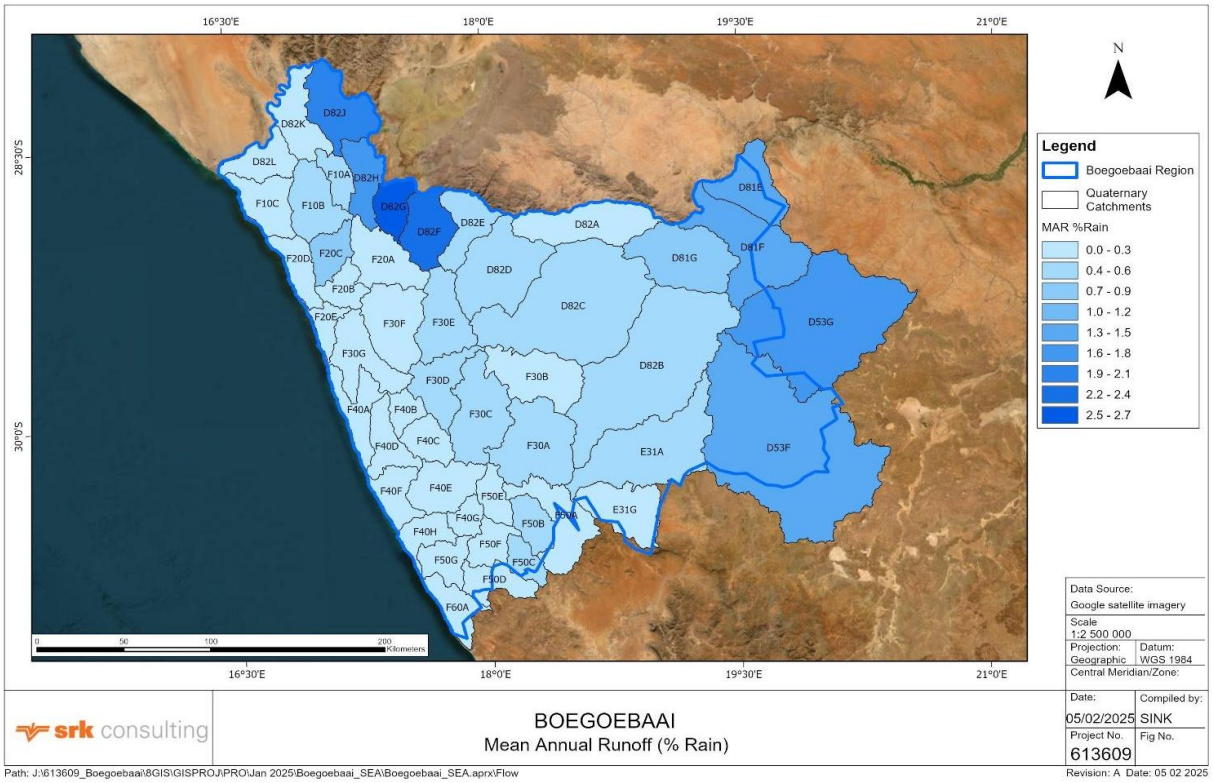

Figure B-4: Distribution of the Quaternary MARs as a percent of rainfall.

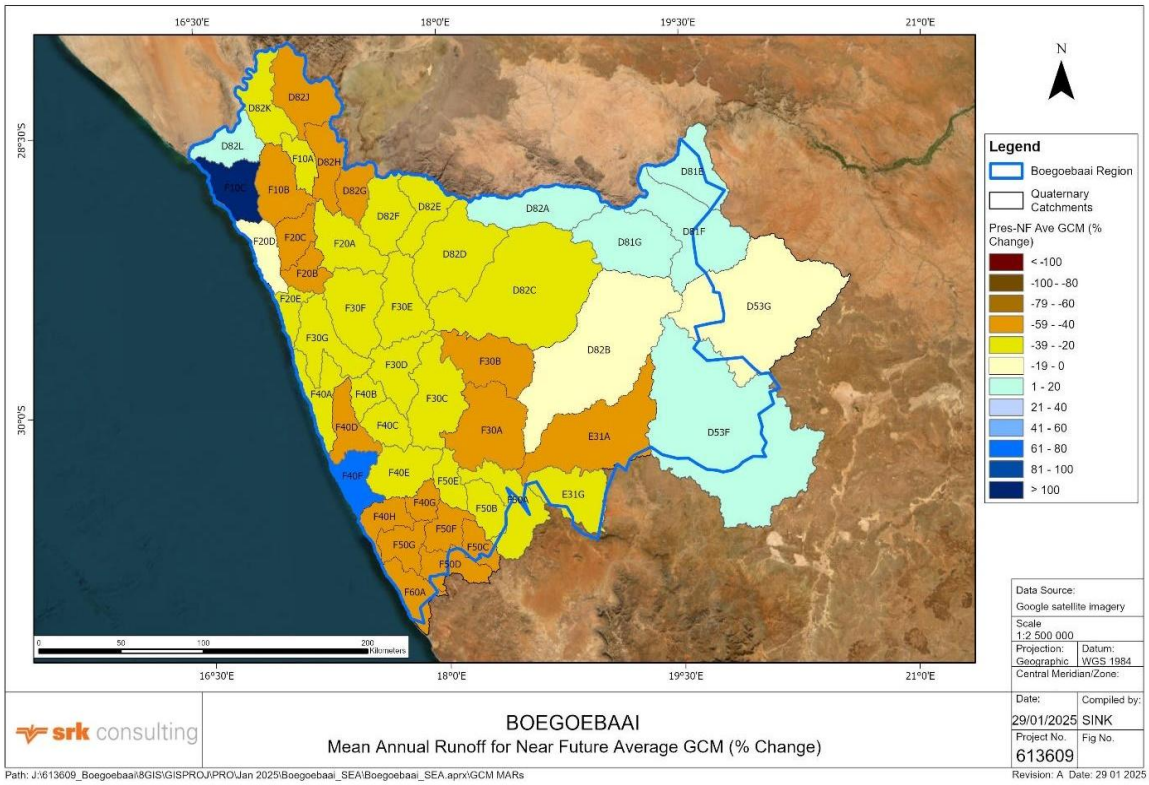

Figure B-5: Percent Change in Near Future Mean Annual Runoff (average of 6 GCMs)

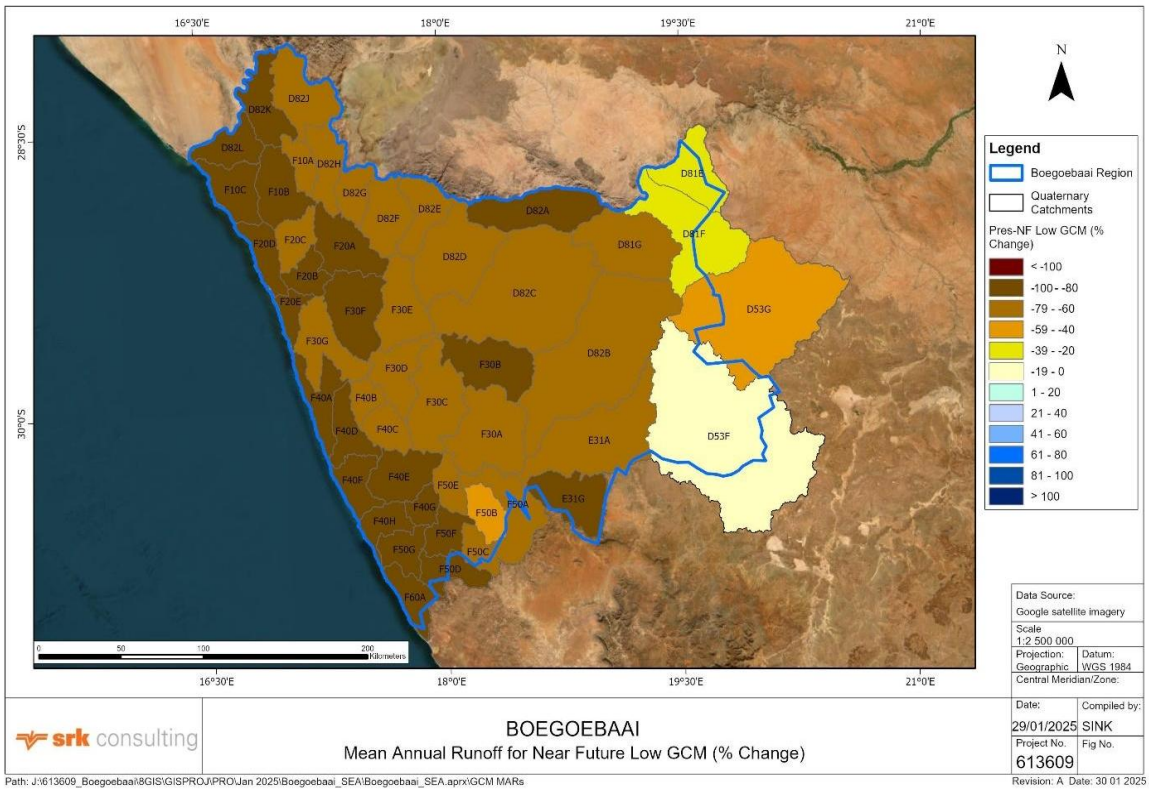

Figure B 6: Percent Change in Near Future Mean Annual Runoff (lowest of 6 GCMs)

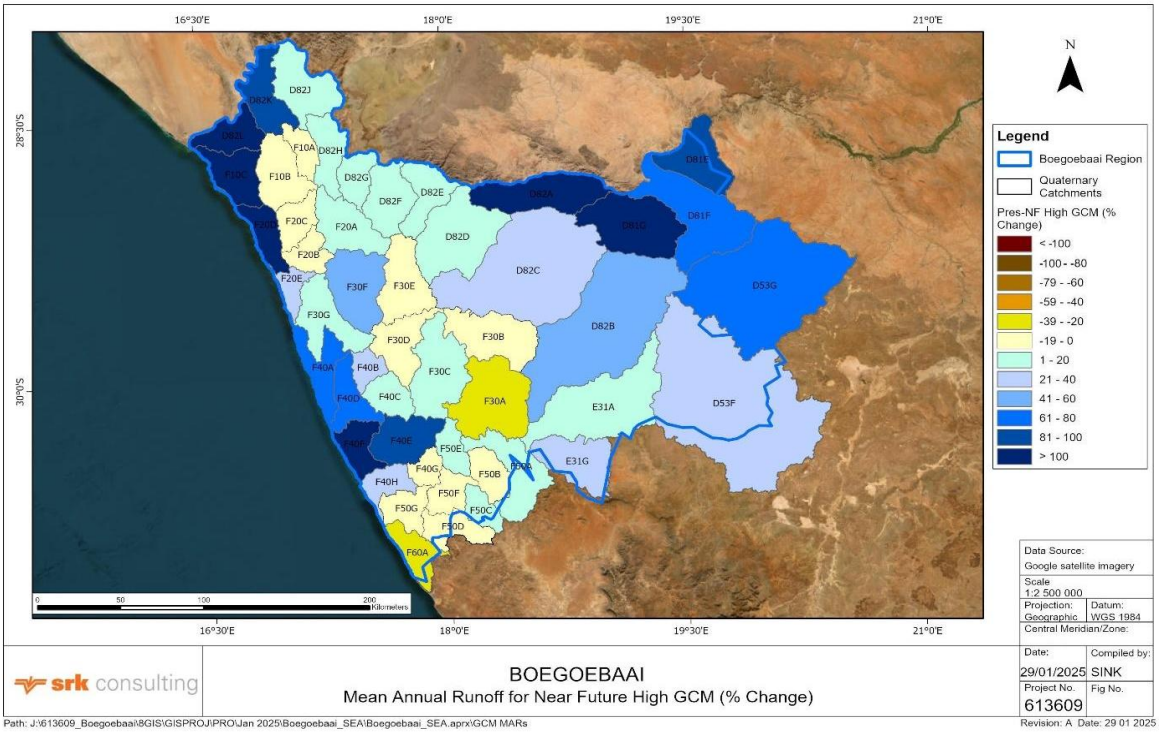

Figure B-7: Percent Change in Near Future Mean Annual Runoff (highest of 6 GCMs)

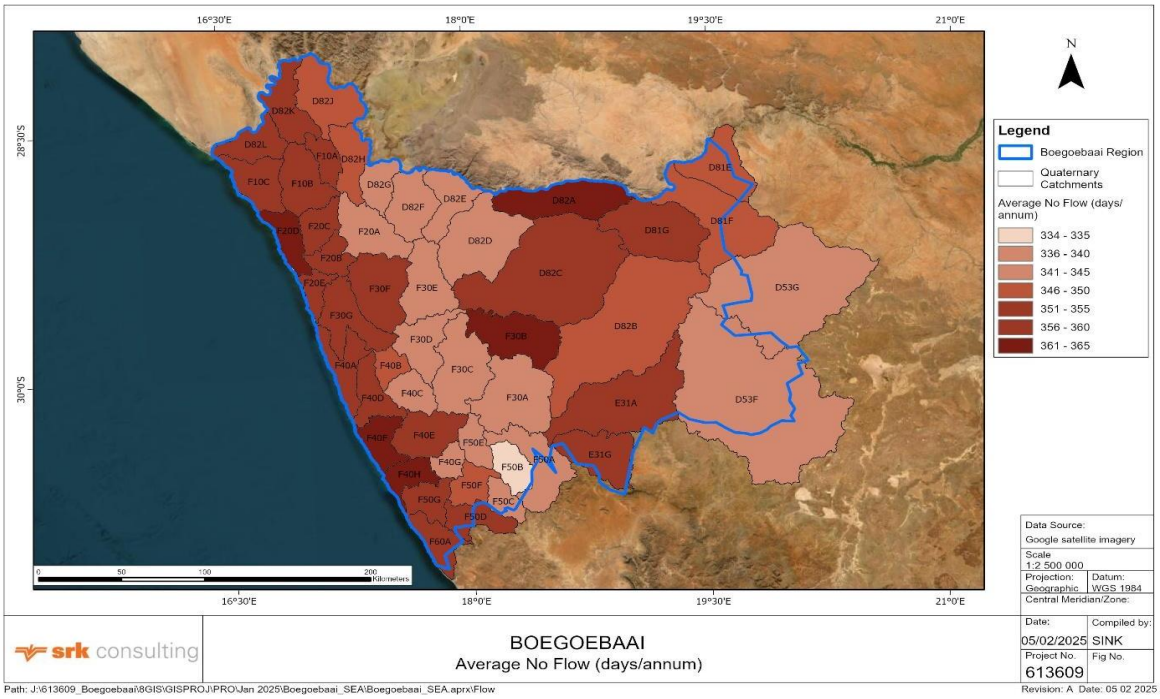

Figure B 8: Distribution of Average Days of No-Flow (extracted from Schütte, et al., 2023)

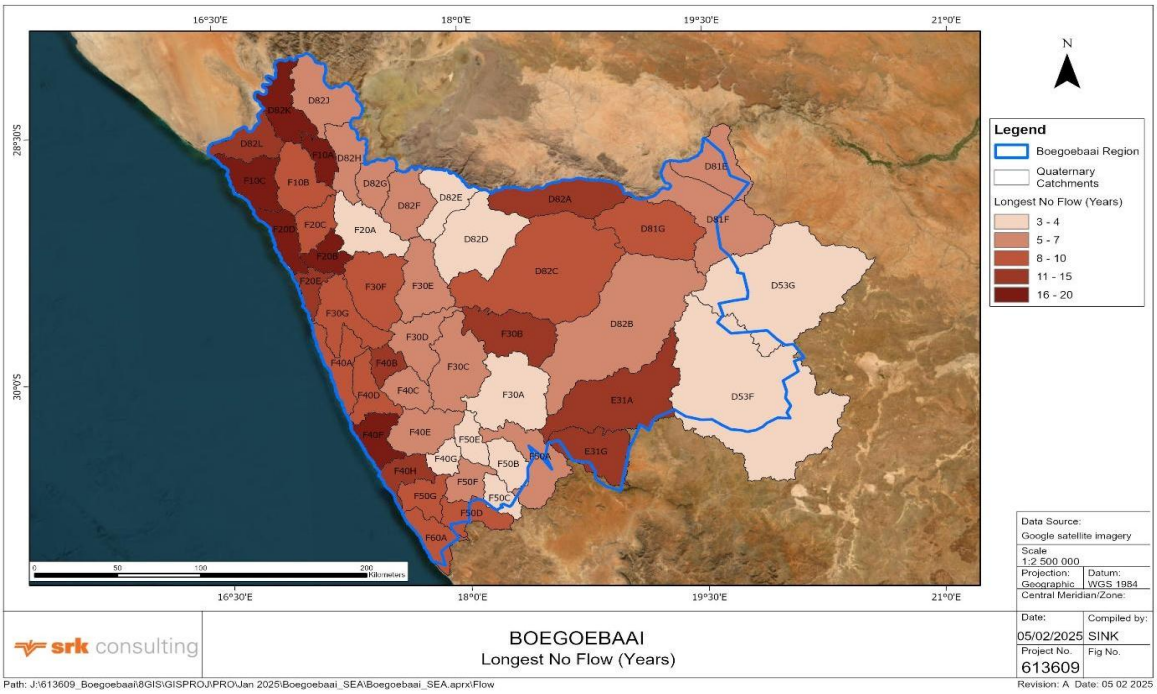

Figure B-9: Distribution of Maximum Period of No-Flow (from Schütte, et al., 2023)

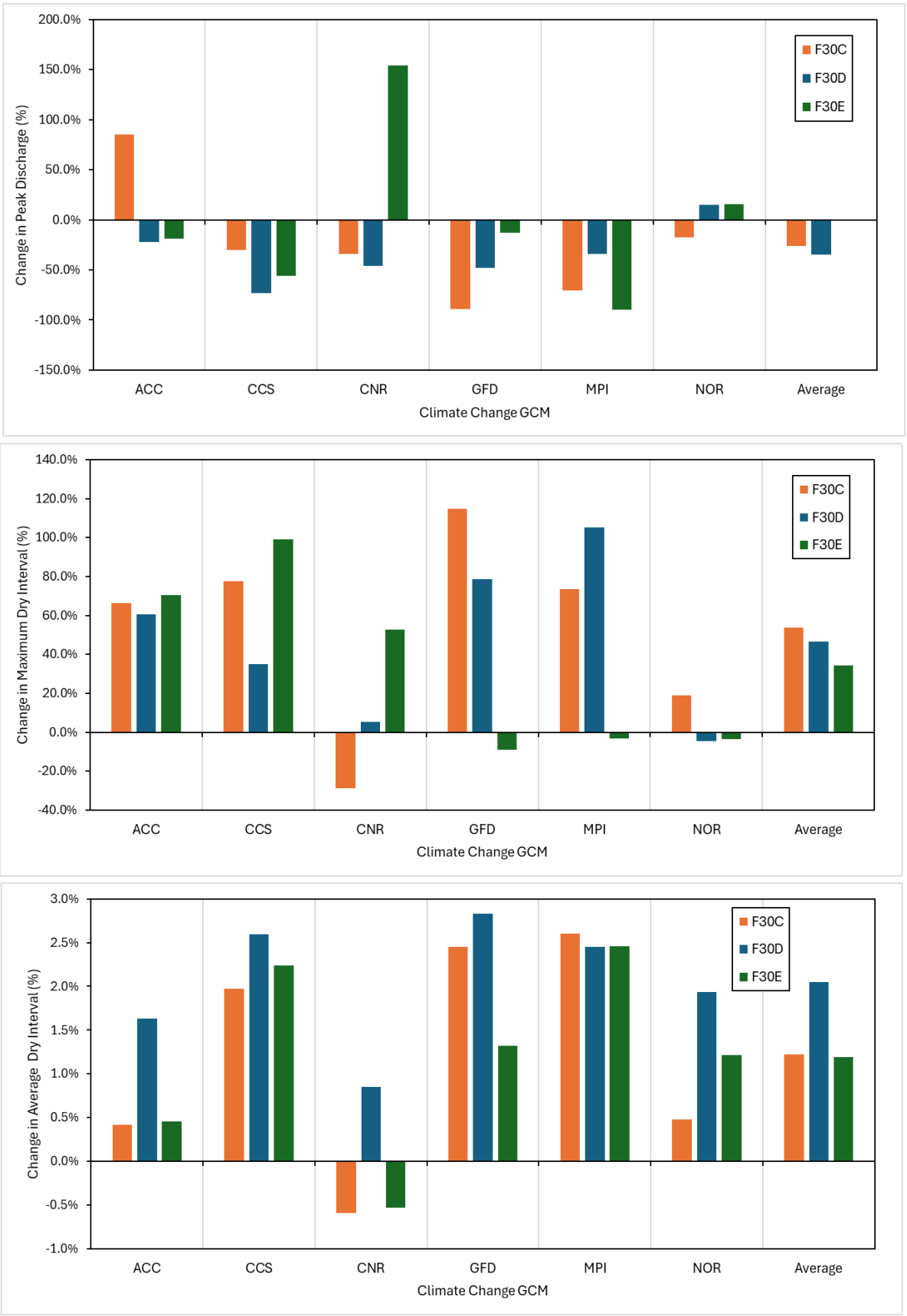

Figure B-10: Percent Change in Peak Discharge and Dry Periods for Quaternaries F30C, F30D and F30E (6 GCMs, Schutte et al., 2023)

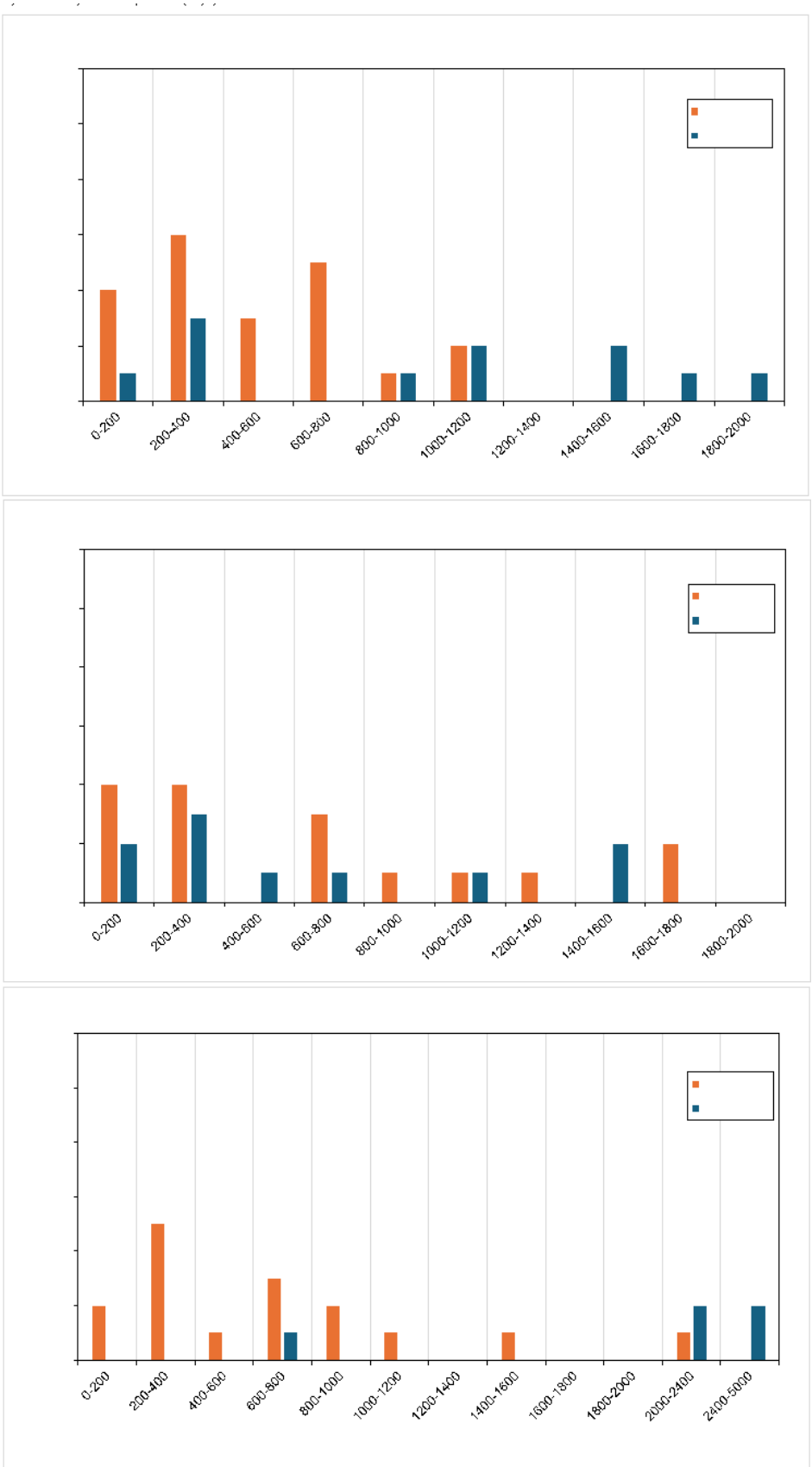

Figure B-11: Dry period changes from Present to Near Future Climate F30C (3 GCMs)

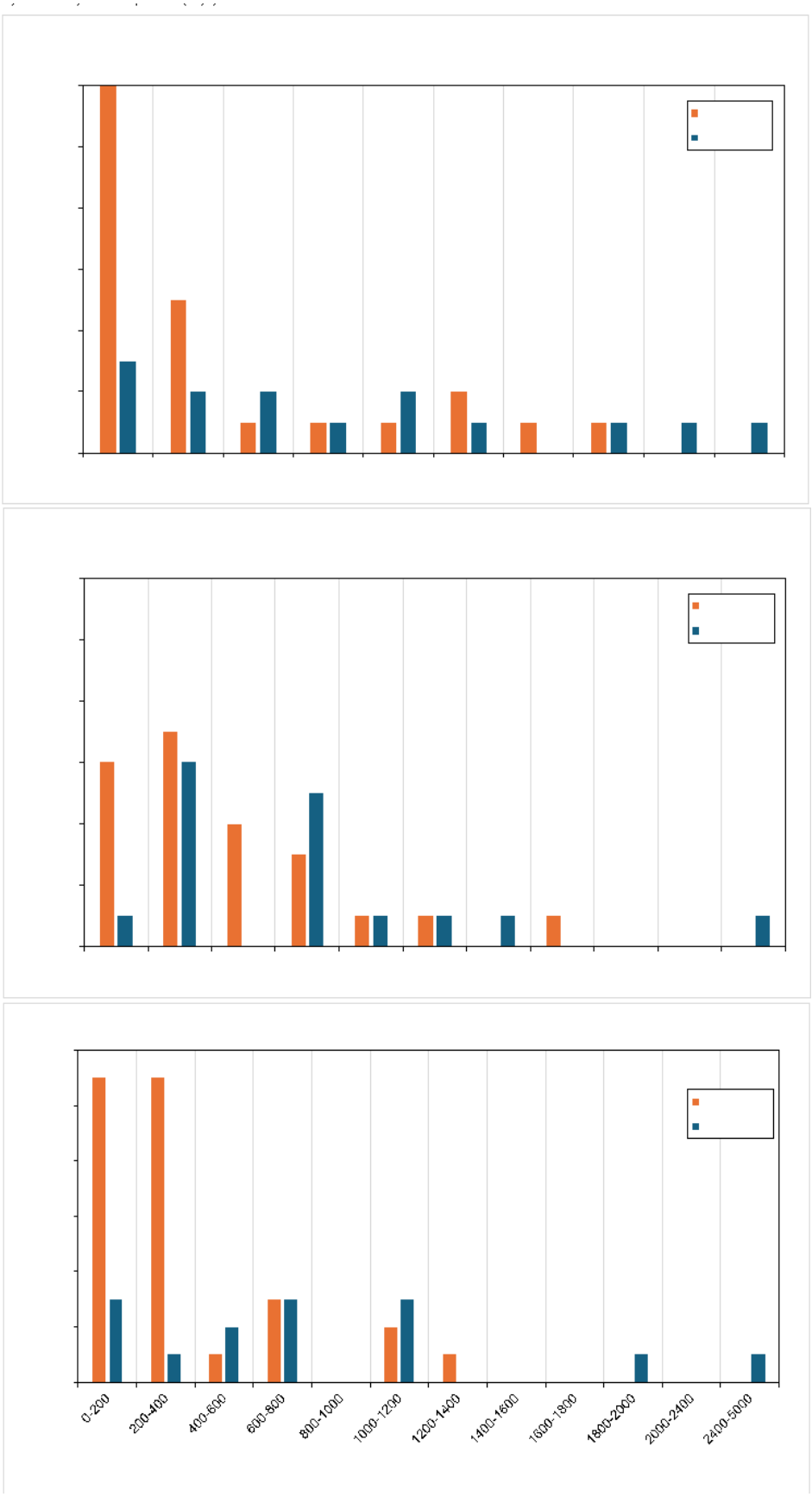

Figure B-12: Dry period changes from Present to Near Future Climate F30D (3 GCMs)

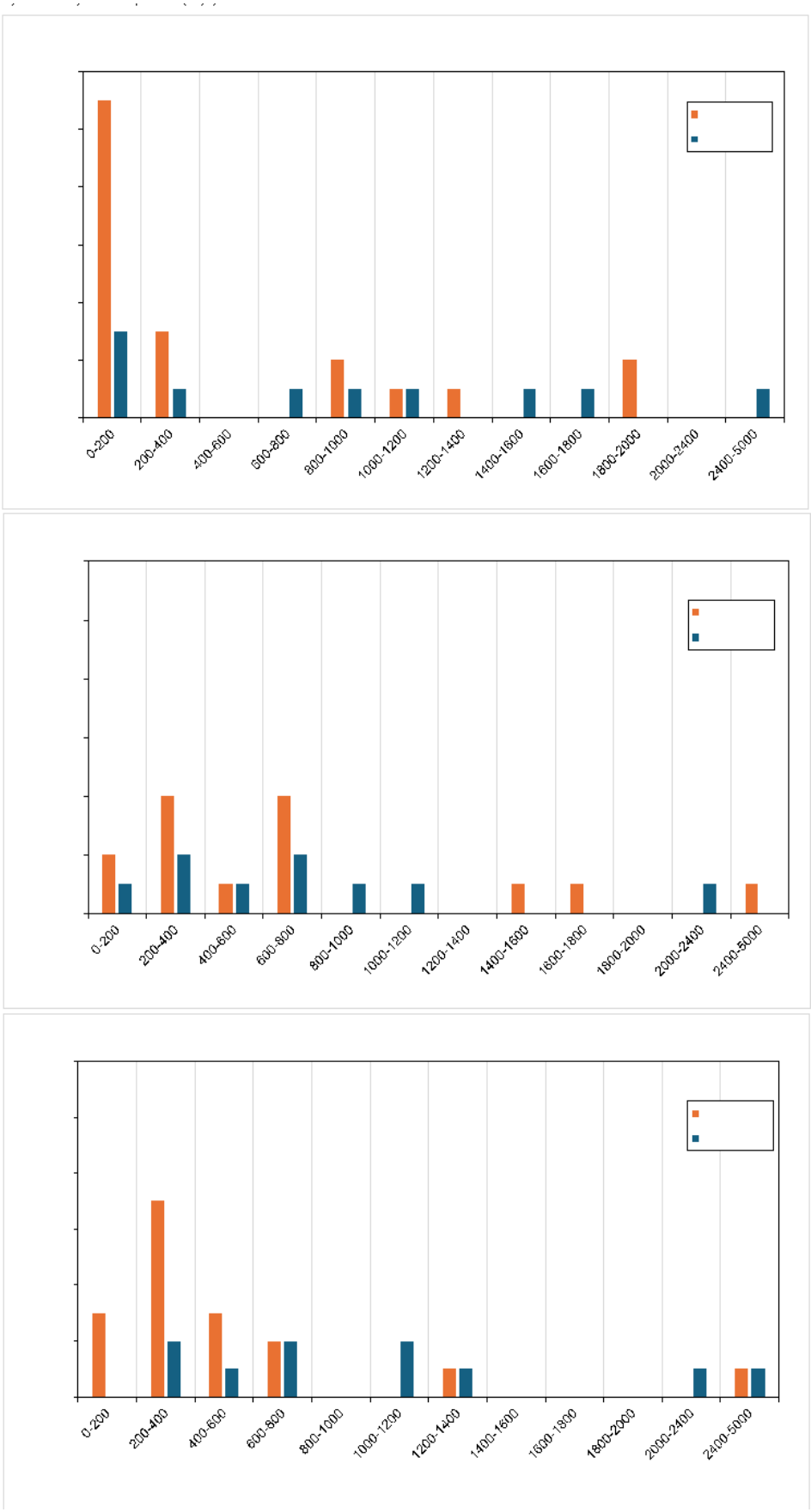

Figure B-13: Dry period changes from Present to Near Future Climate F30E (3 GCMs)

Appendix C: Orange River Yield

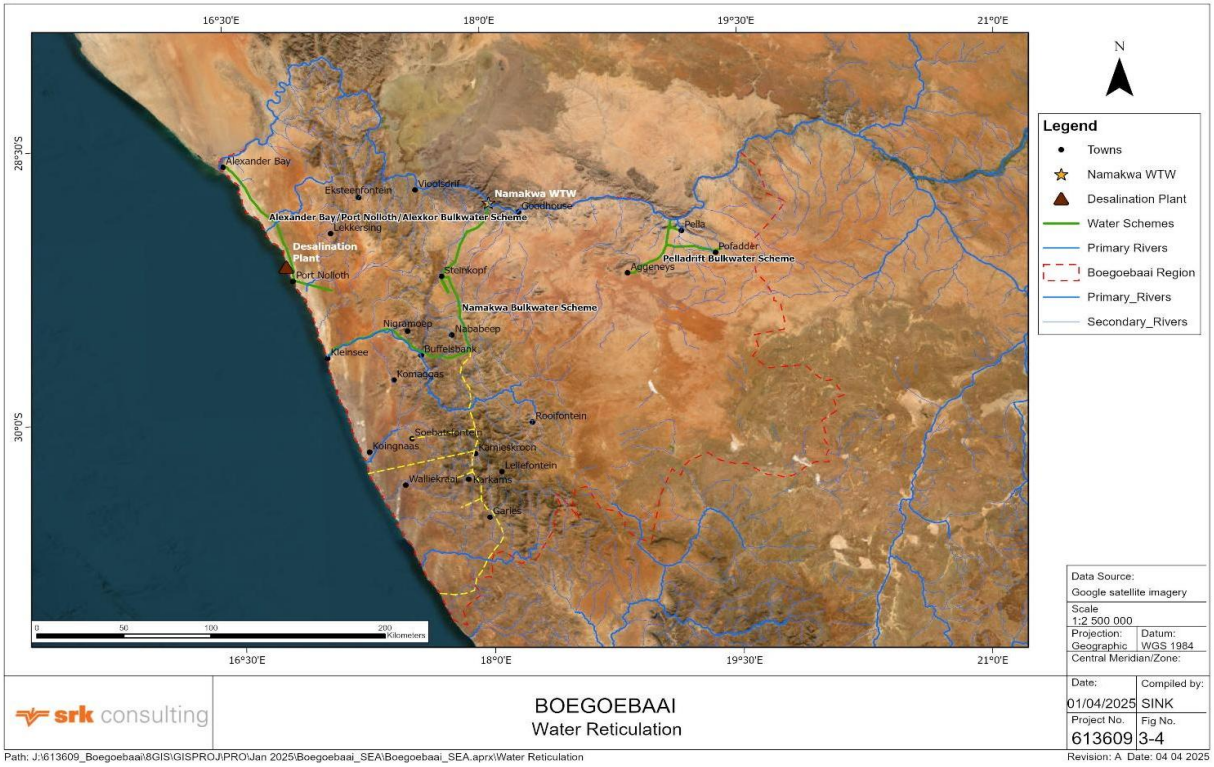

Figure C-1: Orange River Water Supply Reticulation

CHAPTER 5

Heritage Resources

CHAPTER 5: Heritage Resources

Integrating Authors:	Jayson Orton[1], Lita Webley[2], John Pether[3], Vanessa Maitland[4]

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[3] Independent Geological and Palaeontologist Consultant

[4] Independent Maritime Archaeologist

Name	Role	Experience
Jayson Orton	- Team leader - Lead author - Specialist author: archaeology	Extensive experience in Namaqualand archaeology
Lita Webley	- Lead author - Specialist author: archaeology - Specialist author: living heritage	Extensive experience in Namaqualand and has also worked on recent pastoralist history
John Pether	- Specialist author: palaeontology	Palaeontologist specialising in West Coast coastal sediments
Vanessa Maitland	- Specialist author: maritime heritage	Maritime archaeologist to deal with shipwrecks

Recommended citation: Orton, J., Webley, L., Pether, J. & Maitland, V. (2026). *Chapter 5: Heritage resources* in Schreiner, G., Mqokeli, B., Snyman-van der Walt, L., Lochner, P. & Tsedu, R. (eds.). (2026). *Work Package 2: Strategic Environmental Assessment for the Proposed Boegoebaai Port, Special Economic Zone and Namakwa Region*. CSIR/SPLS/Ems/EXP/2026/0001/A, CSIR: Pretoria: ISBN 978-0-7988-5676-8. Available at Boegoebaai Port | CSIR

Executive Summary

This review considers the nature and distribution of various heritage resources within the Namakwa Region SEA study area. It determines the cumulative impacts of the proposed regional Green Hydrogen economy on the heritage of the area in view of a dynamic baseline scenario.

Baseline Scenario (Sc0)

Palaeontology

Most of the study area is of zero or low palaeontological sensitivity. However, some areas of moderate sensitivity occur in the east and areas of high sensitivity occur in the mountains northwest of Springbok and in the southeastern part of the study area. The surficial sands of the coastal plan are rated as low sensitivity but are underlain by marine formations of high sensitivity below about 100 m above sea level (Figure S-1a).

Terrestrial Archaeology

- Early Stone Age (ESA) finds occur on the coastal plain, generally beneath the surface aeolian sands, and also among the gravels of Bushmanland.
- Middle Stone Age (MSA) finds are more commonly identified along the current coastline and particularly in the Bushmanland gravels.
- Later Stone Age (LSA) sites are abundant. The coastline is most sensitive because of the high density of sites there (Figure S-1a), but inland they occur far more sporadically in deflation hollows in dunefields, and around rocky hills and pans in Bushmanland. Rock shelters with stratified deposits are extremely rare.
- Rock paintings are generally rare but occur in a few locations. Geometric rock engravings are found along the Orange River. Engravings are not known from the remainder of the study area but may be found in the southeast where dolerite occurs.
- Historical archaeological remains are frequently found around old farmhouses and other places of permanent or temporary settlement. Historical remains are also found in the copper mining areas and at prospecting locations. Historical remains relating to the Anglo-Boer War are also known.

Graves

- Pre-colonial graves could be found throughout the study area, but particularly in coastal dunes. Most are not marked at the surface and cannot be identified until disturbed. Occasionally graves with stone-packed mounds are found. These are likely to be very late/historical graves. In addition to archaeological graves, all villages and towns, as well as farms, have local cemeteries which are usually marked and can be avoided during development. It is not feasible to try and map these.

Maritime Heritage

- Shipwrecks are recorded along the Namaqualand coastline, but location data are often poor. Only a few small areas that feature more prominently in shipwreck databases are of potential concern (Figure S-1a).

Living Heritage

- The **Richtersveld Cultural and Botanical Landscape World Heritage Site (RCBL WHS)** reflects the long-standing and persistent traditions of the indigenous Nama community including the transhumance lifestyle of the pastoralists. The Richtersveld, Leliefontein, Steinkopf, Komaggas, Concordia and Pella communal areas (Figures S-1a & S-1b) remain in use for seasonal grazing with herders still staying in stockposts.

Cultural Landscape

- The area has four distinct components, namely the coastline, coastal plain, the granite mountains of the Kamiesberg and the inland plain of Bushmanland which includes many smaller mountains. The landscape is arid and desolate and has great aesthetic value.
- The **RCBL WHS** and buffer zone (see Living Heritage above), and the Richtersveld and Namaqualand National Parks protect iconic sections of South Africa's semi-arid landscapes (Figures S-1a & S-1b).
- "The Namaqualand Copper Mining Landscape" is a part of the regional cultural landscape.
- Gamsberg has been identified as a place of "genocide of the San people".
- The N7, N14 and R382 are identified as scenic routes while Wildeperdehoek Pass (on the Messelpad Road) is Provincial Heritage Site (Grade II) (Figure S-1a).

Baseline Scenario - Key threats

Palaeontology:

- Desertification and increased mining.

Terrestrial Archaeology (pre-colonial and colonial):

- Increasing agricultural development along the Orange River.
- Renewed copper mining around Okiep, and continuation of mining elsewhere, especially along the coast.
- Continued renewable energy development and transmission lines.
- Development of new roads and the industrial corridor along the N14.

Maritime:

- Offshore mining and gas and oil exploration.

Graves:

- Increased mining, especially along the coast.

Built Environment:

- New mining and infrastructure development.

Living Heritage:

- New mining and infrastructure development and climate change.

Cultural Landscape:

- New mining and infrastructure development and climate change.
- Population growth and associated development.

Baseline Scenario - Positive Impacts

- Benefits to science the discovery and recording of fossils and archaeological sites.
- Growth in tourism may reinforce the need to protect heritage resources which attract tourists.

Scenario 1 (by 2035) - Negative impacts

Palaeontology:

- Impacts are likely to be largely insignificant because most development will affect surficial sediments which are generally of low palaeontological sensitivity.

Terrestrial Archaeology (pre-colonial and colonial):

- Impacts to surface resources across the area are possible, but generally not likely to be of high significance. The exception is for increased development along the coastline where archaeological sites of higher significance are more concentrated. However, the overall impact area close to the coast is likely to still be small compared to the existing and ongoing impacts from mining, and the same applies with regards to agriculture inland along the Orange River.

Maritime heritage:

- Impacts are unlikely to significantly increase due to the generally low probability of wrecks being found. However, there is always a chance of impacts.

Graves

- Impacts to graves are unpredictable and it is equally possible that several or no graves could be affected.

Historical resources and built environment

- Given the relatively small footprint of Scenario 1, significant impacts to historical and built environment resources are unlikely. The main potential threat could be the insensitive 'restoration' of historical structures or even potentially their demolition in towns where new residential areas are required. Steinkopf, Okiep and Springbok may be most at risk here.

Living Heritage:

- The relatively small footprint is unlikely to impact on communal areas in which living heritage traditions are still practiced because they could be easily avoided. Nonetheless, the Communal Areas of Steinkopf, Concordia and the Richtersveld are perhaps most at risk as these areas are located near potential centres of development.

Cultural Landscape:

- The relatively small overall footprint should not have significant impacts on the cultural landscape unless specific developments are situated in close proximity to prominent and aesthetically pleasing landscape features such as the RCBL, National Parks and reserves, the Kamiesberg and the coastline.

Scenario 2 (by 2050) – Negative Impacts

Impacts from Scenario 2 will be very similar to Scenario 1 but with higher intensity. This is because the larger overall footprint will mean more pressure on available land and a reduced likelihood of being able to avoid impacts. This will be worst along the coastline. Inland developments, either on the coastal plain (more than 2 km from the coast) or in Bushmanland are likely to be able to avoid the majority of significant sites. Due to the far larger land requirement, there is a greater chance of impacts to the communal areas.

Positive Impacts associated with the proposed development

Scenario 1 (by 2035)

- Positive impacts will largely relate to the increase in scientific knowledge in terms of the discovery, recording and sampling of fossils and archaeological sites. These would be of benefit to science. It must be noted, however, that impacts to highly significant sites would still be seen as negative such as the RCBL.
- Another potential benefit comes with the responsible restoration and reuse of historical structures which might otherwise become degraded over time through neglect and disuse. This reuse may relate directly to the development or indirectly through the need for increased accommodation in the area.
- Growth in tourism may increase the need to protect heritage resources which are tourist attractions.

Scenario 2 (by 2050)

- As for the small development scenario, but with a greater increase in scientific knowledge.
- Due to the far larger land requirement, there is an increased likelihood that the communal area will be used for at least some development. Although loss of communal land is an impact, financial benefit could accrue to the affected communities with the proper agreements in place.

Risk/Opportunity Assessment

The destructive nature of impacts to heritage resources means that most negative impacts to the various types of heritage are in the moderate to high range. Mitigation measures will generally reduce the ratings to acceptable levels. Benefits/opportunities are generally rated very low to moderate and they tend to relate the increase in scientific knowledge. Built heritage could experience significant benefits related to tourism.

Recommended Strategic Management Actions

A Heritage Impact Assessment (HIA) under Section 38(8) of the NHRA will be required for ***every*** *Environmental Impact Assessment. Notwithstanding the heritage resources on site, HIAs will be needed in order to satisfy the requirements of the National Heritage Resources Act (No. 25 of 1999). A separate Visual Impact Study must be included in every EIA process where visual impacts to the landscape are a potential concern.*

Palaeontology

- There are no areas of highly sensitive fossiliferous strata in the study area that may require protection as NO-GO areas.
- Every EIA conducted within the WP2 study area MUST be evaluated by a palaeontologist to determine the need for a palaeontological specialist study despite the surface sensitivity grading because, depending on depth of excavation, significant impacts could still arise, especially on the coastal plain.

Terrestrial Archaeology

- Archaeological specialist studies will be required in all EIAs which trigger Section 38(8) of the NHRA, and detailed surveys of each project footprint must take place.
- Due to the density and distribution of archaeological sites along the coastline, it will not be feasible to mitigate all impacts there. The appointed archaeologists will need to determine the sites to sample in order to best characterize the archaeology in each development footprint.
- Away from the coast mitigation measures will effectively mitigate impacts.
- It is likely that monitoring of development may be required in the coastal areas where middens can be buried within sand dunes.

Maritime Heritage

- A Maritime Heritage specialist study will need to be included in any developments that might require, for example, undersea pipelines.

Graves

- Graves would be considered along with archaeology in any EIA. Because many graves are unmarked and cannot be spatially identified in advance, the SEA adopts a precautionary approach, particularly in coastal dune systems and historically occupied landscapes where the probability of encountering burials is elevated. Graves and Burial grounds are protected under Section 36 of the NHRA.
- Given the size of the study area, it is possible that many graves could be present. Discussions with SAHRA and the Northern Cape Heritage Resources Authority and representatives of local communities must be initiated in advance of development to determine whether reburial of human remains should be considered and which locations should be chosen for this.

Living heritage

- The local herder communities in each of the communal areas must be consulted to determine their response to the loss of their grazing lands. Among other things, consultation should aim to understand:
    - Why these areas were chosen for grazing.
    - The value of the pasturage in terms of seasonal grazing requirements and mobility routes.
    - Any alternative options; and
    - How nature and culture are intertwined within their world view.

Cultural landscape / sense of place

- The N7, N14 and the R382 and surrounding area are significant for a number of reasons, largely tourism-related. SANParks, UNESCO, SAHRA and local tourism operators should all be engaged in the consultation process because the arid to semi-arid landscapes of the area are key elements of the aesthetic beauty and attract tourists. Any proposed development in or close to the buffer zone of the RCBL Heritage Site could cause significant impacts. Discussions will need to be initiated with the South

African Government and the UNESCO commission regarding potential impacts on the World Heritage status of the RCBL in such instances.

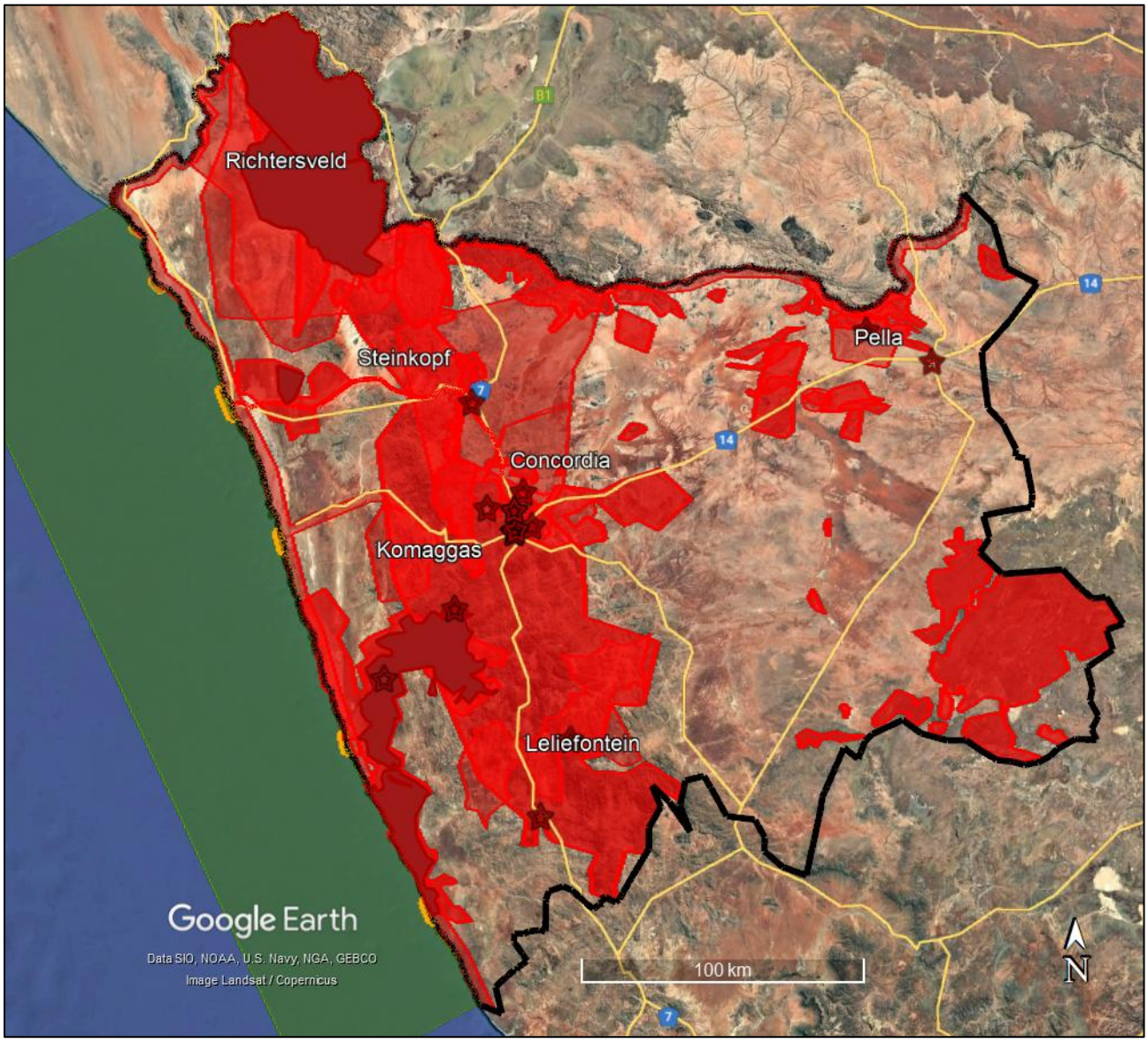
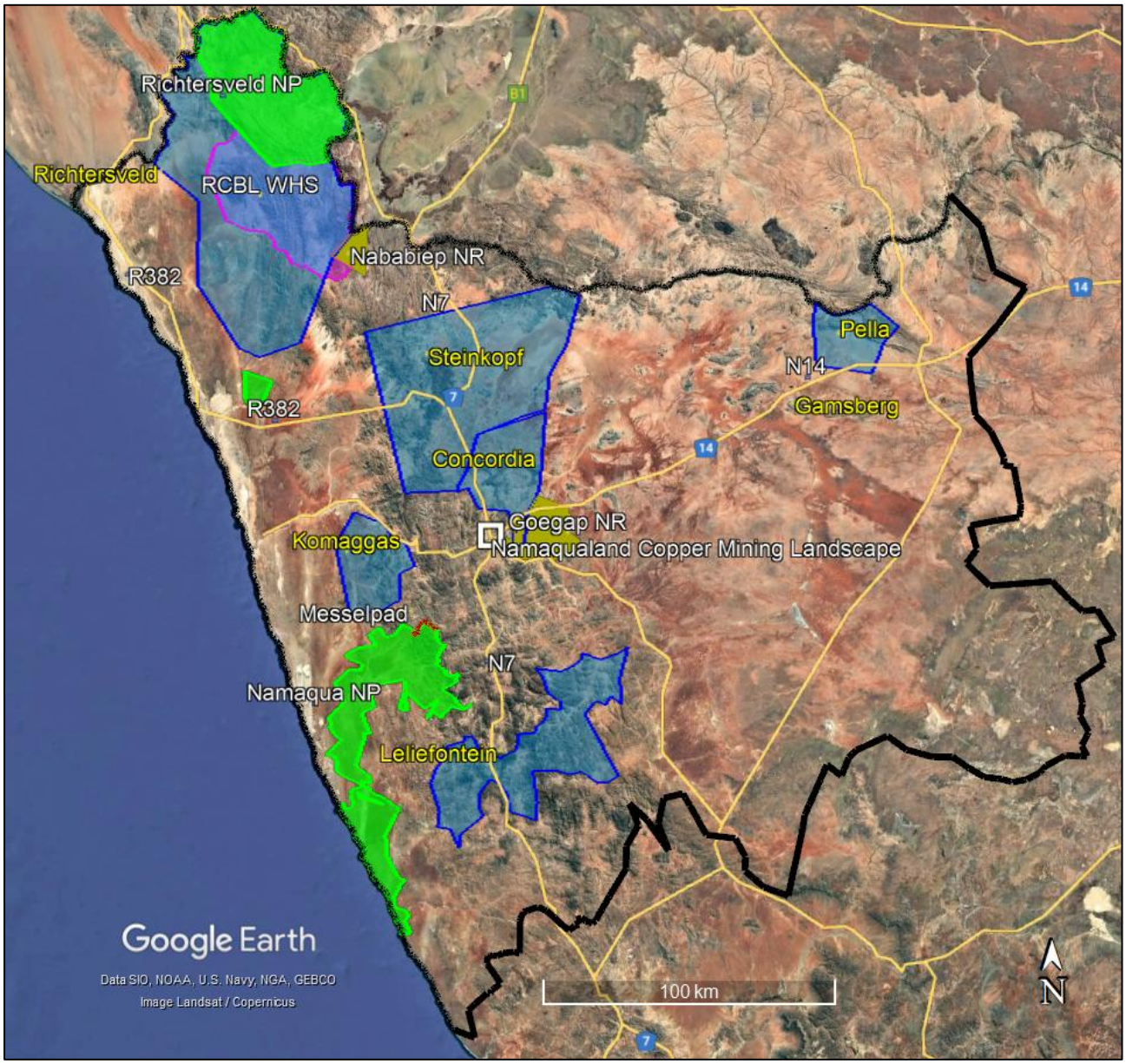


Figure S-1a: Sensitivity map of the study area. Terrestrial areas known to be of high (red) and very high sensitivity (dark red) are indicated as are marine areas of low (green) and moderate sensitivity (orange). The stars indicate the position of the Provincial Heritage Sites in the study area (very high sensitivity). For clarity, lower sensitivity ratings are not mapped here. Note that the primary concentrations of patches of high and very high visual sensitivity have been incorporated into larger polygons for the sake of clearer mapping, but the roads have been omitted here; see **Figure 5-36** for detail.



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CHAPTER 5. HERITAGE RESOURCES

5.1 BRIEF LEGISLATIVE CONTEXT

The National Heritage Resources Act No. 25 of 1999 (NHRA) protects a variety of heritage resources as follows:

- Section 34: structures older than 60 years.
- Section 35: prehistoric and historical material (including ruins) more than 100 years old as well as military remains more than 75 years old, palaeontological material and meteorites.
- Section 36: graves and human remains older than 60 years and located outside of a formal cemetery administered by a local authority; and
- Section 37: public monuments and memorials.

While living heritage is not specifically protected by the NHRA, places and objects associated with living heritage are protected by virtue of being listed in Section 3(2)(b) and 3(2)(i)(ii) as part of the National Estate. Similarly, landscapes with cultural significance do not have a dedicated Section in the NHRA, but Section 3(2)(d) includes "landscapes and natural features of cultural significance" as part of the National Estate. A Living Heritage landscape may also be graded and declared as a formally protected site i.e. under Section 27, 28 or 30 of the NHRA.

Any development in the region will require an impact assessment under S38 of the NHRA with the following being the primary triggers:

- Section 38(1)(a): Any development that involves a linear feature more than 300 m long
- Section 38(1)(c)(i): Any development that involves changes to the character of a site exceeding 5000 m^2.

5.2 THE WORK PACKAGE 2 STUDY AREA

The study area extends from the semi-arid West Coast in northern Namaqualand, through the Richtersveld, the Kamiesberg, and into north-western Bushmanland. This is an area which spans over 5 million hectares and includes four Local Municipalities, namely the Richtersveld Municipality, the Kamiesberg Municipality, the Nama Khoi Municipality and the Khâi-Ma Municipality.

The extensive coastal plain is characterised by sandy flats (**Figure 5-1**) and occasional dunefields and rises gently towards the east. Rock exposure is rare until one reaches the foothills of the Kamiesberg. The mountains themselves are mostly of granite and gneiss with many exposed granite domes visible (**Figure 5-2**). Over the mountains to the east are the extensive gravel and sand plains of Bushmanland with occasional inselbergs (**Figure 5-3**) and a scattering of pans (known locally as '*vleis'*), often with bedrock exposed in their bases.

Figure 5-1: Looking west of the coastal dunes near Koingnaas. A mine dump is visible in the background and the Atlantic Ocean beyond it.

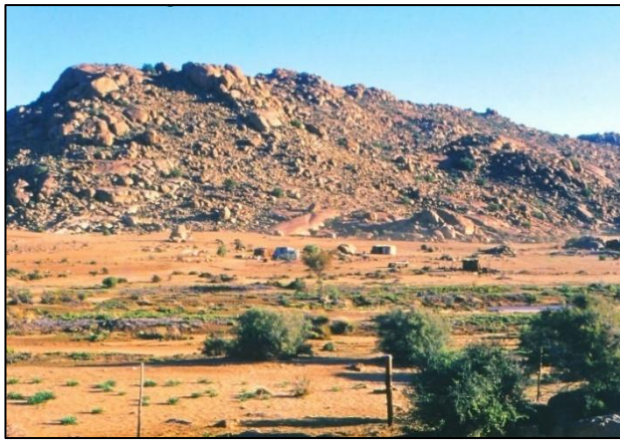

Figure 5-2: Typical view in a valley between the granite hills of the northern Kamiesberg.

Figure 5-3: Sandy substrate in the eastern part of the study area near Aggeneys with the large inselberg of Gamsberg visible. This photograph was taken prior to the removal of part of the northern face of the mountain for mining.

5.3 METHODOLOGY

- All assessments in this report are desktop studies. They are based on published scientific literature, grey literature, and the authors' extensive field experience.
- Although extensive locational data are available in grey literature, no attempt has been made to map specific archaeological sites. Away from the coastline the culturally significant sites tend to be associated with landscape features such as pans, water courses and the bases of hills which are generally less likely to be impacted.
- The inherent unreliability of shipwreck location data is noted.
- Visual sensitivity mapping was commissioned to inform the landscape study. It was undertaken by visual specialists and based on available databases (Oberholzer & Lawson 2024). The lack of a visual chapter in the SEA is a significant limitation.

5.4 DESCRIPTION OF THE RECEIVING ENVIRONMENT/SCENARIO 0

5.4.1 Palaeontology

Rocks of the **Namaqua Metamorphic Province** underlie the study area. They consist of very ancient, much altered, metamorphosed and deformed sediments. In the area northwest of Springbok they are overlain by **Nama Group** sediments which are only mildly deformed and are recognizable by their thick shale units and interbedded quartzites. They are famous for their body and trace fossils spanning the Precambrian/Cambrian boundary. Overlying the metamorphic rocks in the east are the **Karoo Supergroup** sediments which include the **Dwyka Group** glacial tillites and the **Ecca Group** shales. These were eroded after deposition and are now only preserved in the east of the WP2 area. They contain trace fossils, plant fossils (including wood) and a variety of marine fossils. At the end of the Cretaceous Period, several hundred small kimberlite-like volcanoes erupted forming the **Gamoep Volcanic Pipe Swarm**, many of them infilled with fossils, including the remains of a dinosaur from the Kangnas pipe.

A broad fossil valley, the **Koa Valley**, traverses the region and its course is marked by a series of pans, the most prominent being Bosluispan. Here the fossils include extinct proboscideans, bovids, giraffids, rhinocerotid, tortoises, rodents, crocodile and fish. The extensive surficial aeolian deposits, overlie older aeolianites, alluvial river deposits, pan infills, alluvial fans and colluvium. In Bushmanland, a major calcreted surface caps the older generation of these deposits. The teeth of an extinct three-toed horse (Hipparion) have been found at Areb, near Springbok. Elsewhere, the teeth of Equus (zebra) have been found in basal river deposits. The alluvial deposits and pans (many of these are filled volcanic craters) along the ephemeral water courses are of moderate sensitivity.

On the coastal plain, the surficial sands are of low sensitivity but are underlain by marine formations of high sensitivity that contain scattered bones and extinct shell species. These sensitive formations generally occur below 100 m above sea level.

The palaeontological baseline environment is not expected to change much by 2050, although further mining may impact on fossils on the coastal plain.

5.4.2 Terrestrial archaeology

Early Stone Age

Early Stone Age (ESA) occurrences (**Figure 5-4**) have been identified throughout the coastal zone but are usually low density. Material of this age generally occurs beneath the surface aeolian sands and on top of the harder dorbank layer and is exposed through natural or anthropogenic disturbance. Inland of the Kamiesberg, ESA artefacts are also found in areas where cover sands are absent, either in association with dorbank or in places where gravel beds are exposed. ESA materials are sometimes found in close proximity to pans and have also been recorded at silcrete outcrops which were quarried for rock to manufacture the artefacts.

Middle Stone Age

Middle Stone Age (MSA) sites are more commonly identified and include both quarry sites and living sites. Most are located along the current coastline, including a site near Koingnaas (Halkett & Orton 2005), but inland rock shelters with MSA occupation have been identified at *Spitzkloof* in the Richtersveld (Dewar & Stewart 2012, 2017; **Figure 5-5**) and in the basal layers of Wolfkraal Cave and Keurbos Cave in the Kamiesberg (Webley 1984; Webley 1992). A significant MSA deposit was recorded on the top of the Gamsberg (Orton 2014) but the site has subsequently been destroyed by mining.

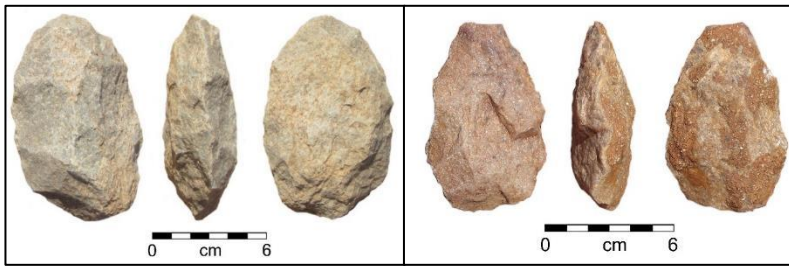

Figure 5-4: ESA handaxes from the coastal plain near Boegoeberg (left) and the plains of western Bushmanland (right).

Figure 5-5: The Spitzkloof rockshelters in the Richtersveld. Source: Dewar & Stewart (2017: fig. 2).

Later Stone Age

Later Stone Age sites are by far the most commonly encountered sites throughout the Namakwa Region study area. They vary substantially in their appearance and size. The main types of precolonial sites are listed below with some notable examples highlighted.

- Shell middens of varying size have been recorded throughout the coastal section of the study area (Dewar & Orton 2013). Especially large middens are known from Port Nolloth, Kleinsee and Boegoebaai. They contain marine shells, ostrich eggshell fragments, stone artefacts and sometimes pottery and ostrich eggshell beads. Shell middens are more numerous close to the shoreline with most being within about 300 m of the beach. Most date to the late Holocene.

- Artefact scatters of varying density are often associated with deflation hollows near the coast, and the foot of rocky hills and the margins of pans in Bushmanland. They contain typical LSA materials and sometimes also historical items (**Figure 5-6**). Grinding grooves or hollows, and ground areas, are often found in exposed bedrock surfaces in or adjacent to pans (**Figure 5-7**). These are likely to have been used as lower grindstones for the processing of plant foods and always occur at places where water could be obtained.

Figure 5-6: LSA and historical items from KK2015/012 near Pofadder (quartz backed bladelet, pot lug, glass truncated backed point and glass bead). Source: Orton (2016a).

Figure 5-7: Large pan with exposed bedrock bearing grinding grooves and surrounded by many artefact scatters. Source: Orton (2016b). Inset: grinding groove at KK2015/012. (Source: Orton 2016b).

- Ostrich eggshell flask caches with varying numbers of flasks. They are generally plain, but some shells decorated with engravings are known.

- Within the study area, rock shelters with stratified deposits currently known to science are extremely rare, numbering less than ten. Namaqualand is critical to the understanding of the spread of pastoralism in southern Africa and Spoeg River Cave (**Figure 5-8**), currently the only known shelter on the coastal plain, yielded the earliest dated sheep bone in South Africa (2105 ± 65 BP [OxA-3862]; Webley 2001; Sealy & Yates 1994). GI2 in the Gamsberg Inselberg has a 30 cm deep late Holocene deposit (undated). The excavation was never completed (Orton 2014) and the site is now extremely vulnerable to total loss through continued mining. Wolfkraal in the Kamiesberg (Webley 1992) and Leeu Klip Cave in Bushmanland (Beaumont *et al.* 1995) are two excavated rock shelters containing rock paintings.

- Rock paintings are generally rare in the Namakwa Region study area (Orton 2013; Rudner & Rudner 1968) but occur in either the fine-line tradition or the geometric tradition. The latter style dominates strongly (e.g. **Figure 5-9**). The rarity of painted sites serves to increase their significance.

- Geometric rock engravings have been found along the Orange River and are likely all the work of Khoekhoe herders (Halkett 1999; Orton 2025). Engravings are not known from the remainder of the study area, but, in the southeast where dolerite occurs, they may still be found. Cupules ground into the rock surface have been located in the vicinity of Kangnas in western Bushmanland (Orton & Webley 2014).

- Isolated special finds, such as complete pastoralist ceramic pots, are made from time to time, such as a pot eroded out of a sand bank on a farm in the extreme east of the study area (Webley & Orton 2012), northeast of Pofadder (**Figure 5-10**).

Figure 5-8: View of Spoeg River Cave near the mouth of the Spoeg River. (Source: L. Webley).

Figure 5-9: Geometric rock painting from Wolfkraal in the Kamiesberg. Scale in 5 cm intervals. (Source: J. Orton).

Figure 5-10: A whole pot found by a farmer near the north-eastern boundary of the study area (Orton & Webley 2014).

Some LSA sites also have historical materials on them indicating their age to be very late, falling into what is commonly referred to as the 'contact period'. These items were likely traded from Europeans, but possibly also from other indigenous groups. Examples have been shown above but further evidence for contact in the form of glass beads and iron fragments has been obtained from Spitzkloof D in the Richtersveld (Hopper & Dewar 2023).

Historical period

Historical archaeological sites are the most tangible sites (making them vulnerable to damage) and are most common in the mountains. Ruins of stone and/or brick (**Figure 5-11**-**Figure 5-13**) are sometimes accompanied by scatters of domestic refuse (**Figure 5-14** &**Figure 5-15**).

Figure 5-11: Example of a stone-walled structure from the Goegap Nature Reserve, northern Kamiesberg. (Source: Orton 2025).

Figure 5-12: Stone ruin, possibly of a house, from the area east of Concordia. Source: (Orton 2019).

Figure 5-13: Stone ruin and threshing floor from the area east of Concordia. (Source: Orton 2019).

Figure 5-14: Collage of historical materials from the coastal plain section of the study area. (Source: Orton)

Figure 5-15: Historical materials from a site in the Kamiesberg north of Concordia. (Source: Orton 2019).

Copper mining in Namaqualand dates back to the 1684 expedition of the Governor, Simon van der Stel. After reaching the "Koperberg" they sank a number of shafts. One of the first shafts, on the Carolusberg, has been declared a PHS (**Figure 5-16**).

Commercial copper mining commenced in 1854, and within a short time mines were sunk at Okiep, Tweefontein (Concordia), Spektakel and sometime later at Nababeep (Smallberger 1975). Initially, ore and later concentrate from the smelters were transported by ox-wagon to Hondeklip Bay from where they were shipped. The Wildeperdehoek Pass along the Messelpad Road was built by convicts over the Wildeperdehoek Mountains and is a PHS. However, in the 1860's a narrow-gauge railway line was built from Okiep to Port Nolloth, which was developed as a port. Copper mining ceased in 1928 but then the Okiep Copper Company (OCC) was formed in 1937 to re-open the mines. The railway line between Port Nolloth and Okiep was finally closed in 1940 although sections were still used for mine purposes. Eventually the railway line was dismantled with only the culverts and water towers remaining (**Figure 5-17** & **Figure 5-18**).

A number of these copper mining sites are declared Provincial Heritage Sites (PHSs):

- Clara is one of the last remining steam locomotives used for conveying copper ore on the historic rail section from Okiep to Port Nolloth and is parked at Nababeep.

- The old smokestack, dating to 1880, was erected at Okiep by the Cape Copper Company to provide energy to the pumping engine, and to pump water from the copper mine shafts (**Figure 5-19**).

- The Cornish pump building has an historic pump engine dating to 1882 and in use until 1929. It was used to pump water from the historic mine (**Figure 5-19**).

- The copper smelting chimney at Springbok is associated with the history of copper exploitation in South Africa.

In 2009, the Dept of Sport, Arts & Culture in the Northern Cape Provincial Administration, South Africa submitted an application to UNESCO to have "The Namaqualand Copper Mining Landscape" listed on the Tentative Listing for a World Heritage Site as a serial nomination consisting of several sites. While it was removed from the list in 2015, the nomination indicates the significant heritage value of the copper mining landscape.

Figure 5-16: Van der Stel's mine near Carolusberg, a declared PHS. Source: (Orton 2021).

Figure 5-17: A water tower near Okiep. (Source: L. Webley).

Figure 5-18: View of a culvert under the 19th century copper railway. (Source: Orton 2019).

Figure 5-19: The Cornish Beam Pump (inset) and smokestack in O'okiep (both declared PHSs). (Source: J. Orton).

Diamonds were first recognized some 9 km south of Port Nolloth in 1925. These discoveries were followed by finds at Kleinzee and further north toward Alexander Bay, precipitating a "diamond rush" (Carstens 1962; Coetzer 1997 and de la Harpe 2024). In 1927, the government passed a proclamation prohibiting further prospecting and mining for diamonds on State land along the coast. They subsequently passed the Precious Stones Act No 44 of 1927. By 1928, the State Alluvial Diggings were established. In 1929, the Minister of Mines & Industries served notice that trekboers and herders on Crown lands within a 15-mile radius had to vacate their land (de la Harpe 2024). The diamond diggings comprised shallow trenches excavated by hand with picks and shovels to recover the diamonds. The diamond-bearing ore was later transported by cocopans on rails. The ore was moved to an area where it was subjected to rollers and sieving. Miners tended to live in Alexander Bay or Kleinzee, but in the early days, many were accommodated in small, corrugated iron buildings and tents, for example near the Boegoeberg (**Figure 5-20**).

Figure 5-20: Diamond miners in the 1920s near Boegoeberg. Note the corrugated iron buildings in the background (Rudd & Watson n.d., in Coetzer 1997:5).

Hand labour was replaced by large bulldozers. Increased security led to the use of x-rays to tackle the illicit traffic in diamonds. The area was surrounded by barbed-wire fencing, and had police patrols, flood lights, etc. Several pickets were maintained by the police along the road between Port Nolloth and Alexander Bay. The archaeology of early 20th century mining would include the study of the mining sites, associated infrastructure, worker compounds and the cultural landscapes they have created. It is possible that the historical middens found on the southern slopes of Boegoeberg 1, relate to early 20th century mining. There is an argument for characterising mine wastes as archaeological landscapes (Lawrence et al. 2023). No one can dispute the significant alteration to the coastal landscape. Although currently not legally archaeology, this section is included based on certain aspects of diamond mining becoming archaeological in the coming years.

5.4.3 Maritime Heritage

The north-western coastline of South Africa has long featured in maritime texts and maps. However, the accuracy of the records is often questionable. The nature of the environment in which foundered vessels can drift a long way before settling, poor historical reporting, and the length of time since the wrecks occurred means that maritime cultural heritage sites are hard to accurately locate. **Figure 5-21** maps known wrecks off the relevant section of the West Coast of South Africa. Given the limitations, 54 wrecks pre-dating 1965 and a further six post-dating 1965 are known to occur off the Namakwa region coastline. Another approximately 60 more may, with a lower level of certainty, be located somewhere off the coast of the study area.

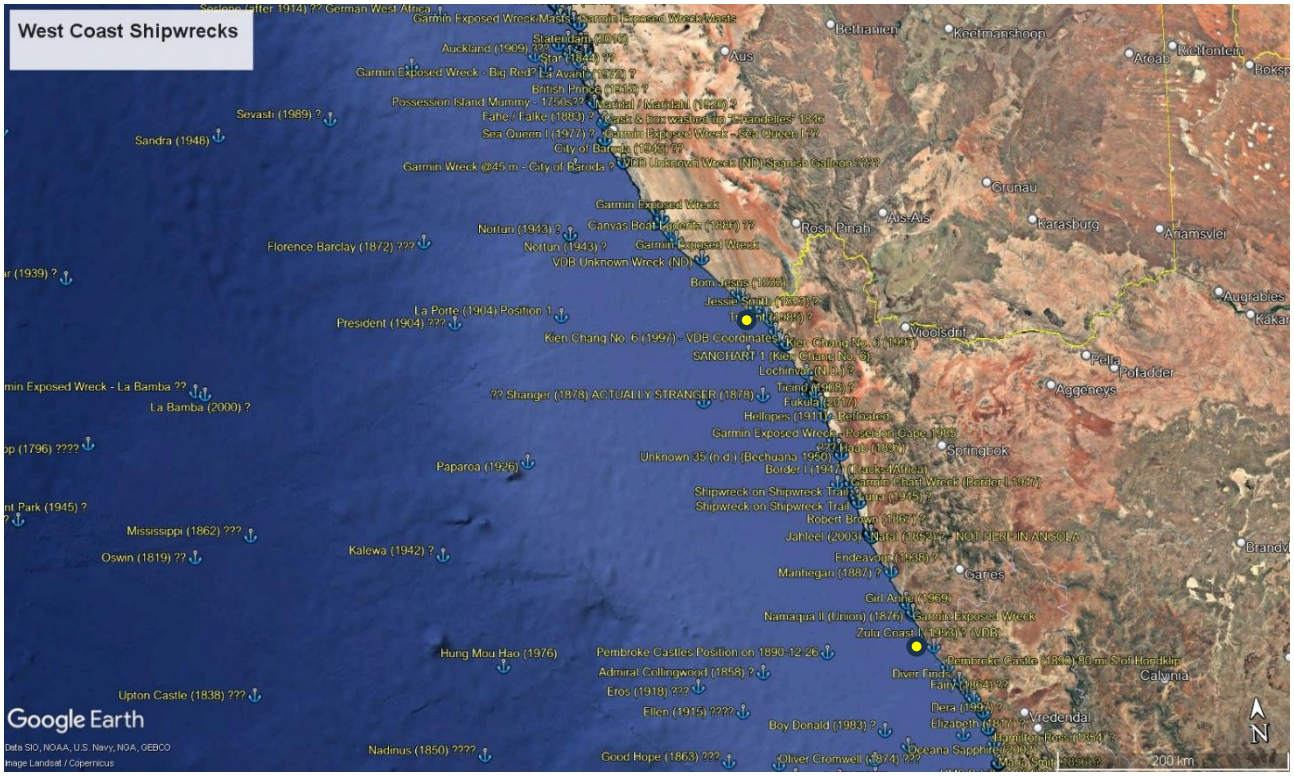

Figure 5-21: West Coast Shipwrecks from southern Namibia to St Helena Bay (Google Earth 2025; Hocking 1969; Levine 1989; Maitland 2023; Reocities 2022; SAHRA 2022; Turner 1988; U-boat.net 2022; van den Bosch 2009). The Namakwa Region study area coastline is between the yellow dots.

5.4.4 Graves

Pre-colonial graves can be found anywhere. They are often found in coastal dune contexts where the sand is easy to excavate by hand and population densities were generally higher than inland. They are only rarely reported from Namaqualand and Bushmanland with most of those on record being from the Kleinsee to Hondeklipbaai area (Dewar 2008; Dewar & Orton 2013) and along the Orange River (Morris 1992). Most precolonial graves are not marked at the surface and are not identified until disturbed. Rare stone-packed graves are likely to be very late/historical graves. **Figure 5-22** shows an example from Boegoeberg, while **Figure 5-23** shows a small cluster of stones that, by its location on a sandy plain, may very well mark a grave. However, stone piles can also arise from prospecting/drilling and may be confused with graves. Unmarked colonial era graves, dating to the Anglo-Boer War or from historical farms may also occur in isolated areas, but historical graves generally have head and/or footstones enabling easy identification during ground surveys.

Figure 5-22: A stone cairn, which may represent a burial, at the foot of Boegoeberg South. It is situated inside the Conservancy area. (Source: Webley 2024)

Figure 5-23: Cluster of rocks likely to represent a grave near Aggeneys. (Source Orton 2016a).

5.4.5 History and built environment

Important themes which are briefly described and illustrated below, include the settlement by the first colonial farmers, missionary activity and the establishment of the communal reserves, the history of copper mining, and the impact of the Anglo-Boer War. The discovery of diamonds in 1925, falls just inside the 100-year minimum age for archaeological remains in terms of the NHRA (see Section 1 above) and is briefly discussed in Section 4.2, but associated structures greater than 60 years old feature in this section.

Various expeditions were sent up to the north-western Cape (Namaqualand) during the latter part of the 17th century, culminating in Commander van der Stel's visit in 1685 (1685). They encountered the Namaqua Khoekhoen, at that time consisting of eight or nine kraals (Penn 2005: 159). By 1740, the Dutch were in control of the southern part of Namaqualand and by 1750 a number of loan farms had been granted, including the farm Leliefontein (on the top of the Kamiesberg) which subsequently became the core of the Leliefontein Communal Area or sometimes called "reserve". By the middle of the 19th century the only land available to the descendants of the Namaqua Khoekhoen was located around the mission stations. There are no historic farmhouses in the study area which have been declared heritage sites or graded as significant, although there are many 19th century farm buildings across the study area (**Figure 5-24** & **Figure 5-25**). However, on the farm *Riethuis (Roodeklip Heuwel)* at the end of the Messelpad, and just before Honde Klip Bay, an outbuilding contains an historic horse mill. The mill, building and 5 m of surrounding land have been declared a PHS (**Figure 5-24**).

Missionary work in Namaqualand led to the establishment of a number of mission stations or communal areas. These in chronological order are:

- Pella: A new mission was established in Bushmanland in 1811, called "Pella". It was abandoned in 1872, because of drought. The first Catholics started their mission in Springbok in 1869 and in 1878 they arrived at Pella. They built a cathedral which was consecrated in 1895 and is now a PHS (**Figure 5-26**).

Figure 5-24: This structure on Riethuis 619 houses an historic horse mill. It is a PHS. Source: Webley (2004).

Figure 5-25: Rondekop in the Namaqua National Park has a distinctive stone, flat roofed house with decorative window and door treatment. Source: Webley (2004)

Figure 5-26: The church at Pella is a Provincial Heritage Site. Source: L. Webley.

- Leliefontein: The Rev Barnabas Shaw, of the London Missionary Society (LMS), set up a mission at Leliefontein on the top of the Kamiesberg in 1816. In order to persuade them to give up their transhumant lifestyle, he introduced the planting of wheat which is still practised today. The property on which the 1855 Church and Manse at Leliefontein stand is a PHS.

- Steinkopf (Kookfontein): In 1818, the Rev. Schmelen of the LMS established a mission at Kookfontein (also known as Kokfontein or Besondermeid). It was later renamed Steinkopf. He also founded the mission at Komaggas. The Church is a PHS.

- Komaggas: Komaggas became the mission station of the London Missionary Society in 1829. The Rev. Schmelen took over as the minister until his death in 1848.

- Concordia: In 1852, the Rhenish Missionary Society established the Concordia Mission, close to Springbok. Construction of a large church commenced in 1874 and it was inaugurated in 1876 (Strassberger 1969).

- Richtersveld: The catechist, Frederick Hein, started preaching among the Namas along the Orange River in 1842. In 1851 he started work at Kuboes which became a 'sub-station' of the Steinkopf

Mission, and they started building a church in 1888. The reserve is called after Dr E Richter of the Rhenish Mission Society.

Tickets of occupation to the land were issued by the Cape colonial government shortly after the territory to the north of the Buffalo River was annexed in 1847. It gave the inhabitants long term security to their lands. The Mission Stations and Communal Reserves Act of 1909 was aimed at removing the control of secular matters from the missionaries at the mission stations (SPP 1995). The nature of the settlement in the reserves is discussed further in Section 4.6.

Copper Mining is an important aspect of the region's history and is discussed at greater length under the section on archaeology. This includes listing of associated structures declared as PHSs.

Namaqualand was impacted by the *Anglo-Boer War* of 1899-1902. A Major Shelton of the British forces was appointed to Namaqualand in 1901 in order to protect the valuable copper deposits around Springbok and Okiep as well as the railway line to Port Nolloth (Burke 1995). The British forces garrisoned themselves in the town of Okiep and a number of blockhouses were constructed around the town. Garies and Springbok eventually fell to the Boers and Okiep was besieged. British reinforcements eventually arrived to relieve the town but at the same time General Smuts had to leave to attend the peace negotiations in Pretoria. The siege of the town, which had lasted a month, was eventually lifted.

Remnants of the war are found throughout the study area and include:

- Letterklip – near Garies. It is a PHS. This rock formation was fortified and occupied from 1901 to 1902 by British forces. It contains names and badges engraved on the rockface.
- The massacre of 35 inhabitants of Leliefontein Communal Area by General Maritz is commemorated by a bronze plaque in the church.
- Darter's Grave (at Darters Poort south of Kamieskroon on the N7) is the grave of Lt James Darter, a member of the Namaqualand Border Scouts who was killed and buried here in 1902.
- There are blockhouses in and around Okiep relating to the siege of the town.
- Remnants of stone-walled features related to the Anglo-Boer War have been found between Springbok and Aggeneys (Orton & Webley 2012).

The discovery of first diamond on the Namaqualand coast, just south of Port Nolloth by Jack Carstens in 1925, has had a significant impact on the coastal landscape and therefore the Cultural Landscape. It is further discussed under the section on archaeology but it is noted here that the earlier buildings connected to 20th century mining are heritage resources.

5.4.6 Living heritage

The National Heritage Resources Act, No. 25 of 1999 (NHRA) defines living heritage as: "cultural tradition, oral history, performance, ritual, popular memory, skills and techniques, indigenous knowledge systems; and the holistic approach to nature, society and social relationships" (Section 2(xxi)). Although living heritage is not specifically protected by the NHRA, places associated with living heritage are. Living Heritage landscapes may be graded and declared as formally protected sites, i.e. under Sections 27, 28 or 30 of the NHRA. There is also a National Policy document on Living Heritage (DAC 2009) that aims to protect and promote living heritage.

The arrival of the first trekboers and Baster groups put increasing pressure on rights to the lands of the Namaqua Khoekhoen pastoralists and hunter-gatherer groups as well as their natural resources. Prior to the arrival of the trekboers, the indigenous people had no formal title to the land. From the 19th century, the colonial government encouraged the establishment of mission stations, seeing them as a way of stabilising indigenous peoples within a fixed geographic area where they could serve as a source of labour. Historically, the government was reluctant to commit to reserve boundaries.

In place of their traditional transhumant lifestyle, the pastoralist descendants were severely restricted. They were encouraged by the missionaries to settle in villages and to practice an agrarian lifestyle. The Mission Stations and Communal Reserves Act of 1909 was intended to administer the "coloured rural communities".

There are six communal areas within the study area.

- Richtersveld
- Steinkopf
- Concordia
- Kommagas
- Pella
- Leliefontein

In the 1980s, the Apartheid government initiated a scheme to divide the communal lands up into "economic units" since it was believed that privatisation of land would increase agricultural output and efficiency. Many of the reserves rejected this proposal, but the proposal was implemented in parts of the Richtersveld, Steinkopf and Leliefontein where there are now dozens of small farms. Those residents who were unable to obtain a farming unit, were forced to graze their livestock on the village commonages, resulting in significant overgrazing. The privatisation scheme was eventually overthrown by the courts in 1988 (SPP 1995).

Each communal area has its own particular history, in terms of early missionary settlement and the impacts of copper and diamond mining. The 19th century Namaqua Khoekhoen camp or kraal consisted of a patrilineal clan under the nominal authority of the chief or 'kaptein'. They were predominantly herders, with cattle, sheep and goats. The transhumance cycles of the Nama herders have been documented in the Richtersveld (Boonzaaier 1980, Mussgunug 1995, Hendricks *et al*. 2004), Steinkopf (Webley 1987), Leliefontein (Webley 1987) and Pella (Klinghardt 1982). Due to the extremely dry climate and differing climatic zones, seasonal mobility was, and continues to be, essential for these small stock herders. In the far western part of the study area they moved historically between the Orange River, the mountains and the coast. In areas such as Steinkopf and Leliefontein, which cross ecological zones, pastoralists move to the mountainous zones in the summer months and to the lower sandveld region in winter. Historical transhumance patterns have been traced through oral history and historic aerial photography.

Most farmers live in permanent dwellings, while their herds move in a seasonal orbit under the care of a shepherd. It is important to emphasise that very few of the inhabitants are full-time herders. Many families may own livestock, but they are often combined into a single herd and cared for by an employed shepherd. The temporary settlements are called "veeposte" (stockposts). They consist of a temporary dwelling and, in the case of winter stockposts, also a kraal or two. The stockpost has been described by Webley (1982 and 2009b), Mussgunug (1995) and Mills (1995). There has been considerable variability in the design and layout of stockposts with accelerated change over the last 50 years.

The traditional "matjieshuise" (mat house or !haru-oms) comprised a lathe framework of about 40 to 60 poles which was covered by up to 16 reed mats (**Figure 5-27**). The decline in the use of such huts relates to a lack of suitable rush. It is also time-consuming to make the mats, and most women no longer know how to make them. The herders therefore use hessian, plastic sheeting, cardboard and other bits of material to cover the frame. Nearby was the "kookskerm" (cooking shelter) which traditionally comprised a semi-circle of bushes enclosing a central hearth (**Figure 5-28** & **Figure 5-29**).

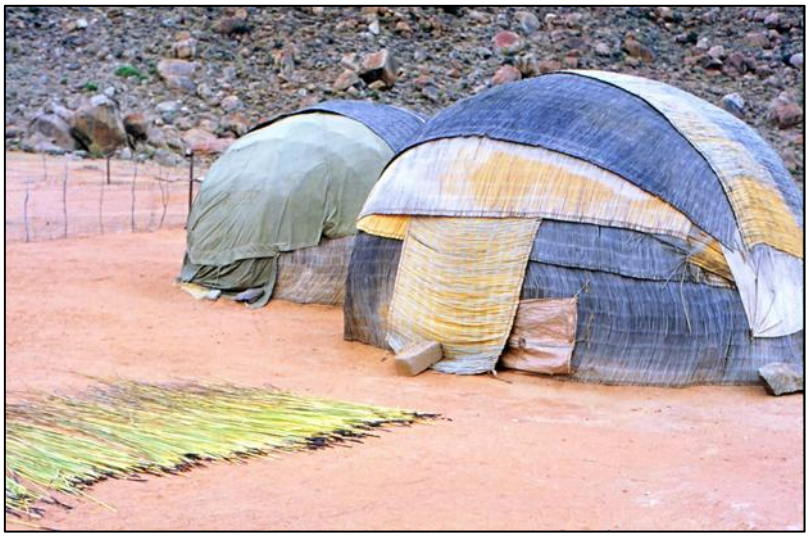

Figure 5-27: A traditional matjieshouse in a village in the Leliefontein Reserve c. 1986 (source: L. Webley). It illustrates the correct placement of the reed mats.

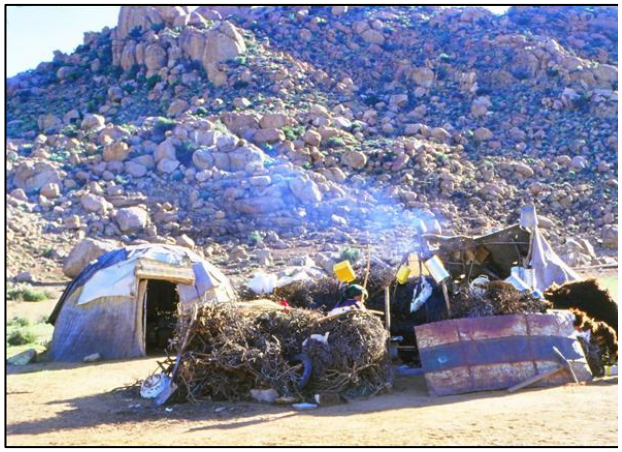

Figure 5-28: A stockpost in the Leliefontein Reserve, showing the matjies house, the circular kookskerm and the forked n//a pole at the entrance c. 1986 (Source: L. Webley).

Figure 5-29: A contemporary stockpost hut in the Boegoebaai study area with barrels of water standing outside. The 'kookskerm' is between the door and barrels c. 2024 (Source: J. Orton).

Figure 5-30: Contemporary lamb kraal in the corner of the main kraal (Source: J. Orton).

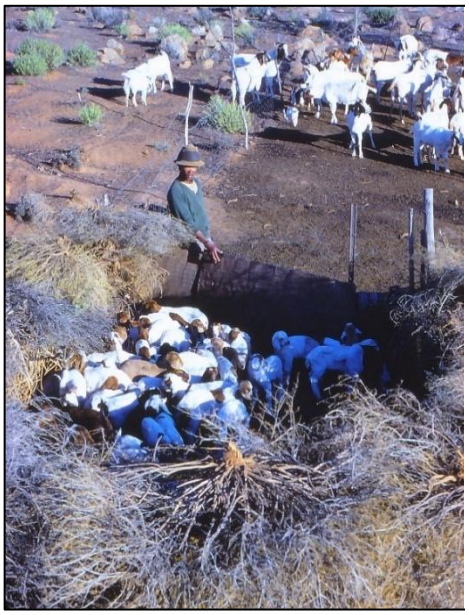

Figure 5-31: Lamb kraal in the foreground c. 1986 (Source: L. Webley).

Kraals are typically constructed in the winter months to provide protection from the cold and predators. Kraals (made of wire, poles, bushes or stone) often included lamb kraals or enclosures (**Figure 5-30** & **Figure 5-31**). Any development which within the communal areas may impact on traditional transhumance patterns and therefore the way of life (living heritage) of the local inhabitants. This review acknowledges that the Living Heritage component is presently based primarily on desktop review of existing literature. Detailed field-based engagement with affected communities will be required during subsequent project-level assessments (Heritage Impact Assessments).

5.4.7 Cultural landscape / sense of place

The area has four distinct physiographic components. The coastline, coastal plain, granite mountains of Namaqualand, and the inland plain of Bushmanland. The latter includes many smaller mountains, often present as inselbergs. The landscape is arid and desolate, but mining traces occur widely. Diamonds are mined along the coast and Orange River, and as a result these areas are largely inaccessible to tourism. Copper mines are located in the granite mountains around Springbok and Okiep. Other minerals are mined further inland around the Gamsberg at Aggeneys. The Kamiesberg range has the highest mountains in the area. Important topographic features are the Boegoeberg Twins near Alexander Bay, the granite mountains around Springbok, Okiep and Concordia, Sneeukop overlooking Kamieskroon and Gamsberg near Aggeneys. All have historical significance. The Orange, Buffels and Spoeg Rivers are the main rivers through the study area, and all have aesthetically significant aspects. Granite mining too, is prevalent in the northeast, near Pofadder and these activities can alter the landscape, and disturb archaeological and historical remains.

The most significant aspect of the cultural landscape is the Richtersveld Cultural and Botanical Landscape (RCBL) World Heritage Site which lies within the north-western part of the Namakwa Region study area (Figure S-1b). The description of the RCBL is as follows (UNESCO 2024):

> The 160,000 ha Richtersveld Cultural and Botanical Landscape sustains the semi-nomadic pastoral livelihood of the Nama people, reflecting seasonal patterns that may have persisted for as much as two millennia in southern Africa. It is the only area where the Nama still construct portable rush-mat houses (*haru om*) and includes seasonal migrations and grazing grounds, together with stock posts. The pastoralists collect medicinal and other plants and have a strong oral tradition associated with different places and attributes of the landscape.

A buffer zone has been created around the RCBL in order to further control impacts on it. It must be noted that the transhumant lifestyle practiced by the Nama also incorporates land both within and beyond the buffer zone. Adjacent, and within the buffer zone, are the Richtersveld National Park and Nababiep Nature Reserve. Immediately east of Springbok is the Goegap Nature Reserve and further south again is the Namaqua National Park (Figure S-1b). All protect iconic sections of South Africa's semi-arid landscapes as well as aspects of the region's cultural heritage (i.e. ruined buildings, kraals, cemeteries, etc).

"The Namaqualand Copper Mining Landscape" was included on South Africa's Tentative World Heritage List in 2009 but was subsequently withdrawn in 2015. This underscores their historical significance. The Gamsberg Mountain, although now partially destroyed by mining, has been identified as having high significance as a place of "genocide of the San people" (Morris 2013). It was considered part of the proposed /Xam Khomani Heartland Heritage Site, on South Africa's Tentative World Heritage List, but has since been removed.

The N7, N14 and R382 are identified as scenic routes because they provide access to the RCBL World Heritage Site, the Richtersveld National Park, the Orange River and Namibia (Figure S-1b). These include a number of historic mountain passes, while the Wildeperdehoek Pass (on the Messelpad Road) is a Provincial Heritage Site (Grade II).

The coastline, scenic route corridors, topographic features and pans are the main highly sensitive areas, while during spring many of the smaller roads in the western half of the study area are frequented by local and foreign tourists alike to enjoy the floral landscapes (**Figure 5-32**).

Figure 5-32: Wildflowers inland of Hondeklipbaai. Photograph: J. Orton.

5.5 SPATIAL CLASSIFICATION OF RECEIVING ENVIRONMENTS

5.5.1 Palaeontology

The theoretical palaeontological sensitivity of the study area is taken from the Palaeosensitivity Map at the South African Heritage Resources Information System (SAHRIS n.d.) but has been altered to align with the desktop study (**Figure 5-33**). In general, the surficial sediments of the coastal plain are of low sensitivity with more highly significant deposits present at depth close to the coast and below elevations of about 100 m above sea level. The band of igneous mountains flanking the escarpment is generally of zero sensitivity but the remnants of depositionally higher rocks to the west and northwest of Springbok are of high sensitivity.

The Bushmanland area is generally of low sensitivity but patches of zero and moderate sensitivity occur, and an area of high sensitivity lies in the southeast.

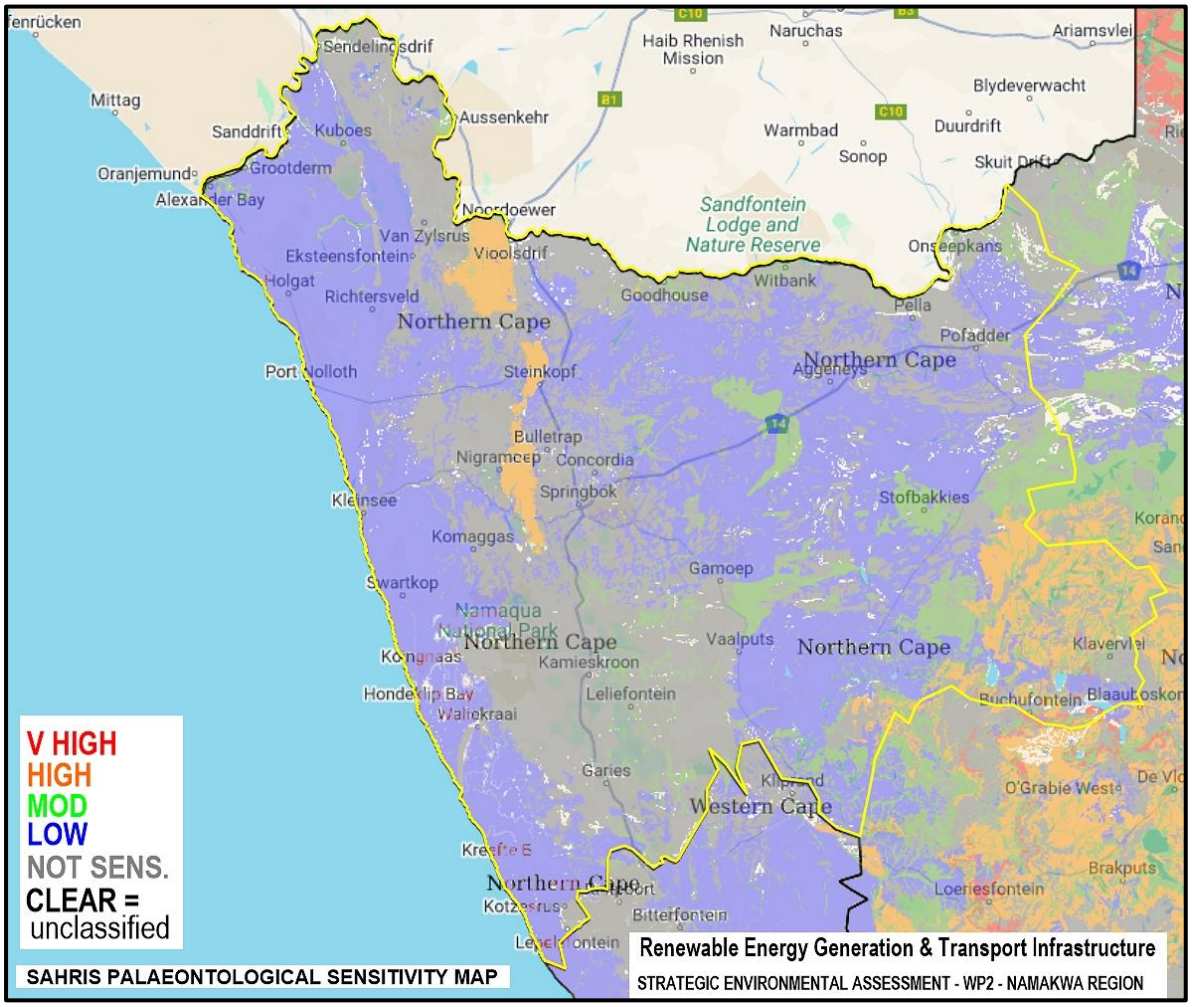

Figure 5-33: The SAHRIS palaeontological sensitivity classification (SAHRA n.d.) but edited to align with the results of the desktop research. The boundaries of the SEA WP2 are shown in yellow. Grey = zero, blue = low, green = moderate, orange = high, red = very high. Note that the surface sediments close to the coast are of low sensitivity but are underlain by very high sensitivity sediments.

5.5.2 Terrestrial Archaeology

Archaeological knowledge is largely derived from Cultural Resource Management work and therefore any map of the distribution of sites would reflect the locations of surveys. Work has focused along the coastline south of Port Nolloth and within the Springbok REDZ. Large parts of the WP2 study area remain poorly explored. These include much of its southern half as well as western Bushmanland and parts of the Richtersveld.

The identification of definitive sensitivity zones is entirely dependent on detailed field surveys. Sites may vary in cultural significance from very low (and not worthy of sampling) to very high (potential provincial significance). Archaeologists therefore rely on their knowledge of which landscape features were conducive to prehistoric settlement. Pans, the margins of rivers, ridges, inselbergs and deflation hollows between dunes are all potentially sensitive in this regard.

For the purposes of this study, the areas where archaeology is likely to be most dense are allocated high sensitivity, as are the remains of the 19th century Copper Railway network (**Figure 5-34**). It must be noted that many thousands of small points scattered across the entire study area where archaeological sites occur will be of variably low to high sensitivity, but these cannot be meaningfully mapped at this scale. Detailed mapping of archaeological sites (using desktop research and field surveys) must be undertaken at the EIA phase.

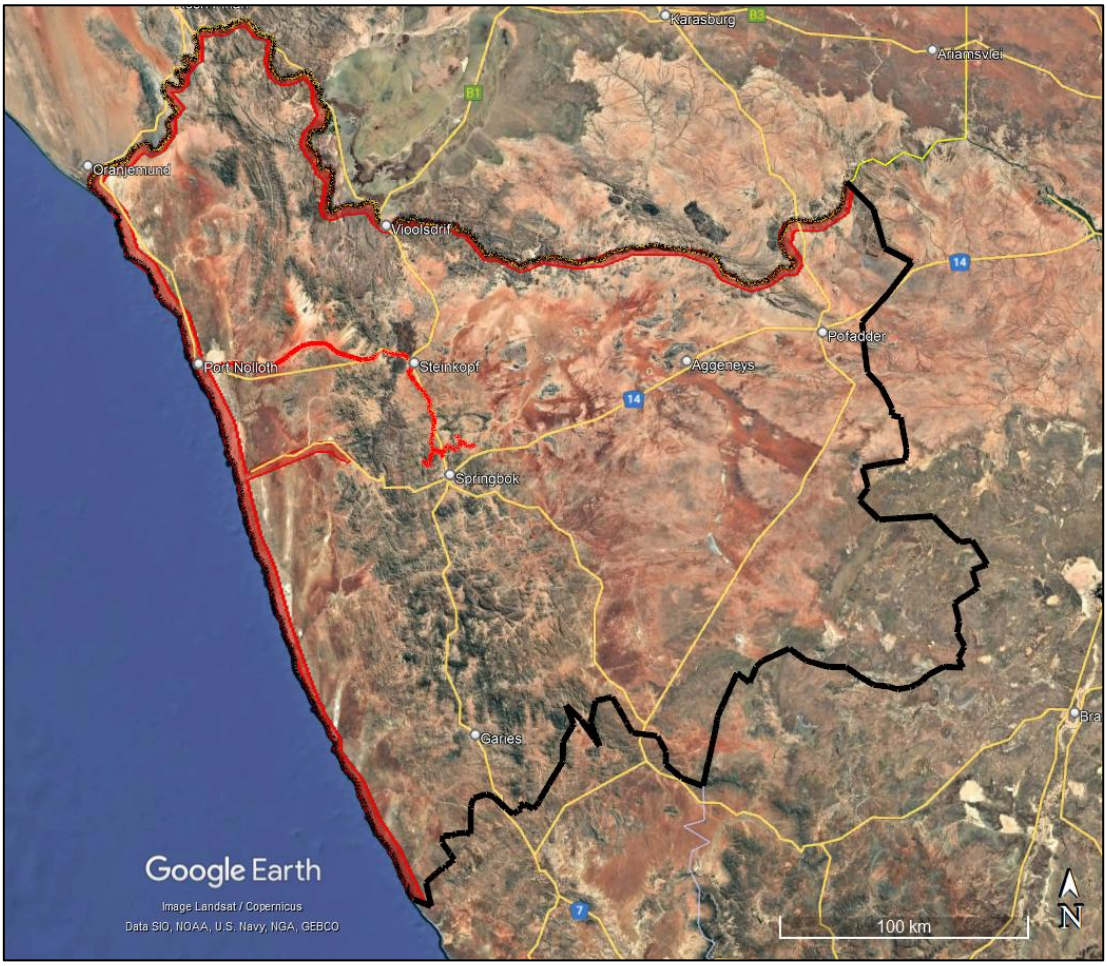

Figure 5-34: Map showing terrestrial archaeological sensitivity. Red = high, with the remainder of the area best seen as low sensitivity.

5.5.3 Maritime Heritage

Because of the low likelihood of actually encountering shipwrecks in general, the area of ocean adjacent to the WP2 study area is almost all considered as of low sensitivity. The exceptions, however, are Cape Voltas, Wreck Point, Soco Reefs, Port Nolloth, Kleinsee, Hondeklipbaai, Groenriviermond and Skulpfontein Point which were all mentioned in the shipwreck database as foundering localities which means that these places have a slightly higher likelihood of hosting wrecks. These latter areas are indicated in **Figure 5-35** as medium sensitivity and are within 2 km of the coastline.

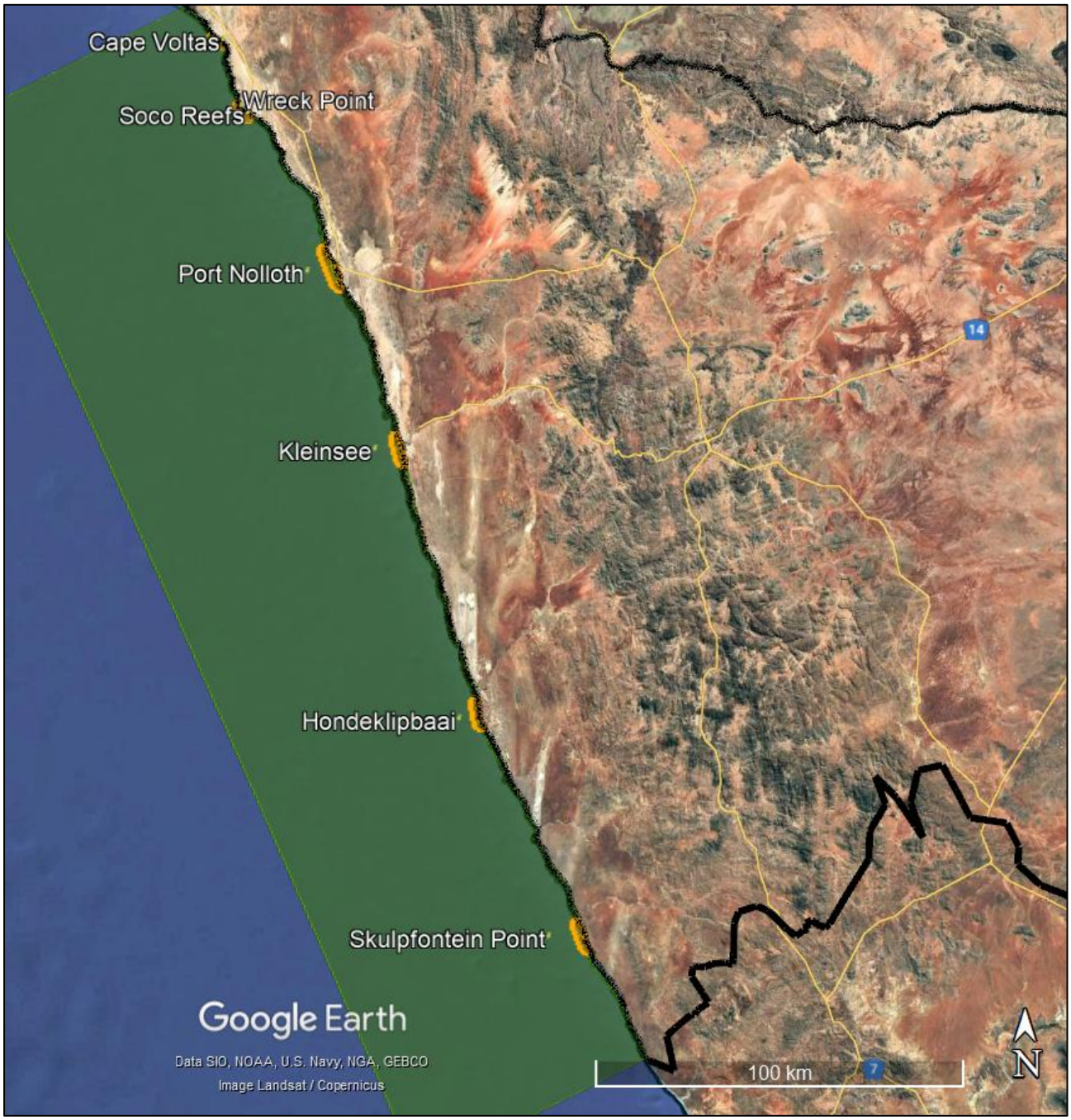

Figure 5-35: Sensitivity mapping for maritime heritage. Orange = medium, green = low.

5.5.4 Graves

It is likely that pre-colonial graves will occur in some archaeological shell middens along the coast. Graves have **high local cultural significance (Grade IIIA)** and are automatically of very high sensitivity. Sensitivity mapping for graves is not feasible, and the entire area is best considered as of low sensitivity because of the low probability of encountering graves. Although graves are particularly concentrated along the coastal margins, their likelihood of occurrence is still low enough to not warrant a medium sensitivity strip there.

5.5.5 *History and Built Environment*

No spatial mapping of sensitivity zones is possible for historical and built environment resources since they are small sites that will be present widely on farms and in towns throughout the region. However, Figure S-1a does include the locations of declared provincial heritage sites which can be regarded as of very high sensitivity. The many other historical structures across the province will need to be evaluated for significance through fieldwork.

5.5.6 *Living Heritage*

The **RCBL** as a cultural landscape, reflects long-standing traditions of the Nama, the indigenous community.

However, transhumant herders from all six communal areas shown in **Figure 5-36** have utilized the land within the study area historically and have a centuries old tradition with respect to the landscape and settlement patterns. As representative examples, the areas within the boundaries of the communal reserves are thus regarded as of high sensitivity.

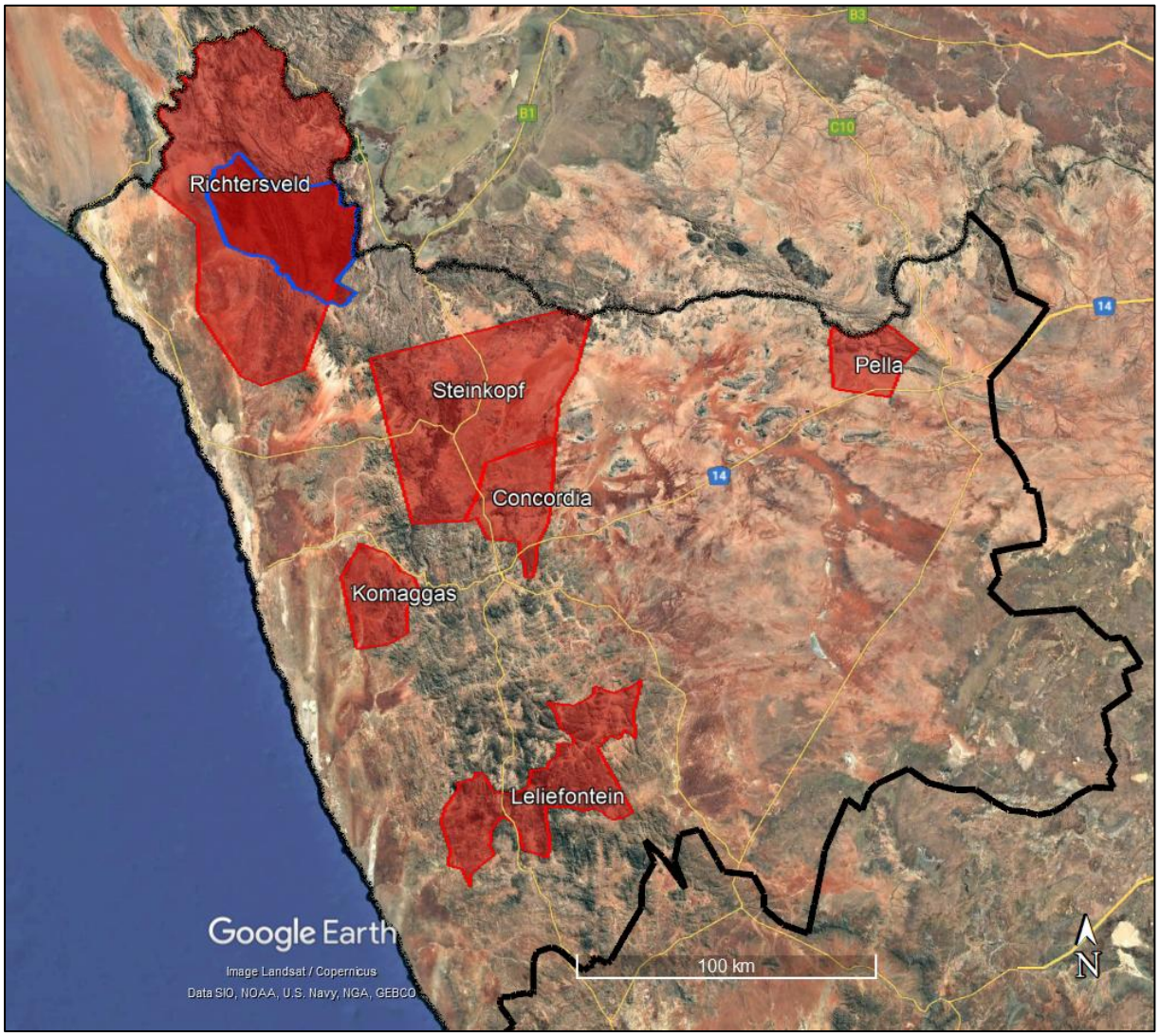

Figure 5-36: Sensitivity mapping for living heritage. Red = high. The 6 communal reserves are shown as red polygons (high sensitivity) and the RCBL WHS is the dark red polygon with blue outline (very high sensitivity). Differing forms of transhumance are followed by the herders in each of the areas.

5.5.7 *Cultural Landscape / sense of place*

From a purely visual point of view, the following features are identified as highly sensitive for their aesthetic value: the WHS and its buffer zone, the various National Parks and other reserves, the coastline, the Kamiesberg, and the various main roads through the area (**Figure 5-37**). From a more cultural point of view, the RCBL (and buffer) and National Parks would also be seen as very high sensitivity (these areas are captured within the visual sensitivity mapping). Further detailed mapping is not possible without ground truthing, but the remainder of the study area is likely to be of at least medium sensitivity for aesthetic reasons. It should be noted, however, that, in terms of impact assessment, sensitivity also varies depending on the type of development, since some developments will be far more visually intrusive than others.

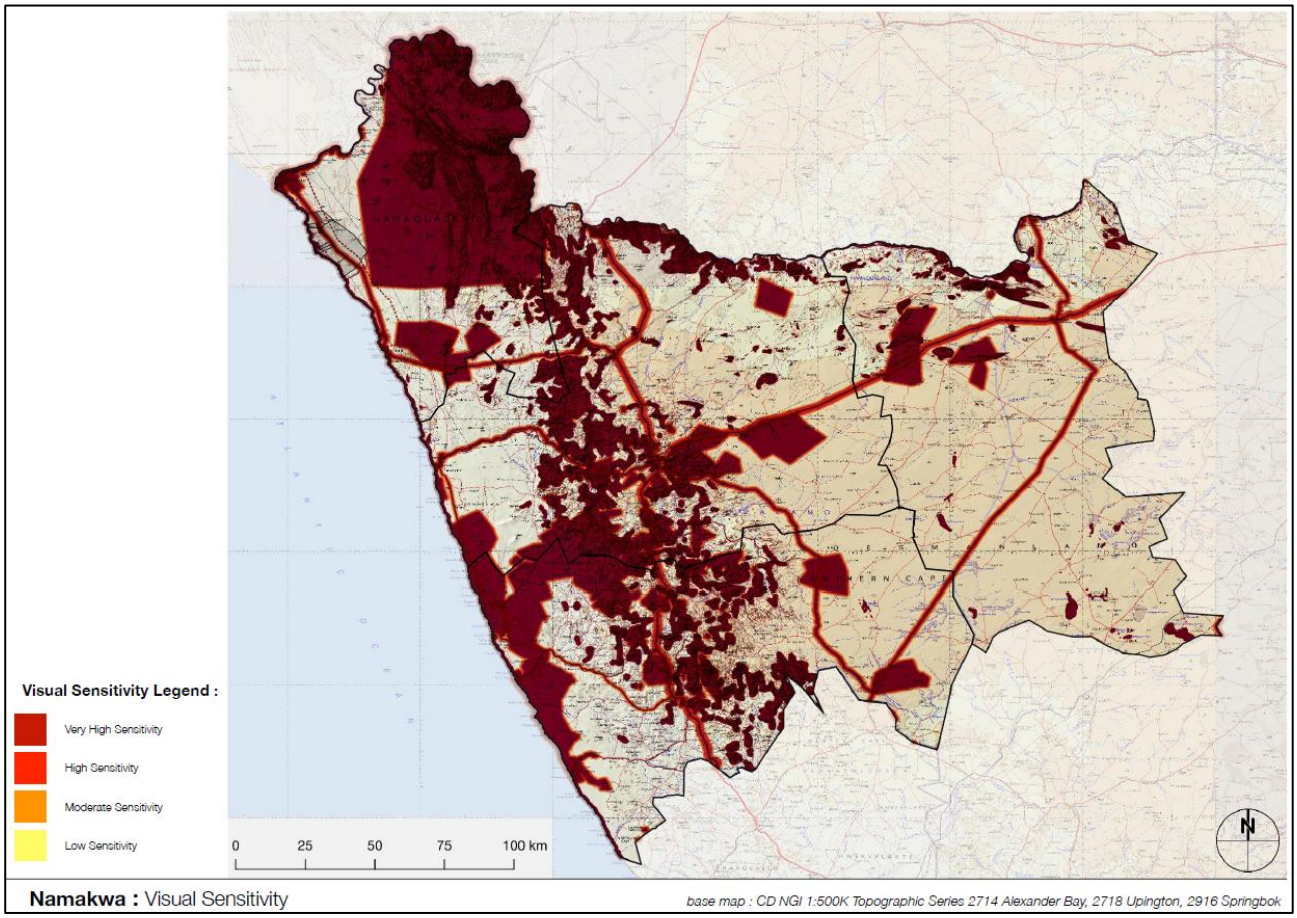

Figure 5-37: Visual sensitivity map for the Namakwa study area.

5.6 POTENTIAL IMPACTS (POSITIVE AND NEGATIVE)

5.6.1 *Baseline Scenario (up to 2050)*

Here we consider the negative and positive effects of the various development scenarios. These include a Baseline Scenario, in which the GH2 economy does not take place. In this scenario, the current social, ecological, climatic and developmental trends continue.

Negative Impacts:

Palaeontology:

- Desertification and increased mining may expose new fossil sites and risk fossil loss.

Terrestrial Archaeology (pre-colonial and colonial):

- Increasing agricultural development along the Orange River and the continuation of diamond mining along the coast continue to threaten significant archaeological sites on the banks of the river and along the coastline. These activities appear to be poorly regulated and pose the greatest threat to archaeology.

- Renewed copper mining centred in Okiep may impact the historic Copper Mining Landscape, damaging historic infrastructure which has not been adequately recorded. Potential artisanal mining licences and an increase in oil and gas exploration along the coast may impact archaeological and historical sites. Prospecting and increase in mining for manganese and iron, as well as granite in the northern part of the study area (centred around Aggeneys and Pofadder, may impact on heritage resources in this area. Despite the implementation of the environmental process, archaeological resources are being lost on an incremental basis.

- Continued development of renewable energy facilities in the REDZ (wind and solar farms) as well as new transmission lines may impact heritage resources, but impacts are generally mitigated during the Environmental Impact Assessment process as prescribed in NEMA (Act 107 of 1998) and the NHRA (Act 25 of 1999).

- The development of new roads and the industrial corridor from Springbok to Upington along the N14 may potentially impact on archaeological resources but impacts can be mitigated during the environmental process.

Maritime heritage:

- Potential offshore mining and gas exploration may impact on unknown wrecks and may result in their destruction.

Graves

- Graves will continue to be impacted very occasionally. Given that they are generally completely unmarked, impacts are unpredictable.

History and Built Environment

- Incremental increases in mining and infrastructure development, may impact on historic places, structures and buildings older than 60 years which may be destroyed, damaged or vandalised.

Living Heritage:

- Small stock farmers in the communal areas are likely to continue with traditional grazing practices despite poor environmental conditions and overgrazing. This may threaten certain aspects of living heritage. Infrastructure and mining development may also occur in communal grazing lands and further threaten traditional landuse patterns.

Cultural Landscape:

- Population growth and associated development will gradually alter the historical and cultural landscapes. This is already happening in the Springbok/Okiep and Aggeneys areas. This is in contrast with the seasonal tourism initiatives which rely on the natural aesthetic and heritage preservation of the region.

Positive Impacts:

- Positive impact can result from the discovery and recording of fossils and archaeological sites. These would be of benefit to science. It must be noted, however, that impacts to highly significant sites would still be seen as negative. Growth in tourism may reinforce the need to protect heritage resources which are tourist attractions.

Potential Negative Impacts associated with proposed development

5.6.2 Scenario 1 (by 2035)

Negative Impacts:

Palaeontology:

- Impacts are likely to be largely insignificant over the bulk of the study area because most development will affect surficial sediments which are generally of low palaeontological sensitivity. However, excavation depths might vary. The main exception is at the coast where buried sediments of high sensitivity are more likely to be encountered.

Terrestrial Archaeology (pre-colonial and colonial):

- Impacts to surface resources across the area are possible, but generally not likely to be of high significance. The exception is for increased development along the coastline where archaeological sites of higher significance are more concentrated. However, the overall impact area close to the coast is likely to still be small compared to the existing and ongoing impacts from mining. Inland sites will be more dispersed and there is the opportunity to avoid them during development.

Maritime heritage:

- Impacts are unlikely to significantly increase due to the generally low probability of wrecks being found. However, there is always a chance of impacts.

Graves

- Impacts to graves are unpredictable and it is equally possible that several or no graves could be affected.

Historical resources and built environment

- Given the relatively small footprint of Scenario 1, significant impacts to historical and built environment resources are unlikely. The main potential threat could be the insensitive 'restoration' of historical structures or even potentially their demolition in towns where new residential areas are required. Steinkopf, Okiep and Springbok may be most at risk here.

Living Heritage:

- The relatively small footprint is unlikely to impact on communal use areas in which living heritage traditions are still practiced because they could be easily avoided. Nonetheless, the Communal Areas of Steinkopf, Concordia and the Richtersveld are perhaps most at risk as these areas are located near potential centres of development.

Cultural Landscape:

- The relatively small overall footprint should not have significant impacts on the cultural landscape unless specific developments are situated in close proximity to prominent and aesthetically pleasing landscape features.

Positive Impacts:

- Positive impacts will largely relate to the increase in scientific knowledge in terms of the discovery, recording and sampling of fossils and archaeological sites. These would be of benefit to science. It must be noted, however, that impacts to highly significant sites would still be seen as negative.

- Another potential benefit comes with the responsible restoration and reuse of historical structures which might otherwise become degraded over time through neglect and disuse. This reuse may relate directly to the development or indirectly through the need for increased accommodation in the area.

- Growth in tourism may increase the need to protect heritage resources which are tourist attractions.

5.6.3 Scenario 2 (by 2050)

Negative Impacts:

Impacts with a large development scenario will be very similar to the small development scenario but just with higher intensity. This is because the larger overall footprint will mean more pressure on available land and a reduced likelihood of being able to avoid impacts. This is likely to be exacerbated along the coastline where space between significant archaeological sites is far more limited. Inland developments, either on the coastal plain (more than 2 km from the coast) or in Bushmanland are likely to be able to avoid the majority of significant sites since they tend to be located adjacent to water courses, pans or rocky hills. Due to the far larger land requirement, there is a far greater chance of impacts to the communal areas.

Positive Impacts:

- As for the small development scenario, but with a greater increase in scientific knowledge.

- Due to the far larger land requirement, there is an increased likelihood that the communal area will be used for at least some development. Although loss of communal land is an impact, financial benefit could accrue to the affected communities with the proper agreements in place.

5.7 RISK/OPPORTUNITY ASSESSMENT OF IMPACTS

Below, we consider a systematic risk/opportunity assessment of the impacts relating to the GH2.

Risk and opportunity are determined by estimating the likelihood of events or trends occurring, in relation to their negative or positive consequences i.e. likelihood x consequence.

The consequence/benefit categories are described in Table 5-1.

Table 5-2 indicates the predefined risk/opportunity categories.

Table 5-3 to Table 5-16 shows the Risk/Opportunity assessments associated with the negative/positive impacts, respectively.

TABLE 5-1: Defined Consequence/Benefit Categories. Note that "Significance" refers to "Cultural Significance" in terms of the NHRA.

Theme/ Receptor	Negative consequences (-)				
	Slight	Moderate	Significant	Drastic	Extreme
Palaeontological Resources	Isolated fossils of low significance damaged or destroyed	Fossils of medium significance damaged or destroyed in a small area	Fossils of high significance damaged or destroyed in a small area	Fossils of high significance damaged or destroyed in a large area	Fossils of high significance damaged or destroyed in multiple large areas
Archaeological Resources	Isolated artefacts or sites of low significance damaged or destroyed	Occasional small sites of low to medium significance damaged or destroyed	Occasional large sites of medium to high significance, or many small sites of low to medium significance damaged or destroyed	Several large sites of medium to high significance, or many small sites of medium significance damaged or destroyed	Widespread destruction of sites of high significance
Maritime	Shipwrecks of low significance minimally damaged	Shipwrecks of low to medium significance minimally damaged	Shipwrecks of medium significance damaged or wrecks of low significance destroyed	Shipwrecks of high significance damaged, or wrecks of medium significance destroyed	Shipwrecks of high significance damaged or destroyed
Graves	Graves uncovered, reported and rescued with minimal damage	Few graves uncovered, reported and rescued after being damaged or disturbed	Many graves uncovered and only reported and rescued after being disturbed or removed	Occasional graves destroyed, or many graves uncovered and only reported and rescued after being disturbed or removed	Many graves destroyed without any record
Built heritage	New buildings near heritage structures affect their context, or low to medium significance heritage structures altered in sensitive ways	New buildings overwhelm heritage structures, or medium significance heritage structures are altered insensitively	Partial demolition of medium significance heritage structures	Partial demolition of high significance heritage structures	Total demolition of high significance heritage structures
Living Heritage	Development in the vicinity of living heritage sites	Occasional living heritage sites damaged, or transhumant settlement patterns constrained	Occasional living heritage sites damaged or destroyed, or transhumant settlement patterns disrupted	Several living heritage sites damaged or destroyed, or transhumant settlement patterns severely disrupted	Widespread destruction of living heritage sites or complete cessation of transhumant settlement patterns

Cultural Landscape	Occasional nodes of development occur in low to medium visual sensitivity areas	Frequent nodes of development occur in low to medium visual sensitivity areas, sense of place disrupted	Frequent nodes of development occur in medium to high visual sensitivity areas, sense of place severely disrupted	Frequent nodes of development occur in high visual sensitivity areas or widespread development in medium sensitivity areas, sense of place severely disrupted	Widespread development in high visual sensitivity areas, sense of place destroyed
Theme/ Receptor	**Positive consequences (+)**				
	Slight	**Moderate**	**Significant**	**Drastic**	**Extreme**
Palaeontological Resources	Occasional fossils of low significance uncovered and rescued	Occasional fossils of medium significance uncovered and rescued	Occasional fossils of high significance uncovered and rescued	Many fossils of high significance uncovered and rescued	Many fossils of high significance uncovered and rescued over large areas
Archaeological Resources	Occasional sites of low to medium significance are rescued with minimal loss	Many sites of low to medium significance are rescued with minimal loss	Many sites of medium to high significance are rescued with minimal loss	Many sites of high significance are rescued with minimal loss	Many sites of high significance are rescued with minimal loss, and some are formally protected (e.g. heritage declaration or in protected areas)
Maritime	Shipwrecks of low significance discovered and protected with minimal damage	Shipwrecks of low significance discovered, recorded and protected with minimal damage	Shipwrecks of medium to high significance discovered, recorded and protected with minimal damage	Shipwrecks of high significance discovered, recorded and protected with minimal damage	Shipwrecks of high significance discovered and extensively studied/excavated
Graves	Occasional marked graves discovered and protected	Occasional marked graves in several areas discovered and protected	Occasional marked graves in widespread areas discovered and protected	Many marked graves in several areas discovered and protected	Many marked graves in widespread areas discovered and protected
Built heritage	Occasional heritage structures are recognised and protected from harm	Many heritage structures are recognised and protected from harm	Many heritage structures are recognised and protected from harm with some receiving formal protection (e.g. heritage declaration)	Many heritage structures receive formal protection (e.g. heritage declaration)	Many heritage structures receive formal protection (e.g. heritage declaration) and celebration

Living Heritage	Occasional living heritage sites are recognised and protected from harm	Many living heritage sites are recognised and protected from harm	Many living heritage sites are recognised and protected from harm with some receiving formal protection (e.g. heritage declaration or in protected areas)	Many living heritage sites receive formal protection (e.g. heritage declaration or in protected areas)	Many living heritage sites receive formal protection (e.g. heritage declaration or in protected areas) and celebration
Cultural Landscape	Some rehabilitation of existing mining impacts in low visual sensitivity areas	Some rehabilitation of existing mining impacts in high visual sensitivity areas	Extensive rehabilitation of existing mining impacts in high visual sensitivity areas	Extensive rehabilitation of existing mining impacts in high visual sensitivity areas and/or some expansion of formally protected areas	Extensive rehabilitation of existing mining impacts in high visual sensitivity areas and/or extensive expansion of formally protected areas

Limitation to above table:

Clearly, the grading of impacts is more complicated than Table 8 suggests above. So, for example, the total number of fossils uncovered, and their significance, cannot be converted to a linear expression. A single hominid fossil fragment, for example, is scientifically more significant than hundreds of fossil tortoise fragments. A similar comment can be made with respect to archaeological sites as well as historic buildings and shipwrecks. The significance of archaeological and fossil heritage sites has been addressed by SAHRA in their grading system. In this scenario, impacts to a single small, but high-graded, heritage resource/site may be much greater than impacts to a large number of low-graded heritage sites. The consequence will be higher without mitigation and the likelihood will be greater.

TABLE 5-2: Predefined risk/opportunity categories

RISK (-)		OPPORTUNITY (+)	
VERY LOW	Almost indiscernible negative impact.	Almost indiscernible positive impact.	VERY LOW
LOW	Slight negative impact, limited extent, and short duration, well within tolerance.	Slight positive impact, very localised, well below expectations.	LOW
MODERATE	Substantial impact, but less than major; within tolerance and below limits of acceptable change.	Substantial positive impact, but mostly short term, and spatially limited.	MODERATE
HIGH	Major consequence, approaching tolerance and limits of acceptable change.	Highly desirable impact, major medium to long term positive impacts across a broad range of stakeholders at local or regional scales.	HIGH
VERY HIGH	Extremely negative impact, persistent/long lasting, beyond tolerance and limits of acceptable change.	Highly desired, grandiose long term positive impacts across a broad range of stakeholders at local, regional, national, and/or international scales.	VERY HIGH

TABLE 5-3: Risk associated with a negative impact on **Palaeontological resources**

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	Very high Sensitivity	Significant	Likely	Moderate	Moderate	Likely	Moderate
	S1: Small GH2		Significant	Likely	Moderate	Moderate	Likely	Moderate
	S2: Big GH2		Drastic	Likely	High	Significant	Likely	Moderate
	S0: Baseline	High Sensitivity	Moderate	Likely	Moderate	Slight	Likely	Moderate
	S1: Small GH2		Moderate	Likely	Moderate	Slight	Likely	Moderate
	S2: Big GH2		Significant	Likely	Moderate	Moderate	Likely	Moderate
	S0: Baseline	Medium Sensitivity	Slight	Likely	Moderate	Slight	Likely	Moderate
	S1: Small GH2		Slight	Likely	Moderate	Slight	Likely	Moderate
	S2: Big GH2		Moderate	Likely	Moderate	Slight	Likely	Moderate
	S0: Baseline	Low Sensitivity	Slight	Likely	Moderate	Slight	Likely	Moderate
	S1: Small GH2		Slight	Likely	Moderate	Slight	Likely	Moderate
	S2: Big GH2		Slight	Likely	Moderate	Slight	Likely	Moderate

TABLE 5-4: Opportunity Associated with positive impact on **Palaeontological resources**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (+)	Likelihood	Opportunity	Consequence (+)	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	Slight	Very unlikely	Very low	Moderate	Unlikely	Low
	S1: Small GH2		Slight	Very unlikely	Very low	Moderate	Unlikely	Low
	S2: Big GH2		Slight	Very unlikely	Very low	Significant	Likely	Moderate
	S0: Baseline	High Sensitivity	Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S2: Big GH2		Slight	Very unlikely	Very low	Moderate	Likely	Moderate
	S0: Baseline	Medium Sensitivity	Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S2: Big GH2		Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S0: Baseline	Low Sensitivity	Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Unlikely	Low
	S2: Big GH2		Slight	Very unlikely	Very low	Slight	Unlikely	Low

TABLE 5-5: Risk Associated with a negative impact on **Archaeological resources**. Note that although only high and low sensitivity have been mapped at the regional scale, other categories could be mapped with fieldwork but would likely be very small areas. For this reason, all sensitivity levels are assessed.

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	*Very High Sensitivity*	Drastic	Definite	Very High	Moderate	More Likely	High
	S1: Small GH2		Drastic	Definite	Very High	Moderate	More Likely	High
	S2: Big GH2		Extreme	Definite	Very High	Significant	More Likely	High
	S0: Baseline	*High Sensitivity*	Moderate	Definite	Very High	Moderate	Likely	Moderate
	S1: Small GH2		Moderate	Definite	Very High	Moderate	Likely	Moderate
	S2: Big GH2		Significant	Definite	Very High	Significant	Likely	Moderate
	S0: Baseline	*Medium Sensitivity*	Slight	More Likely	High	Slight	Likely	Moderate
	S1: Small GH2		Slight	More Likely	High	Slight	Likely	Moderate
	S2: Big GH2		Moderate	More Likely	High	Moderate	Likely	Moderate
	S0: Baseline	*Low Sensitivity*	Slight	Likely	Moderate	Slight	Unlikely	Low
	S1: Small GH2		Slight	Likely	Moderate	Slight	Unlikely	Low
	S2: Big GH2		Slight	Likely	Moderate	Slight	Unlikely	Low

TABLE 5-6: Opportunity Associated with positive impact on **Archaeological resources**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (+)	Likelihood	Opportunity	Consequence (+)	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	Slight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S1: Small GH2		Moderate	Very Unlikely	Very Low	Slight	Unlikely	Low
	S2: Big GH2		Moderate	Very Unlikely	Very Low	Moderate	Unlikely	Low
	S0: Baseline	High Sensitivity	Slight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S1: Small GH2		Moderate	Very Unlikely	Very Low	Slight	Unlikely	Low
	S2: Big GH2		Moderate	Very Unlikely	Very Low	Moderate	Unlikely	Low
	S0: Baseline	Medium Sensitivity	Slight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S2: Big GH2		Moderate	Very Unlikely	Very Low	Slight	Unlikely	Low
	S0: Baseline	Low Sensitivity	Sight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Very Unlikely	Very Low	Slight	Unlikely	Low
	S2: Big GH2		Slight	Very Unlikely	Very Low	Slight	Unlikely	Low

TABLE 5-7: Risk Associated with a negative impact on **Maritime resources**

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	Very high Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Medium Sensitivity	Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: Small GH2		Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S2: Big GH2		Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S0: Baseline	Low Sensitivity	Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low
	S1: Small GH2		Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low
	S2: Big GH2		Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low

TABLE 5-8: Opportunity associated with positive impact on **Maritime resources**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (+)	Likelihood	Opportunity	Consequence (+)	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Medium Sensitivity	Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: Small GH2		Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S2: Big GH2		Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S0: Baseline	Low Sensitivity	Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low
	S1: Small GH2		Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low
	S2: Big GH2		Slight	Very unlikely	Very Low	Slight	Very unlikely	Very Low

TABLE 5-9: Risk associated with a negative impact on **Graves**

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	Very high Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Medium Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Low Sensitivity	Drastic	More likely	High	Significant	Likely	Moderate
	S1: Small GH2		Drastic	More likely	High	Significant	Likely	Moderate
	S2: Big GH2		Extreme	More likely	Very High	Drastic	Likely	High

TABLE 5-10: Opportunity Associated with positive impact on **Graves**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence	Likelihood	Opportunity	Consequence	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Medium Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Low Sensitivity	Slight	Very unlikely	Very low	Moderate	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S2: Big GH2		Moderate	Very unlikely	Very Low	Significant	More likely	High

TABLE 5-11: Risk Associated with a negative impact on **Built Environment**

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	Very high Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: Small GH2		Moderate	Likely	Moderate	Slight	Unlikely	Low
	S2: Big GH2		Significant	More likely	High	Moderate	Likely	Moderate
	S0: Baseline	High Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: Small GH2		Moderate	Likely	Moderate	Slight	Unlikely	Low
	S2: Big GH2		Significant	More likely	High	Moderate	Likely	Moderate
	S0: Baseline	Medium Sensitivity	Slight	Unlikely	Low	Slight	Very Unlikely	Very Low
	S1: Small GH2		Slight	Unlikely	Low	Slight	Very Unlikely	Very Low
	S2: Big GH2		Moderate	Likely	Moderate	Slight	Unlikely	Low
	S0: Baseline	Low Sensitivity	Slight	Unlikely	Low	Slight	Very Unlikely	Very Low
	S1: Small GH2		Slight	Unlikely	Low	Slight	Very Unlikely	Very Low
	S2: Big GH2		Slight	Likely	Moderate	Slight	Unlikely	Low

TABLE 5-12: Opportunity Associated with positive impact on **Built Environment**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (+)	Likelihood	Opportunity	Consequence	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	Slight	Unlikely	Low	Moderate	More likely	High
	S1: Small GH2		Slight	Unlikely	Low	Moderate	More likely	High
	S2: Big GH2		Slight	Likely	Moderate	Significant	Definite	Very High
	S0: Baseline	High Sensitivity	Slight	Unlikely	Low	Moderate	More likely	High
	S1: Small GH2		Slight	Unlikely	Low	Moderate	More likely	High
	S2: Big GH2		Slight	Likely	Moderate	Significant	Definite	Very High
	S0: Baseline	Medium Sensitivity	Slight	Very Unlikely	Very Low	Slight	Likely	Moderate
	S1: Small GH2		Slight	Very Unlikely	Very Low	Slight	Likely	Moderate
	S2: Big GH2		Slight	Unlikely	Low	Moderate	More likely	High
	S0: Baseline	Low Sensitivity	Slight	Very Unlikely	Very Low	Slight	Likely	Moderate
	S1: Small GH2		Slight	Very Unlikely	Very Low	Slight	Likely	Moderate
	S2: Big GH2		Slight	Unlikely	Low	Slight	Likely	Moderate

TABLE 5-13: Risk Associated with a negative impact on **Living Heritage**. Communal areas where living heritage is practised are rated high with no other sensitivity rating recognised.

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Opportunity
	S0: Baseline	Very high Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	Significant	Likely	Moderate	Moderate	Unlikely	Low
	S1: Small GH2		Significant	Likely	Moderate	Moderate	Unlikely	Low
	S2: Big GH2		Drastic	More Likely	High	Significant	Likely	Moderate
	S0: Baseline	Medium Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Low Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a

TABLE 5-14: Opportunity Associated with positive impact on **Living Heritage**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (+)	Likelihood	Opportunity	Consequence (+)	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	High Sensitivity	Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S2: Big GH2		Slight	Unlikely	Low	Significant	More Likely	High
	S0: Baseline	Medium Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S0: Baseline	Low Sensitivity	n/a	n/a	n/a	n/a	n/a	n/a
	S1: Small GH2		n/a	n/a	n/a	n/a	n/a	n/a
	S2: Big GH2		n/a	n/a	n/a	n/a	n/a	n/a

TABLE 5-15: Risk Associated with a negative impact on **Cultural Landscape**

Negative Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
	S0: Baseline	Very high Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: Small GH2		Moderate	Likely	Moderate	Slight	Unlikely	Low
	S2: Big GH2		Significant	More Likely	High	Moderate	Likely	Moderate
	S0: Baseline	High Sensitivity	Drastic	Likely	High	Moderate	Likely	Moderate
	S1: Small GH2		Drastic	Likely	High	Moderate	Likely	Moderate
	S2: Big GH2		Extreme	More Likely	Very High	Significant	More Likely	High
	S0: Baseline	Medium Sensitivity	Moderate	Unlikely	Low	Slight	Likely	Moderate
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Likely	Moderate
	S2: Big GH2		Significant	Likely	Moderate	Moderate	More Likely	High
	S0: Baseline	Low Sensitivity	Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: Small GH2		Slight	Unlikely	Low	Slight	Very unlikely	Very Low
	S2: Big GH2		Slight	Unlikely	Low	Slight	Unlikely	Low

TABLE 5-16: Opportunity Associated with positive impact on **Cultural Landscape**

Positive Impact	Scenario	Spatial Receiving Environment	Without Management			With Management		
			Consequence	Likelihood	Opportunity	Consequence	Likelihood	Opportunity
	S0: Baseline	Very High Sensitivity	Slight	Very unlikely	Very Low	Significant	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Significant	Likely	Moderate
	S2: Big GH2		Slight	Very unlikely	Very Low	Drastic	More likely	High
	S0: Baseline	High Sensitivity	Slight	Very unlikely	Very Low	Significant	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Significant	Likely	Moderate
	S2: Big GH2		Slight	Very unlikely	Very Low	Drastic	More likely	High
	S0: Baseline	Medium Sensitivity	Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S2: Big GH2		Slight	Very unlikely	Very Low	Significant	More likely	High
	S0: Baseline	Low Sensitivity	Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S1: Small GH2		Slight	Very unlikely	Very Low	Moderate	Likely	Moderate
	S2: Big GH2		Slight	Very unlikely	Very Low	Significant	More likely	High

5.8 RECOMMENDED STRATEGIC MANAGEMENT ACTIONS

A Heritage Impact Assessment (HIA), compliant with Section 38(3) of the NHRA and relevant heritage authority minimum standards, will be required for every Environmental Impact Assessment that triggers Section 38(8) of the NHRA. .

A separate Visual Impact Study must be included in every EIA process where visual impacts to the landscape are a concern.

- *An assessment of the impact to heritage resources must be undertaken for each specific development as part of the NEMA authorisation process.*
- *These HIAs may include specialist assessments such as Archaeological Impact Assessments, Palaeontological Impact Assessments, Built Environment Assessments, Cultural Landscape Assessments and other relevant specialist studies.*
- *The HIA must comply with Section 38(3) of the NHRA and published Minimum Standards or reporting requirements issued by the relevant heritage authorities.*
- *All HIAs must be submitted through the relevant heritage authority application system, in this case SAHRIS, together with supporting documentation including EIAs, BARs, SSVRs and applicable processing fees.*
- *All NEMA authorisation applications submitted to DFFE or the provincial competent authorities must include comments from the relevant heritage authorities. Applications lacking heritage authority comment may be considered incomplete and subject to rejection.*
- *The final SEA must be submitted to SAHRA for record purposes.*
- *The decision regarding the Gazette process must be uploaded to the relevant SAHRIS case for record purposes.*

Management actions will vary depending on the type of resource being impacted, the nature of the impact, and the nature of the proposed development. The list below thus serves as a general guide for further assessment and best practice.

5.8.1 Palaeontology

- There are no areas of highly sensitive fossiliferous strata in the study area that may require protection as No-Go areas.
- Every project MUST be evaluated by a palaeontologist to determine the need for a palaeontological specialist study despite the surface sensitivity grading because, depending on depth of excavation, significant impacts could still arise, especially along the coast.

5.8.2 Terrestrial Archaeology

- Archaeological specialist studies will be required in all EIAs and detailed surveys of each project footprint must take place.
- Due to the density and distribution of archaeological sites along the coastline, it will not be feasible to mitigate all impacts there. The appointed archaeologists will likely need to determine the sites to sample in order to best characterize the archaeology in each development footprint.
- Desktop study and fieldwork suggest that No-Go areas are unlikely to be identified in the region. However, the possibility of preserving certain coastal areas found to contain a high density of

archaeological resources might be considered during EIAs, especially if there are other reasons to protect these same areas.

- Away from the coast mitigation will be easier to implement and all significant sites could be sampled.
- It is likely that monitoring of construction excavations and grubbing may be required in coastal areas where middens can be buried within sand dunes.

5.8.3 Maritime Heritage

- A Maritime Heritage specialist study will need to be included in any developments that might require, for example, undersea pipelines.
- The need for fieldwork within EIAs must be determined based on the development proposal, but it is likely that most underwater fieldwork can be conducted during the pre-construction/micrositing phase of any development.

5.8.4 Graves

- Graves would be considered along with archaeology in any EIA.
- Given the size of the study area, it is possible that many graves could be present. Discussions with the Northern Cape Heritage Resources Authority and representatives of local communities should be initiated in advance of development to determine whether reburial of human remains should be considered and which locations should be chosen for this. Exhumations should only occur where no other options for mitigation are possible.
- When retained close to developments, graves should be fenced in order to enhance their long term protection.

5.8.5 History and built environment

- Historical and built environment sites would need to be evaluated against a development proposal during any EIA because reuse and buffer size would vary based on the proposal and what the potential impacts would be. Restoration work may also be recommended in order to enhance the future protection and cultural significance of such sites.
- In general, it will be best practice to avoid farmsteads with a buffer large enough so as to not render the structures 'uninhabitable' due to the close proximity of undesirable development. Uninhabited structures tend to fall into disrepair.

5.8.6 Living heritage

- The local herder communities in each of the communal areas should be consulted to determine their response to the loss of their grazing lands. Among other things, consultation should aim to understand:
    - The Grazing Management Plan should be informed by social research in order to account for the potential impacts on the living heritage practices of local communities, including seasonal grazing patterns, mobility routes, stockpost use, and associated intangible heritage traditions.
    - Why these areas were chosen for grazing.
    - The value of the pasturage in terms of seasonal grazing requirements.
    - Any alternative options; and
    - How the local environment (nature) and culture are intertwined within their world view.

5.8.7 Cultural landscape / sense of place

- The N7, N14 and the R382 and surrounding area are significant for a number of reasons, largely tourism-related. SANParks, UNESCO, SAHRA and local tourism operators should all be engaged in the consultation process because the arid to semi-arid landscapes of the area are key elements of the aesthetic beauty and attract tourists.
- Any proposed development in or close to the buffer zone of the RCBL Heritage Site could cause significant impacts. Discussions will need to be initiated with the South African Government and the UNESCO commission regarding potential impacts on the World Heritage status of the RCBL in such instances. It is here suggested that the entire RCBL, and preferably also its buffer zone, be considered a No-Go area.

Any development that will reuse heritage sites or preserve them within close proximity to the development may require the compilation of a management plan that guides reuse, restoration and or preservation of the resources. This would be compiled under the conditions of authorisation.

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CHAPTER 6

Infrastructure and Planning

CHAPTER 6: Infrastructure and Planning

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Executive Summary

This chapter evaluates the implications of the proposed Boegoebaai Port and SEZ development, with a focus on three key risk areas: (1) Development Planning and Regulatory Capacity, (2) Settlement Infrastructure Development and Management, and (3) Construction of Economic Infrastructure. The assessment considers three scenarios; Baseline, Small Green Hydrogen, and Large Green Hydrogen, to identify risks, assess severity, and propose mitigation measures. The key risk areas and mitigation recommendations can be summarised as:

1. Development Planning and Regulatory Capacity

Baseline: Existing planning demand is low. Current mechanisms such as the District Municipal Tribunal are sufficient for limited applications.

Small Green Hydrogen: A sharp increase in land-use applications is expected, particularly in Richtersveld. Without new capacity, institutions will be unable to manage high volumes, and delays may arise from complex land ownership and CPA-related issues. Risk severity: severe without mitigation.

Large Green Hydrogen: Regional infrastructure projects (green energy, pipelines, new rail) will sustain high pressure across several municipalities. The risks remain severe if not addressed. Risk severity: severe without mitigation; moderate with mitigation.

Mitigation Recommendations can be summarised as:

- Establish a strengthened planning support mechanism at district/provincial level to manage high volumes of land-use applications and related planning decisions.
- Build municipal planning capacity, including dedicated planners, to ensure effective processing and compliance, and
- Develop clear, coordinated processes for securing servitudes and addressing communal land ownership disputes.

2. Settlement Infrastructure Development and Management

Baseline: Limited growth is occurring, with incremental pressures in Pofadder, Aggeneys, and Springbok. Infrastructure conditions remain largely unchanged elsewhere.

Small Green Hydrogen: Settlement pressure will increase sharply, particularly in Port Nolloth and Alexander Bay, driven by construction workers, in-migration, and port- and SEZ-related activities. Social services and bulk infrastructure (water, sanitation, electricity) will be under significant strain. Risk severity: severe without mitigation; moderate with mitigation.

Large Green Hydrogen: Sustained demand across multiple towns, with Richtersveld and secondary towns facing high growth. Without intervention, service breakdowns, informal settlement growth, and inequality risks rise. Risk severity: severe without mitigation; moderate with mitigation.

Key mitigation recommendations include:

- Prioritise bulk service upgrades (water, sanitation, electricity) in Port Nolloth and Alexander Bay
- Strengthen municipal financial viability and planning to manage settlement growth

- Focus housing and service delivery in nodal areas to reduce informality and concentrate resources, and
- Align social infrastructure investments (schools, clinics, waste facilities) with settlement growth patterns.

3. Construction of Economic Infrastructure

Baseline: Roads (R382, N7, N14) currently experience low traffic volumes and routine maintenance. No pipelines or rail infrastructure are present, with only minor Eskom upgrades underway.

Small Green Hydrogen: Multiple simultaneous projects (port, SEZ, pipelines, transmission, renewable energy) will create severe pressure on transport, land, and resource systems. Key risks include deterioration of the R382 from heavy vehicle traffic, high demand for construction materials and water, and accommodation of large construction workforces. Risk severity: high to severe.

Large Green Hydrogen: Risks escalate with additional rail and pipeline development. Land acquisition, servitude processes, and environmental impacts will be complex. Heavy traffic will further strain regional roads. Risk severity: severe without mitigation; moderate with mitigation.

Key mitigation recommendations identified:

- Shorten maintenance cycles on the R382 and secure sustainable budgets for upkeep
- Implement systematic monitoring of road conditions to enable timely intervention
- Coordinate land acquisition and servitude processes across agencies (rail, pipelines, transmission)
- Develop guidelines for construction camps in collaboration with municipalities to avoid overburdening local services, and
- Monitor and plan for water demand associated with construction, including borehole use and licensing

In summary, the successful implementation of the Boegoebaai Port and SEZ development will require substantial enhancements in municipal planning capacity, settlement service delivery systems and coordinated infrastructure management (also see section 7.6.5). Without mitigation, risks range from moderate to severe across all three key areas, with the most acute pressures expected in land-use planning capacity, settlement services, particularly water and sanitation, and transport infrastructure. With targeted mitigation, risks may be reduced to moderate only where institutional, financial and infrastructure measures are implemented as preconditions in advance of peak development phases. In particular, development planning support mechanisms, water and sanitation upgrades, municipal service protection measures, land access protocols and road rehabilitation requirements must be operational before the relevant phases of development proceed. Where these enabling measures are not demonstrably secured, the development pathway should be regarded as carrying moderate to severe strategic risk.

The scenarios therefore highlight the importance of early planning, coordinated land access, cumulative infrastructure planning and investment in bulk services as conditions precedent for enabling the Port and SEZ to contribute to sustainable regional development.

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Definitions

The following reflects a number of selected definitions applicable to this section:

Breaking New Ground (BNG)	The Department of Human Settlements is mandated with the implementation of Breaking New Ground (BNG) Developments, formally known as Reconstruction and Development Programme (RDP) Developments. BNG provides fully subsidised houses to low-income families. (Urban4Site, 2024)
Core regions	Refers to the four local municipalities that comprise the SEA study area region namely Richtersveld, Nama Khoi, Kamiesberg, and Khai-Ma.
District Municipal Tribunal (municipal cooperation)	A District municipality may, with the agreement of the local municipalities within the area of such district municipality, establish a Municipal Planning Tribunal to receive and dispose of land development applications and land use applications within the district municipal area (Department of Rural Development and Land Reform (DRDLR) , 2013)
Electricity Grid Infrastructure (EGI)	Electricity Grid Infrastructure (EGI) is a term used to describe the network of transmission lines and stations that deliver electricity to consumers.
Green Energy (GE) Site	A green energy (GE) site refers to a location where renewable energy sources are harnessed and utilized. In the context of the Boegoebaai study these sources include solar and wind.
Green Hydrogen (GH_2)	GH_2 typically refers to Green Hydrogen, which is hydrogen produced through the electrolysis of water using renewable energy sources.
Greenfields development	Greenfield development refers to constructing new infrastructure or developments on previously unused land. Greenfield development presents a blank canvas, allowing planners and developers to design and build structures from scratch (Energylink, 2023).
Integrated development planning and plan	The planning instrument and process set in place by the Municipal Systems Act, 2000 (MSA), to enable coordinated service delivery and development between the three spheres of government and other role players within a municipal area, to 1) improve quality of life, 2) support sustainable development and transformation, and 3) facilitate democratic and multi-sector planning processes. The municipal Integrated Development Plan (IDP) addresses current and future societal needs within the context of social and ecological systems in which they exist. All project and activities related to infrastructure, land development, service delivery, and land and environmental management within any area needs to form part of the relevant IDP and associated sector plans and infrastructure investment frameworks.
Interim Protection of Informal Land Rights (IPILRA)	The Interim Protection of Informal Land Rights Act, 31 of 1996 (IPILRA), is a temporary but repeatedly extended law that protects people who hold informal or customary land rights from being deprived of those rights without their consent. Prior consent of informal right-holders is needed if a development would deprive or significantly infringe their land rights.
Land development	SPLUMA defines land development as the "*erection of buildings or structures on land or the change of use of land, including township establishment, the subdivision or consolidation of land or any deviation from the land use or uses permitted in terms of an applicable land use scheme*" (Department of Rural Development and Land Reform (DRDLR) , 2013, p. 13).
Land use	SPLUMA defines land use as the purpose for which land is or may be used lawfully in terms of a land use scheme, existing scheme or any other authorisation, permit or consent issued by a competent authority, and includes any conditions related to such land use purposes. This could be related to "zoning" in the traditional sense (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021).
Land use management	Land Use Management is the system of legal requirements and regulations that apply to land in order to achieve desirable and harmonious development of the built

	environment (Department of Rural Development and Land Reform (DRDLR) , 2013).
Local access roads	In the context of this report, these are any direct access roads used to access green energy installations, power lines, and pipelines. They also include any roads built in formal settlements developed to accommodate workers or to access informal settlements resulting from the in-migration of aspirant job seekers.
Municipal planning governance	The planning function undertaken by a municipality to manage land development within the municipal area.
Municipal service delivery	Delivery of housing, electricity and basic services such as water and sanitation, to which South African citizens have a constitutional right.
Municipal Spatial Development Framework (MSDF)	The objective of the Municipal SDF is to guide the spatial distribution of current and future land uses, infrastructure investment, development, and protection of the natural environment, considering financial realities, whilst giving effect to the vision, goals and objectives of the Municipal Integrated Development Plan (IDP). The SDF is intended to show desired patterns of land use, directions for future growth, indicate the alignment of Urban Edges, and depict special development areas, at a municipal level as well as local level. The impact of the SDF is limited to providing policy to guide and informing land development and management (Saldanha Bay Municipality, 2025)
National Development Plan	The NDP is seen as a guiding document for South Africa. It was released in 2011 and is positioned as a blueprint for tackling South Africa's challenges. In 2012, Cabinet adopted the NDP as a long-term vision and plan for the country. (National Science and Technology Forum, 2019).
Notified Maximum Demand	The Notified Maximum Demand (NMD) is the capacity in kVA, measured over a 30-minute integration period, per point of delivery/supply that the customer requests and Eskom contractually agrees to make available during all periods (ESKOM (a), 2024).
National Spatial Development Framework	A national spatial planning instrument with a long-term horizon that (1) is mandated by the Spatial Planning and Land Use Management Act, 2013 (SPLUMA), (2) has to be aligned with the National Development Plan (NDP), and (3) is adopted by Cabinet as official national spatial development policy for implementation throughout the country. As such, it provides: (1) an overarching spatial development framework including a set of principle-driven spatial investment and development directives for all three spheres and sectors of government, meaning 'where, when, what type, and how much to invest and spend throughout the country'; and (2) a set of strategic spatial areas of national importance from an ecological, social, economic and/or ICT or movement infrastructure perspective to be focused on and targeted by government and the private sector in the pursuit of strategic national development objectives and/or the prevention or mitigation of national crises (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021).
Renewable Energy Development Zones (REDZs)	Renewable energy development zones, essential for the development of large-scale wind and solar photovoltaic facilities. (Department of Forestry, Fishing and Environment, 2024a). REDZs are zones in which large-scale renewable energy development would be considered most appropriate based on environmental, social and economic factors (McEwan, 2017).
Regional infrastructure	This includes all national, provincial, and district roads, railway lines, power lines, water, and gas pipelines used to access and pass through the area. Road, rail, and pipelines are the main modes of transport considered for freight to and from the harbour and SEZ.
Renewable Energy Independent Power Producer Procurement (REIPPP) Programme	An initiative by the South African government aimed at increasing electricity capacity through private sector investment.
Regional Spatial Development Framework.	SPLUMA provides for the establishment of a planning instrument to enable focused temporal and spatial coordination of governance and investment actions in and between different spheres of government, within areas with unique but interrelated attributes or development challenges that span more than one municipality and/or

	province (Van Hyussteen, et al., 2016, p. 5).
Settlement	A settlement refers to a place where people live, work, study, play and relax. A settlement can range in size from a small number of dwellings grouped together, to a large city or groups/conglomerations of cities tied together through dense transport and communication networks (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021).
Spatial planning	This is the term used to describe a high level planning process that is inherently integrative and strategic, that takes into account a wide range of factors and concerns and addresses the uniquely spatial aspects of those concerns (South African Government, 2001).
Strategic Environmental Assessment (SEA)	Strategic Environmental Assessment (SEA) is a systematic process for evaluating the environmental consequences of policies, plans, and programs at an early stage of decision-making, alongside economic and social considerations (European Union, 2025).
Special Economic Zone (SEZ)	An area with different business and trade laws from the rest of the country. SEZs are located within a country's national borders, and their aims include increasing trade balance, employment, increased investment, job creation, and effective administration.
Strategic Integrated Project (SIP)	Projects designated as SIPs need to be of significant economic or social importance to the Republic, contribute substantially to any national strategy or policy relating to infrastructure development, or be above a certain monetary value determined by the PICC. (Infrastructure SA, 2024)
Spatial Planning and Land Use Management Act (SPLUMA)	SPLUMA is “The Spatial Planning and Land Use Management Act 16 of 2013” and came into operation on 1 July 2015. SPLUMA is a national framework act that requires provincial legislation to enable municipalities to enact spatial planning and land use management by-laws. The municipal SPLUMA by-laws prescribe how land use applications and appeals are dealt with. (Farrell, 2017)
Strategic Transmission Corridors	Important for planning electricity transmission and distribution infrastructure and for following the procedure for applying for environmental authorisation for electricity transmission and distribution expansion in these corridors. (Department of Forestry, Fishing and Environment, 2024b)
Sustainable settlement development	This term refers to the processes of planning for, investing in, and governing human settlements in such a way that they are economically vibrant, spatially and socially integrated, self-generating, safe and overall sound places to live in. It also includes using resources to achieve these characteristics that are cognisant of the cumulative needs of current and future generations (Van Hyussteen, et al., 2016, pp. 18-6).
Town	A place (1) where people, economic activities and social services are geographically concentrated in a distinct and identifiable area, (2) that has a legally enshrined form of local/municipal government (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021)
Township	This term has two meanings in the South African context. Firstly, it is a colloquial name given to residential townships which were established during the Colonial and Apartheid Eras for temporary occupation by Black South Africans on the outskirts of towns and cities, and where only the most basic of amenities and infrastructure were provided. During colonial times, these townships were called “locations”, and sometimes still are, albeit increasingly less so. Secondly, it is the legal name given to new human settlements and extensions to existing settlements in planning legislation, e.g. ‘Sunnyside Extension 3’, dating back to the first Town National Spatial Development Framework 2022 21 Planning Ordinances passed in the early 1900s, and also appearing in the more recent Spatial Planning and Land Use Management Act (2013) (SPLUMA) (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021).

CHAPTER 6. INFRASTRUCTURE AND PLANNING

6.1 INTRODUCTION AND SCOPE

6.1.1 Sustainable Infrastructure development in support of the Boegoebaai Port and SEZ development

The proposed port and Special Economic Zone (SEZ) development is located within the Richtersveld Local Municipality. The core region, as defined in this SEA, comprises several local municipalities, including Richtersveld, Nama-Khoi, Kamiesberg and Khai-Ma. This core area is also situated within a broader region which experiences several challenges including vast distances between sparsely populated settlements, arid and dry climate (featuring water scarcity), limited socio-economic services and social facilities. The region is facing increased outmigration, especially by younger people seeking opportunities in other parts of the country (DBSA, 2024). These challenges pose a risk to the long-term future of the area. At the same time there are many growth opportunities which can be unlocked through investment that has to confront the higher costs associated with the challenge of the vast geography and climate. The region has several natural endowments which give the area a distinct advantage compared to other regions in South Africa and many other regions globally. Over and above the unique landscape and tourism potential, the two significant natural endowments which have not been fully initiated up to this point include: i.) The west coast ocean with its ocean economy opportunities and deep harbour potential; and ii.) Optimal sun radiation for solar power generation; and iii.) The area also has good wind energy potential in places. The Boegoebaai Port development is part of the proposed "green hydrogen" economy in South Africa. The project is designated as a Strategic Integrated Project (SIP) under the National Development Plan (NDP). Sasol is leading the feasibility studies for the proposed development under a Memorandum of Understanding (MoU) with the Northern Cape Economic Development Agency (NCEDA) (Namakwa District Municipality, 2022), while TRANSNET has undertaken several investigations for the proposed port. The preceding associated feasibility studies are acknowledged as components of the broader policy and planning context; however, they do not predetermine or constrain the findings or recommendations of this assessment.

The receiving environment in the context of the Boegoebaai SEA comprises the Richtersveld and three surrounding municipalities: Nama-Khoi, Kamiesberg, and Kai-Ma. A strong focus is placed on the Richtersveld municipality as the recipient of the port and SEZ investment along with the majority of its associated development components. This chapter adopts a regional cumulative assessment that spans infrastructure elements, including induced settlement expansion and related secondary development, instead of limiting the analysis to a narrow project envelope. This broader approach ensures that key features that are affected by, or that substantially influence, the proposed development are taken into account.

The core region (illustrated in Figure 6-1) consists of large open areas of shrubland, natural rock, and bare patches; it features a diverse landscape that transitions from flat, sandy coastal plains to jagged, sharp mountains of volcanic rock and the lush banks of the Orange River, which forms the border with neighbouring Namibia. Within this setting are several small settlements as well as zones primarily dedicated to coastal and riverine mining. The region also hosts several protected areas, national parks, and a UNESCO World Heritage site. Mountainous areas extending from north to south, particularly through the Richtersveld Municipality, play a significant role in shaping settlement patterns and infrastructure provision. Figure 6-1 further illustrates the site designated for the new port and SEZ.

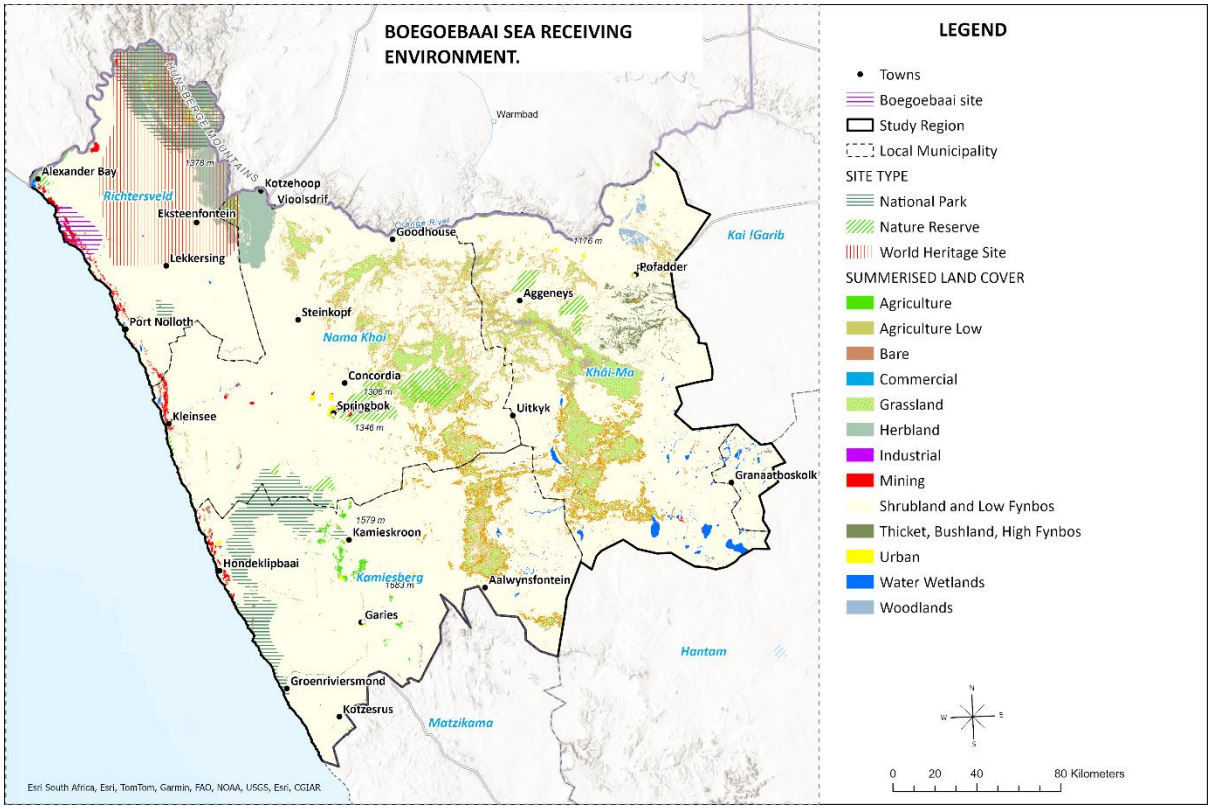


Figure 6-1: Broad receiving environment comprising land utilisation, settlement, and summarised land cover reflection.

(Source: (EGIS, 2022)

Existing infrastructure, including water lines, power lines, roads, and settlements (not reflected in the map), will be impacted by the proposed development. Various landowners will also be affected by the establishment of new infrastructure, modifications to existing infrastructure, or the expansion of existing facilities settlements. The range of infrastructure-related items required to produce the proposed port and SEZ development, as well as the range of associated stakeholders, increases the complexity of the planning landscape and necessitates that an integrated and participatory approach to planning be a strong requirement of this initiative.

Since the introduction of Spatial Planning Land Use and Management Act in 2013 (introduced to create a more **uniform, equitable, and efficient** system for spatial planning and land use across all spheres of government), and in alignment with a series of pronouncements by the Constitutional Court since 2010, the responsibility for land use change approvals lies with the local municipality. The decisions of national or provincial departments cannot overturn those of the municipality. Therefore, it is emphasised that an applicant can only successfully commence development when all required regulatory approvals have been granted. SPLUMA is now used alongside other related planning legislation, such as NEMA (National Environmental Management Act), to ensure consistency, uniformity, and alignment with other legislation on land management (AWARD, 2017).

6.1.2 Scope of this Chapter

This chapter explores the potential implications of the proposed Boegoebaai Port and SEZ development for the Richtersveld municipality and surrounding region. The issues considered include the infrastructure components consisting of the following: 1) critical infrastructure corridors that serve the port and sez, including electricity, water, roads, a rail line (proposed), and green energy distribution (network); 2) settlement development; and 3) associated municipal service delivery and implications for spatial planning and land use management. The study incorporated a review of relevant literature and documentation, complemented by site visits to the region. Consultations were held with municipal and district officials, as

well as key infrastructure stakeholders including NCEDA, Department of Water and Sanitation, ESKOM and SANRAL, etc.

Short and longer-term implications, risks and possibilities for mitigation are outlined within the context of 1) the set of development principles and priorities, as well as, 2) the institutional realities focussed predominantly on the municipal and district spatial planning and integrated development planning and governance system, which is primarily aimed at supporting intergovernmental alignment to facilitate effective service delivery, job creation, transformation of apartheid legacies and long term sustainability.

At the same time, it is crucial to recognise that land, infrastructure and settlement development often are the result (and the spatial footprint) of complex socio-economic and socio- ecological systems. Therefore, despite focusing on planning and infrastructure components, this chapter does not stand alone, as other related aspects are also included, such as terrestrial ecology and conservation planning, socio-economics (which encompasses tourism and governance aspects), and coastal livelihoods. This section should also be viewed along with other sections of this report that feature the social, economic, population and migration dynamics. (please also see Chapter 7 of the SEA, Atkinson et al., 2026).

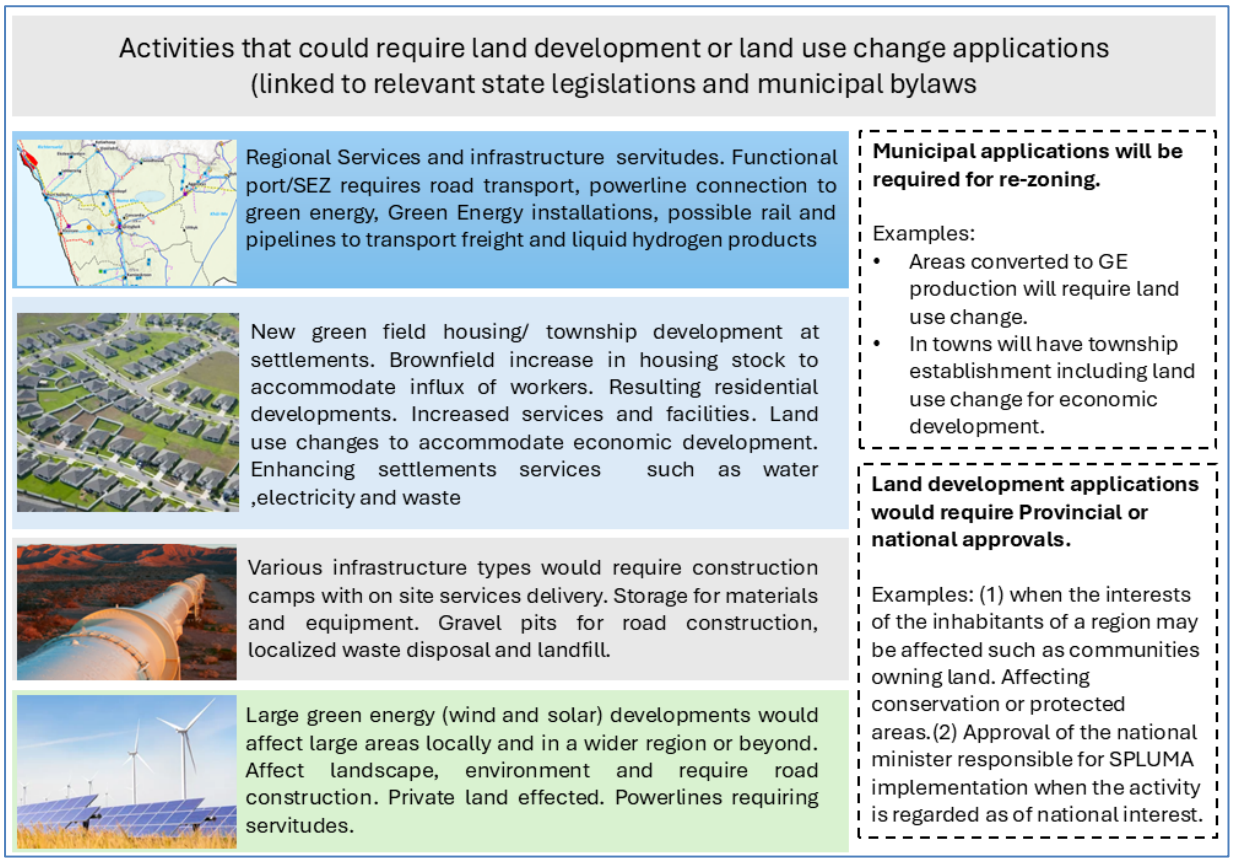


Figure 6-2: Activities that could typically require land development and land use change applications in the study area.

Source: (Van Hyussteen, et al., 2016) adjusted by authors.

The focus on hydrogen within the port and SEZ significantly impacts realisation timelines, scale, location, cost, and associated effects due to a complex regulatory framework for securing rights. Numerous development activities linked to the Boegoebaai port and SEZ could affect current land use and future development. Proposed activities may necessitate land use changes, development applications (see Figure 6-2) and EIAs in accordance with relevant regulations. This chapter highlights implications for settlement development, regional infrastructure, and spatial planning, while also considering tourism, agriculture, and conservation. Furthermore, ensuring sustainable benefits for local communities is crucial for success, particularly in this impoverished region.

This chapter is structured as follows:

- **Baseline Environment Description (Section 6.2):**

  This section outlines the current state of the region, excluding the proposed port and SEZ developments. It focuses on existing settlement patterns, key infrastructure challenges, and regional planning dynamics. Development opportunities within the current trajectory are also highlighted.

- **Potential Impacts and Management (Section 6.3):**

  This section describes anticipated impacts of the proposed port and SEZ developments. It considers major infrastructure components, potential effects on settlements, and implications for spatial planning, land use management, and governance.

- **Risk Assessment (Section 6.4):**

  This section identifies key risks associated with development pressures, settlement impacts, and the construction of large-scale proposed projects. It introduces a methodology for evaluating risks and opportunities, supported by risk matrices that illustrate the potential consequences across major risk themes.

- **Management Guidelines and Monitoring Requirements (Sections 6.5 and 6.6):**

  This component outlines strategic actions to address identified risks. It focuses on high-level management priorities and monitoring needs to ensure effective mitigation.

- **Knowledge Gaps (Section 6.7):**

  Despite the identification of key planning and infrastructure risks, uncertainties remain. This section highlights areas requiring further research or detailed analysis to fully understand the potential impacts of the proposed developments.

6.1.3 The importance of Integrated Inter-governmental Development Planning

Given that the integration of planning, budgeting, and implementation in South Africa remains essential, the process has been slow, uneven, and challenging (Pieterse et al., 2016; Oranje & Van Huyssteen, 2011). The context of the proposed Boegoebaai development underscores the need for an integrated planning approach that addresses the hardships of distance, inaccessibility, and limited options, particularly for 1) historically marginalised groups who resided in areas impacted by Apartheid policies before 1994, 2) rural municipalities with limited resources where state spending typically drives the local economy, like Richtersveld, and 3) ecologically vulnerable regions. The area proposed for the port and SEZ is ecologically sensitive, with extensive conservation zones, and includes several under-resourced municipalities as noted in the Auditor-General's 2023 reports. Each municipality relies heavily on grants to supplement its limited revenue base. Financial and performance reporting across these municipalities was consistently poor, with systemic challenges in data accuracy and accountability. Furthermore, all reported skills shortages, hampering their ability to effectively perform key municipal functions (Auditor General, 2023).

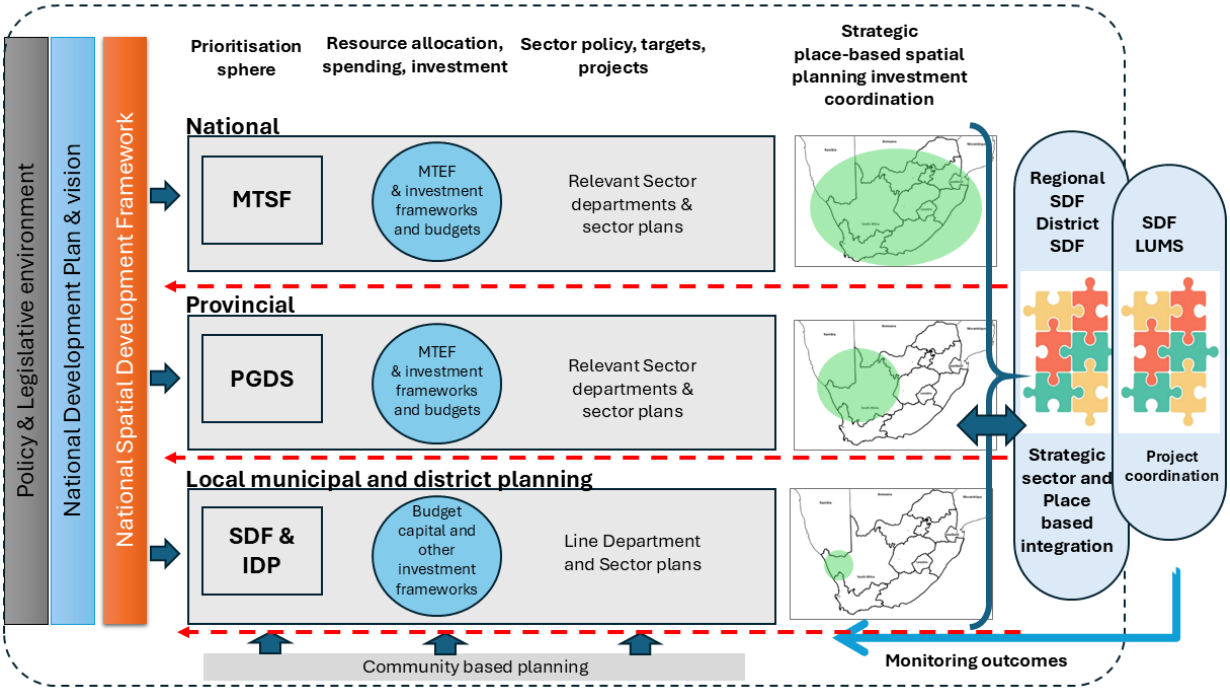


Figure 6-3: Highlight the specific roles of national, provincial, district and local planning instruments in sequencing port, SEZ and associated infrastructure.

Source: (Van Hyussteen, et al., 2016, pp. 18-13), modified by authors.

It is imperative that careful, coordinated, and integrated planning must be conducted. The opportunities and challenges for coordinated inter-governmental planning become even more evident when considering the wide array of spatial and integrated development planning and governance instruments (graphically illustrated in Figure 6-3), all of which requires annual review, adaptation, and alignment relevant to the study area. This can include the following:

- Integrated and strategic national, local, and regional plans,
- The Richtersveld Spatial Development Framework (Erioloba Consulting, 2024), which, given that it is the focal region for the proposed development, represents a critical guiding planning document.
- Integrated Spatial Development Frameworks (SDFs) to guide spatial development across national, provincial, regional, local, and precinct scales, see SPLUMA and the Department of Rural Development and Land Reform's SDF Guidelines (Southworth, 2017).
- Integrated provincial and municipal sector plans, i.e. integrated housing plans, integrated transportation plans, and integrated disaster management plans.
- Integrated investment frameworks, i.e. Integrated Infrastructure Investment Framework (provincial and municipal), Capital Investment Framework (municipal), and spatially targeted budgeting instruments introduced by National Treasury; and
- Land use management schemes, which are largely established for towns and generally require support to develop across the full extent of the municipal area, along with assistance to ensure alignment with SDFs and to prepare relevant by-laws to guide development.

While it is both 1) legally mandated and 2) evident from the situation on the ground that government needs to establish an enabling and guiding context for development and investment in the region through effective proactive and coordinated planning, budgeting, and targeted investment and governance, the risks and mitigations associated with the potential impact of the proposed port and SEZ development on

land, infrastructure, and settlements could in many respects also be addressed through such proactive planning and associated implementation.

In the context of the proposed Boegoebaai Port and SEZ, integrated planning must also be understood as a legal and institutional requirement rather than only a good planning principle. This includes alignment with SPLUMA principles of spatial justice, sustainability, efficiency, resilience and good administration; the Municipal Systems Act requirements for credible IDPs and sector alignment; and the NEMA principles of precaution, environmental justice, cooperative governance and the consideration of cumulative effects in decision-making. The chapter should therefore be read as supporting coordinated implementation through IDPs, SDFs, land use schemes, infrastructure investment frameworks, environmental authorisation processes and intergovernmental coordination mechanisms relevant to the region.

6.2 DESCRIPTION OF BASELINE ENVIRONMENT

This section summarises the dynamic baseline concerning the Planning and Infrastructure elements identified in this report. The dynamic baseline, Scenario 0, represents the region and its current development path without the construction of the Boegoebaai Port and the associated SEZ. While this proposed development is not included in this scenario, it doesn't prevent other initiatives from taking place in the region. Therefore, for this scenario, we assume that other major development projects will proceed as scheduled within the region. The discussion begins with an overview of current municipal development planning and management in the area.

6.2.1 Municipal Development Planning and Management

Land use and settlement trends in the Namakwa region are notably distinct, predominantly characterised by rural and peri-urban settings, with few towns displaying features of growing urban environments (Tshani Consulting, 2023). It is essential to prioritise settlement planning to ensure vital elements are addressed, thus enabling the establishment or expansion of functional communities to meet anticipated developmental growth requirements.

The governance capacity is already limited in the local and district municipalities in the Namakwa SEA (Strategic Environmental Assessment) region for coordinated and aligned spatial and infrastructure investment planning and management, including the mitigation of any new activities in their areas of jurisdiction. The complex institutional context for service delivery and the associated roles and responsibilities in South Africa, often negotiated at local and district municipal levels, adds an additional challenge and requires dedicated capacity and support for the relevant municipalities.

The municipalities of Nama Khoi, Khai-Ma, Richtersveld, and Kamiesberg have stable councils with no vacant councillor positions and regular meetings. However, Nama Khoi and Kamiesberg lack key management roles such as Technical Managers and Project Management Unit (PMU). These positions are crucial for operational tasks, as well as for strategic planning and improved grant access. A shortage of skilled personnel affects service efficiency. Only Richtersveld and Kamiesberg adopted the Framework for Infrastructure Delivery and Procurement Management, with Richtersveld utilizing 100% of its infrastructure budget for 2023/24, while others spent less than 80%, leading to budget roll-overs and concerns about infrastructure delivery (DBSA, 2024).

The context of the region, characterised by its vast geography—sparse settlements spaced by large distances, an arid climate leading to water scarcity, a small and slowly growing population, low levels of education and skills, as well as outmigration—results in a more limited scale of economic development that also impacts spatial and development planning across its four municipalities. Furthermore, the infrequent planning and development-related activities, combined with a restricted financial base, hinder the appointment of full-time planners.

Municipalities face common challenges related to development, spatial and economic planning, characterised by a lack of essential planning staff, dedicated units, and geographic information system (GIS) personnel. Although most municipalities have approved Integrated Development Plans (IDP), Service Delivery and Budget Implementation Plans (SDBIP), Spatial Development Frameworks (SDF), and a

promulgated Land Use Management (LUM) scheme, these are often compliance focussed with varying degrees of contextual innovation and alignment with provincial and environmental plans. The following table reflects the extent of compliance with critical spatial planning documents and planning functions.

Table 6-1: Spatial Planning and Functions, 2024

No	Municipality	IDP	SDBIP	LUM	SPLUMA	SDF	MPT	LED unit	GIS unit
1.	Richtersveld	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
2.	Kamiesberg	Yes	Yes	No	Yes	review	Yes	Yes	No
3.	Khai-Ma	Yes	Yes	No	Yes	review	Yes	Yes	No
4.	Nama Khoi	Yes	Yes	No	Yes	review	Yes	Yes	No

(DBSA, 2024, p. 17).

The Namakwa District Municipal Planning Tribunal (NDMPT) is currently the main mechanism for making decisions on land use and land development applications received by the municipalities. The exception to this is when a municipality official is authorised to consider and make decisions on certain, specific land use applications (Poswa, 2024). The NDMPT is constituted of 16-19 members meeting quarterly. Annexure B presents a gazetted notice for the NDMPT. The current district municipal tribunal and municipal planning systems seem adequate for handling the present volume of development and land use applications. However, if there is a sharp increase in applications, their capacity could become a strategic limitation.

6.2.2 Settlement dynamics

The study area is an arid region that has contributed to low population numbers and density due to the harsh climate with low rainfall and limited water resources. Limited, or in some cases declining, economic opportunities have resulted in small, sparse settlements spread over large distances. Determining and projecting the growth of settlements is critical for establishing the baseline and identified scenarios.

Two primary sources of recent population data are utilised in regional planning documents: Statistics SA Mid-Year Estimates (prior to the 2022 census) and the 2022 census. The 2022 census was selected for this SEA as it offers a more current perspective on the region's population. The SEA team acknowledges the discrepancies between these two sources; however, state entities consider limited alternatives acceptable. A notable surge in population growth rates was identified when comparing the Statistics SA 2021 mid-year estimates to the 2022 census, which appeared excessive given the preceding population trend data. To address this issue, growth in residential structures was used as an alternative method for calculating population growth. Downscaled settlement data from the CSIR and residential structures data were utilised to provide a more precise estimate of the current growth rate per settlement. Analysing the changes in residential structures across all settlements reveals that growth associated with settlements varies significantly throughout the region. Overall, settlements in the region experienced growth of less than two percent per annum, with only a handful showing higher growth rates (refer to Table 6-2).

Table 6-2: Increase in settlement structures

Municipality	Municipal growth	Towns/ settlements	Per annum growth (2015-2022)1

[1] Some might be from a small base (small number of residents)

Kamiesberg	1.2%	Koingnaas	More than 10% pa
		Soebatsfontein	2.6%
Khai-Ma	2.2%	Aggeneys	4.3%
		Poffadder	3.4%
Nama Khoi	0.8%	Kleinsee	3.6%
		Springbok	7.5%
		Vioolsdrift	More than 10% pa
Richtersveld	1.7%	Alexander Bay	More than 10% pa

Source: Calculations by authors.

Overall, the low growth rates across most settlements signify the region's depressed state. Moreover, diamond mining in the Richtersveld is on the decline, resulting in reduced employment levels, which further limits opportunities in the area. These patterns do not consider the potential effects of new development. Significant investments, like a new port and SEZ, could attract attention to the area, potentially leading to substantial changes in settlement dynamics. The skills needed for the proposed developments might prompt an influx of people, contributing to growth in several settlements. Annexure A details all settlements in the region, their growth rates based on historic structural growth, and projected populations for 2030 and 2050.

Most settlements in this area are small, with populations under 5,000 residents. Port Nolloth is the only settlement within the Richtersveld Municipality housing more than 5,000 residents. In the broader region, only Steinkopf and the cluster of settlements around Springbok are larger. The remaining areas consist of smaller settlements. Population growth rates are derived from the increase in residential structures.

As outlined in the 2024 Partner-a-District diagnostic assessment by the DBSA (DBSA, 2024), two out of five residents in the Namakwa District live in poverty, highlighting the region's ongoing difficulties. While over 93% of households reside in formal homes, there exists a housing backlog in these municipalities; the National Housing Needs register reveals a backlog of more than 9,000 houses. Although the primary responsibility for housing lies with national and provincial government, local municipalities play a critical supporting role by planning for the provision of serviced stands. This responsibility must be integrated into their planning and policy frameworks, including the Human Settlements Plan, Informal Settlement Upgrading Strategy, Land Protection Policy, Land Alienation Policy, and Anti-Land Invasion Strategy. These instruments ensure alignment between strategic housing goals and practical land use management at the local level.

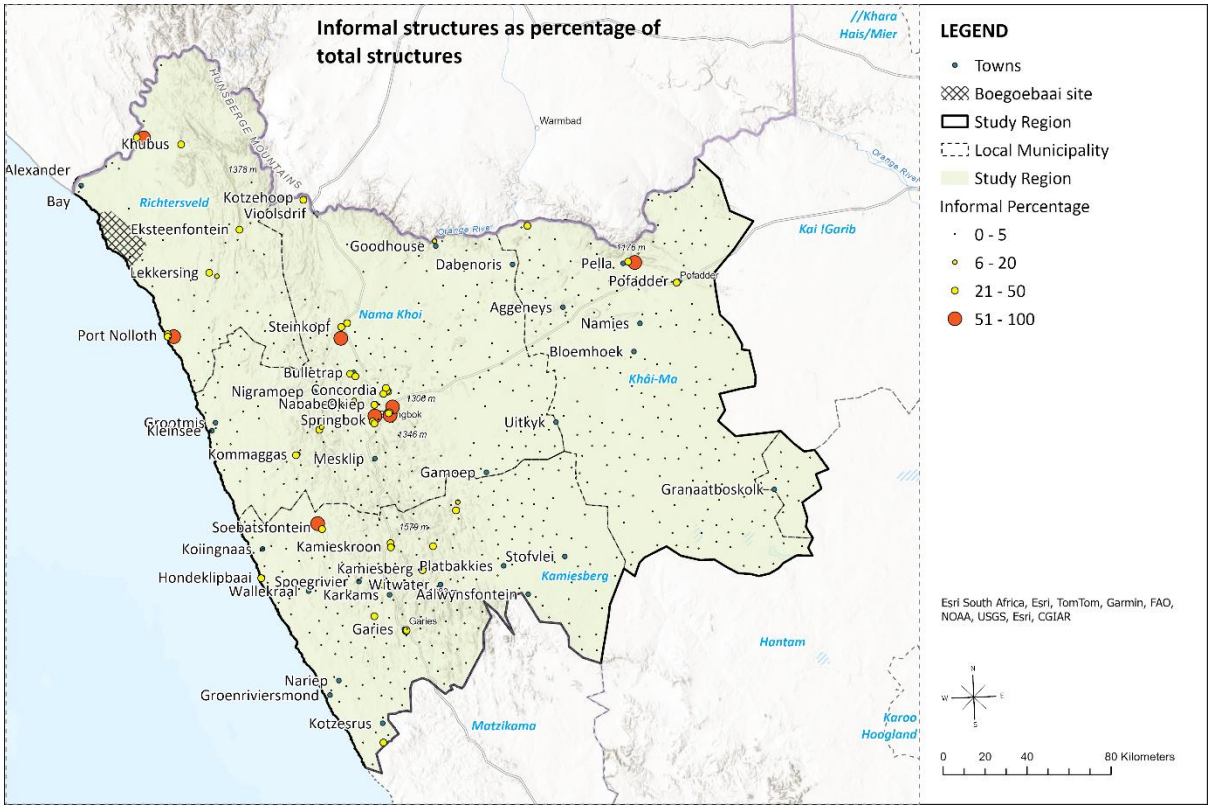


Figure 6-4: Extent of Informal structures.

Source: (Maritz, 2022)

The lack of serviced stands and the slow or non-existent expansion of urban areas contributes to these backlogs. This situation poses a risk of informal settlements arising in high-risk areas where dangers such as floods, fires, and erosion can further jeopardise residents. Related challenges include outdated sector plans, illegal occupation of municipal property, poor housing construction, and financial and infrastructure risks. The Northern Cape's Housing Construction Project will build 448 'Breaking New Ground' houses across the Namakwa District to address the current housing backlogs. Figure 6-4 illustrates settlements in the core region where informal housing structures are present. It should be noted that several settlements in close proximity to the proposed development also exhibit a high number of informal structures, including Sanddrift, Port Nolloth, Steinkopf, Carolusberg, and Bergsig (Springbok settlement cluster).

6.2.3 Settlement and regional related infrastructure challenges

The region, particularly the settlements within it, currently faces several infrastructure challenges. Municipal incomes are inadequate to meet these needs, thus relying on government transfers, sector projects, or private sector investments. To understand the municipal realities in this region, all facets of municipal governance must be considered. This section will focus on infrastructure components; please also refer to Chapter 7 of the SEA (Atkinson et al., 2026) which includes additional socio-economic and municipal governance aspects.

6.2.3.1 Water and sanitation

Responsibility for water and sanitation planning and infrastructure management in the region lies with local municipalities. According to the 2022 census:

- 76.8% (26,070) of households in the Namakwa District Municipality have piped water within their homes

- 83.8% (28,442) have flush toilets connected to the sewer system
- Approximately 13.4% (4,534) still depend on pit latrines or the bucket system

These figures underscore persistent water and sanitation backlogs in certain settlements. Reliability of water supply remains a concern across the region as reflected in Table 6-3:

Table 6-3: Water reliability.

Municipality	Water Reliability
Khai-Ma	77%
Nama Khoi	52% (lowest)
Kamiesberg	62%
Richtersveld	64%

Source: (DBSA, 2024, p. 20).

The common water and sanitation challenges faced by municipalities include ageing infrastructure, insufficient capacity, a shortage of skilled personnel, a lack of Operations and Maintenance (O&M) plans, and financial constraints. The most recent Blue Drop report assessing the quality of municipal water systems reveals critically low scores across the region. The municipalities recorded the following results: Richtersveld at 21.94%, Khai-Ma at 15.19%, Nama Khoi at 36.61%, and Kamiesberg at just 8.02%. Scores below 31% are classified as being in a critical condition (Department Water and Sanitation, 2023, p. 22). Table 6-4 highlights the scores for individual towns within the Richtersveld Local Municipality, all of which are alarmingly low and show a downward trend compared to previous Blue Drop assessments.

Water and sanitation capacities act as critical limiting factors for settlements and must be improved before they can accommodate incoming and expanding populations, which are likely to result from major regional projects.

Table 6-4: Blue Drop scores - Richtersveld Local Municipality.

Performance Area	Port Nolloth/ Alexander Baai	Eksteensfontein	Khuboes	Lekkersing	Sanddrift
Blue Drop score 2023	23.0%	29.75%	10.90%	28.25%	10.09%
Blue Drop score 2014	47.0%	39.0%	43.0%	36.0%	28.0%
Blue Drop score 2012	35.0%	44.0%	29%	41.0%	42.0%

Source extracted from: (Department Water and Sanitation, 2023, p. 444)

Specific issues include high water debt and difficulty in collecting water rates in the Nama Khoi Local Municipality, deteriorating water infrastructure in Khai-Ma, and water scarcity exacerbated by developments in Richtersveld Local Municipality. Kamiesberg Local Municipality faces challenges with a dilapidated sewer network and billing inefficiencies. Annexure C lists the proposed water and sanitation projects for the region. The following challenges affect water and sanitation in the region (DBSA, 2024):

Nama Khoi Municipality – Water losses due to aging infrastructure limit supply. New housing developments are putting pressure on the sewer network requiring the upgrading of oxidation ponds.

Khai-Ma Municipality - The water infrastructure has deteriorated, with aging asbestos pipelines over 50 years old causing frequent bursts and maintenance issues. There is inadequate storage capacity in the water supply, which hampers sustainable service delivery. To address current problems the upgrading the bulk water reticulation, wastewater treatment facilities, and enhancing storage to a 48-hour norm is required.

Richtersveld Municipality – Settlements in this municipality faces water scarcity, which will be exacerbated by the proposed development of Boegoebaai Port and SEZ. Without significant intervention this development will put further strain on the already insufficient potable water supply, necessitating the installation of bulk and reticulation services, including water, sanitation, electricity, and roads. A study to investigate the alignment of a new water pipeline to Port Nolloth projected an additional 2000 households to be accommodated in this town (BVi Consulting Engineers, 2023). Proposals by the municipality to address this includes increasing water extraction and purification, as well as installing solar backup to mitigate the impact of power interruptions, such as load shedding (DBSA, 2024). In addition to meeting the domestic water needs of surrounding settlements, the proposed Boegoebaai Green Hydrogen infrastructure will necessitate the development of desalination facilities within the Special Economic Zone (SEZ). These plants will be essential to ensuring a reliable supply of high-purity water for the production of green hydrogen at scale.

Kamiesberg Municipality - The sewer network infrastructure of Kamiesberg is dilapidated and inadequate. This results in frequent breakdowns, leaks, and failures, necessitating new construction, refurbishment, and upgrades to meet the growing demand. The installation of prepaid water meters and the construction of large-scale sewage infrastructure to enhance capacity and ensure effective wastewater treatment are some of the interventions planned by the municipality (DBSA, 2024).

6.2.3.2 Road Infrastructure.

Roads play a crucial role in this sparsely populated and isolated region. The area features two national roads: the north-south N7 that connects Namibia and Cape Town, and the east-west N14 link providing access through Springbok to the eastern part of the Northern Cape and onto Gauteng (these roads fall under the South African National Roads Authority (SANRAL)). Currently, these roads are in good condition.

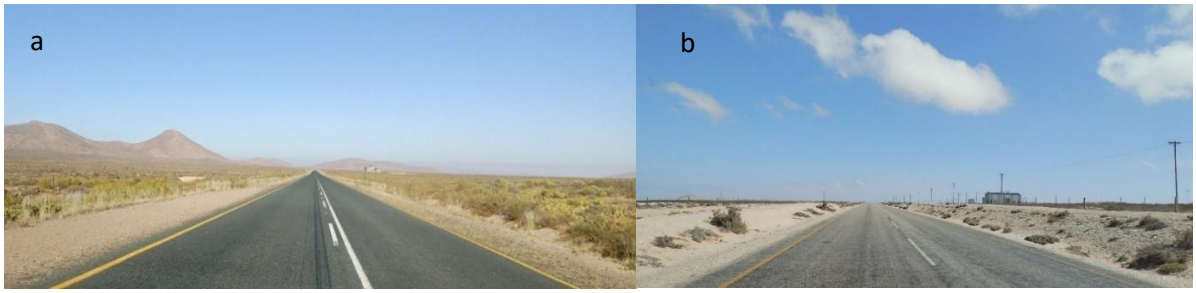


Figure 6-5: R382 road a) Steinkopf to Port Nolloth, b) Port Nolloth to Alexander Bay.

(Maritz, J., 2024b)

Near the proposed Boegoebaai site, the provincial access road (R382) branches off the N7 from Steinkopf (70 km north of Springbok) to Port Nolloth, covering approximately 90 km of bituminous surfaced road (Figure 6-5a). The route from Port Nolloth to Alexander Bay (R382) is also a bituminous surfaced road. Boegoebaai lies approximately 60 km north of Port Nolloth (Figure 6-5b).

This road will serve as a crucial access route to and from the proposed port and SEZ. These roads have been taken over by SANRAL (2024), which has recently appointed engineering firms to carry out condition and design assessments in preparation for planned standard maintenance activities on the R382. However, these planned maintenance projects do not consider the anticipated developments and likely increased usage at Boegoebaai. Annexure D outlines current priority road projects aimed at addressing the most pressing needs in the region.

Many gravel roads in the study area are in poor condition, limiting access to smaller settlements. Several municipal roads require substantial repairs to meet acceptable standards. Within these smaller settlements, internal gravel roads—often damaged by water—require paving, while existing tarred roads need rehabilitation due to water ingress and deterioration.

According to the **Rural Roads Asset Management System (RRAMS)**, a significant portion of surfaced roads are classified as being in poor condition. Addressing these issues will require a combination of new road construction, upgrades, refurbishments, and improved drainage systems to enhance safety, accessibility, air quality, and the overall user experience. Due to funding constraints, some municipalities rely on **Expanded Public Works Programme (EPWP)** grant funding to carry out essential repairs and maintenance (DBSA, 2024).

6.2.3.3 Electricity

The current electricity distribution network in the region is sparse, as historically it had to cater to a relatively small load (ESKOM, 2024b, p. 123). Eskom and local municipalities jointly distribute electricity to consumers, with local municipalities typically serving towns and Eskom managing distribution in townships and villages (DBSA, 2024). Without any significant development in the region, the energy demand forecast remains gradual. However, the mining sector has recently expanded in Khai-Ma, and there has also been a rise in mining activities near Springbok. Currently, many municipalities utilise electricity at capacity on their Notifiable Maximum Demand (NMD) (ESKOM, 2024a), often exceeding thresholds and incurring penalties from Eskom. Discussions with ESKOM have revealed that the supply into the Namakwa supply area is sufficient, with generation significantly exceeding demand in the area (Marais, 2024). Some upgrades to the existing power infrastructure and distribution within settlements are needed to support growth in demand and facilitate electrification for new developments. This situation, however, does not account for the considerable impact on demand from the proposed Port and SEZ development. The 2024 Transmission Development Plan (TDP) indicates that the current evacuation of power from the region is limited and can be described as a constrained transmission grid (ESKOM, 2024b).

6.2.3.4 Renewable Energy (RE)

The growing demand for energy in South Africa, along with the need to reduce greenhouse gas emissions and diversify the energy mix, has driven the country's gradual expansion of its renewable energy sector (Akinbami, et al., 2021). Since the promulgation of South Africa's long-term electricity infrastructure roadmap, the Integrated Resource Plan (Department of Energy, 2011), renewable energy has been integrated into the national energy mix. The Renewable Energy Independent Power Producer Programme (REIPPP) has enabled private sector participation in power generation, increasing the country's renewable energy capacity.

This region has exceptional potential for solar energy production. Photovoltaic (PV) panels are preferred over Concentrated Solar Power (CSP) technology, as CSP requires large amounts of water, which is scarce in the area. Wind energy resources are also promising, particularly along the coastal plain and in the interior mountains. While offshore wind power is technically feasible, it is less ideal due to the significant depth of the ocean floor along this coastline (Grobler, 2024).

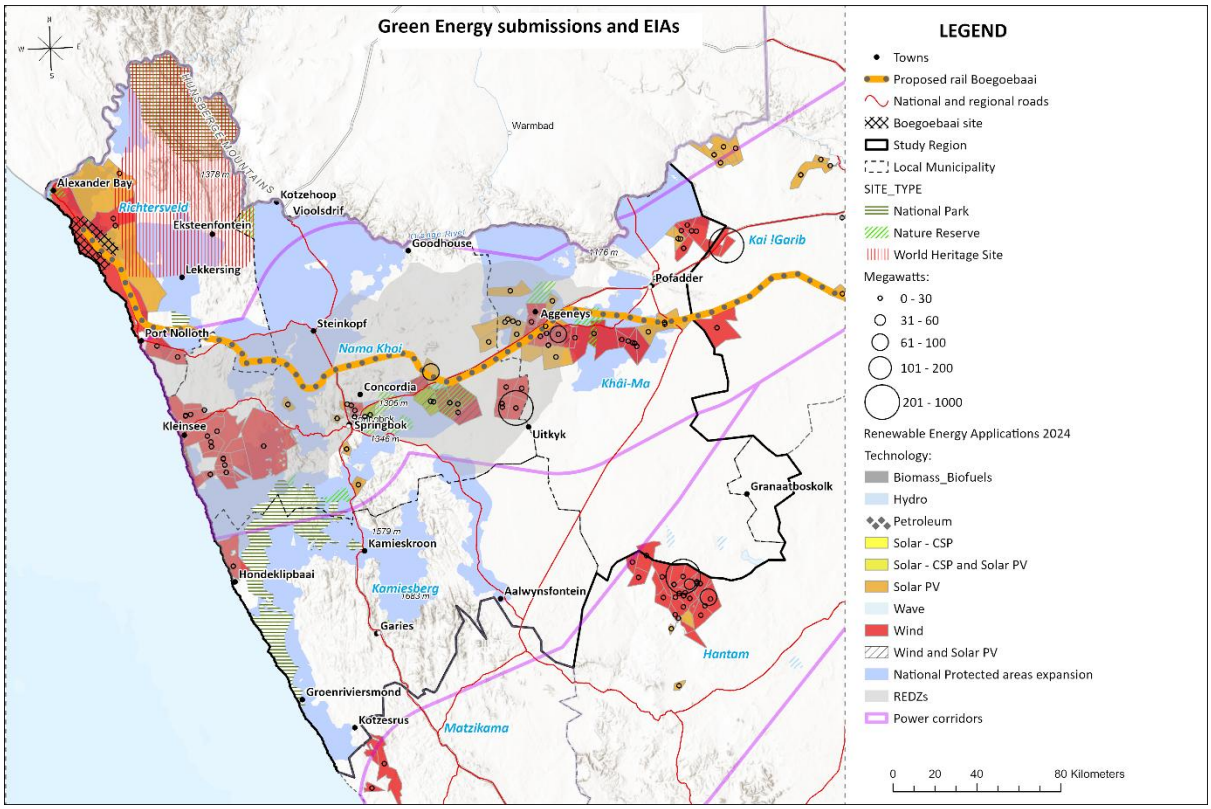


Figure 6-6: Green energy submission and EIAs

Source: (Department of Forestry, Fishing and Environment, 2024a)

The location of these renewable energy developments is often influenced by Renewable Energy Development Zones (REDZ) and strategic transmission corridors (see Figure 6-6). Within this region, the Northern Power corridor extends east-west, bordering Port Nolloth along the southern border of the Richtersveld Municipality. The RED Zone is within the power corridor and extends from the west coast towards Pofadder along the N17. A total of 171 projects or project applications are present within the power corridor in the region (Department of Forestry, Fishing and Environment, 2024a). Their status varies from approved projects that are operational to those that have been approved for construction or are in the process of evaluation. The wind and solar projects (applications) within the Richtersveld are located outside the power corridor and the RED Zone, indicating that some projects require additional transmission lines to connect to the grid or directly to sites such as the proposed Boegoebaai development.

6.2.3.5 Land and land ownership

The land ownership information reflected in Figure 6-7 combines the 2023 Richtersveld land audit and land ownership information from the Department of Rural Development and Land Reform. The Richtersveld Sida !Hub Communal Property Association (CPA) owns the land in the vicinity of Boegoebaai following a successful land claim. Alexkor currently uses the land for diamond exploration purposes in a pooling and sharing joint venture (PSJV) with the Richtersveld Mining Company (Department Transport, Safety and Liason, 2020, p. 33).

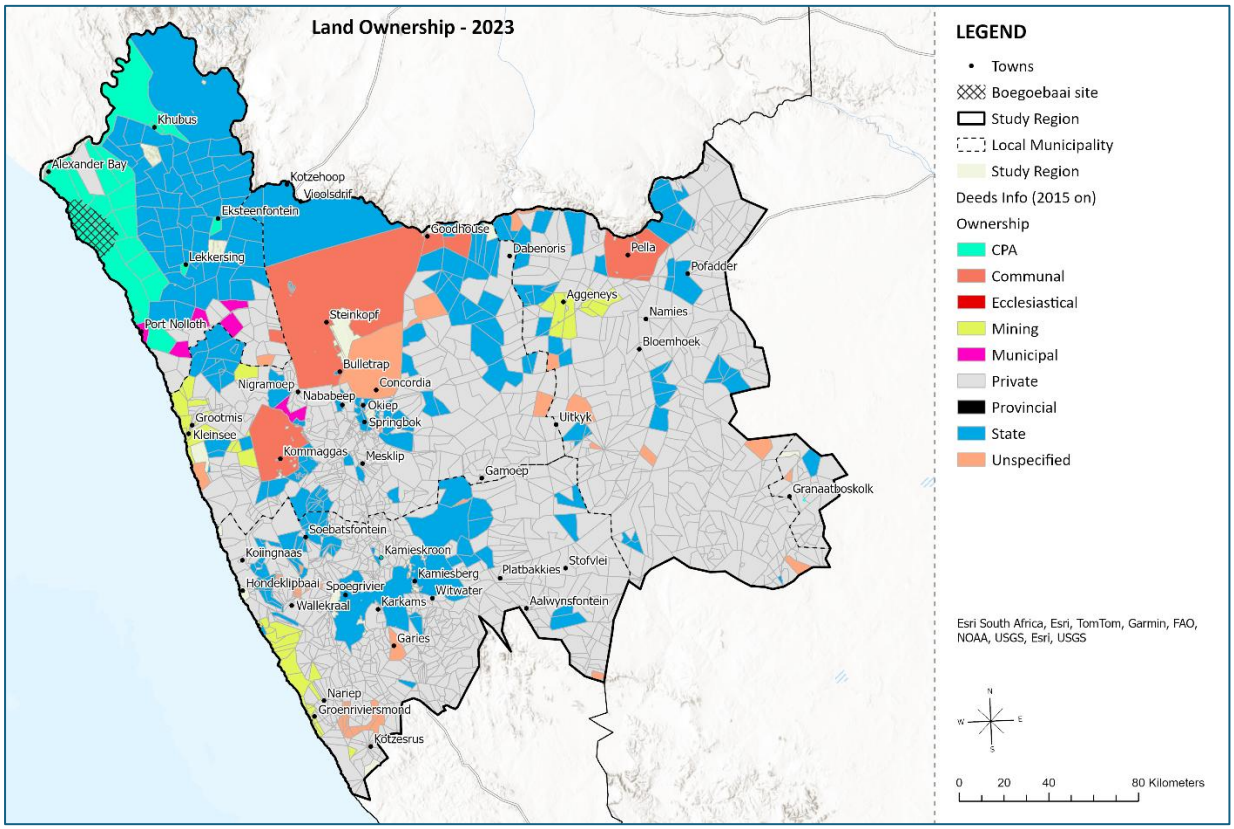


Figure 6-7: Land Ownership in region.

Source: (Maritz, 2023)

The southern part of the region is characterized by greater private land ownership, whereas the Richtersveld consists of approximately 28% CPA land, 58% state land, and 12% private land. The remaining land is designated for mining, communal, and municipal use. Any proposed development must align with the relevant municipal land use scheme, requiring agreements with landowners and developers. Given the various infrastructure projects that will require land, this aspect demands significant attention.

The CPA has approximately 2,630 beneficiaries across several towns, including Sanddrift, Kuboes, Lekkersing, Eksteensfontein, and Alexander Bay (Commision on Restitution of Land Rights, 2023). Internal disputes have emerged among members of the Richtersveld Communal Property Association (CPA) concerning management practices, financial expenditure, and the awarding of contracts. The matter was escalated to the National Department of Land Reform and Rural Development in 2024, but it remains unresolved (Fredericks, 2024).

Addressing communal land ownership is central, not peripheral, to the Boegoebaai port and SEZ: it affects legal permissibility, social licence, timing, risk and ultimately proceeding with the development. The proposed Boegoebaai Port and SEZ are located on land that forms part of a restituted communal landholding managed through the Richtersveld Communal Property Association (CPA), with land and associated rights held on behalf of the broader community. In this context, strategic support for the

development pathway is contingent on lawful, inclusive land governance processes that are consistent with applicable restitution outcomes and the protections afforded to informal and customary land rights, including the requirements of the Interim Protection of Informal Land Rights Act and related jurisprudence. Clear and transparent arrangements for land access, servitudes and decision-making in communal areas should therefore be treated as key enabling conditions for implementation, rather than assumptions, and should be advanced in parallel with other institutional and infrastructure readiness measures (also see section 7.5.4.3.3).

The town of Alexander Bay, previously a mining village for Alexcor, was consolidated into a new cadastral unit on which the township of Alexander Bay was incorporated into the Richtersveld Local Municipality in 2013. The Richtersveld local municipality has been reluctant to take over the responsibility of providing municipal services and managing engineering infrastructure over concerns related to aged infrastructure, poor road infrastructure and noncompliance of the electricity network to municipal standards (Public Enterprises, 2023).

With the anticipated development of new linear infrastructure corridors—such as electricity transmission lines, pipelines, and railways—careful planning, stakeholder engagement, procurement, and land use management will be essential for securing the necessary servitudes.

6.2.3.6 Rail infrastructure

There is no rail infrastructure in the region. The Sishen-Saldanha rail line runs along the southern border of Khai-Ma. All freight moving to and from the region is transported by road. Future rail lines will be considered when freight volumes increase and if a new port is developed at Boegoebaai.

6.2.3.7 Information and Communication technology

To assess ICT access in the region, current mobile phone coverage was examined. As shown in Figure 6-8, coverage is generally absent across most of the area but is more prevalent along national roads and in larger settlements. This indicates that certain technologies, such as EDGE, do not extend to the proposed port and SEZ site. While LTE is available at the site, its coverage may be limited. Currently, Vodacom 5G is not available in the region, and coverage from other providers, including MTN, TELKOM, and Cell C, is similarly restricted.

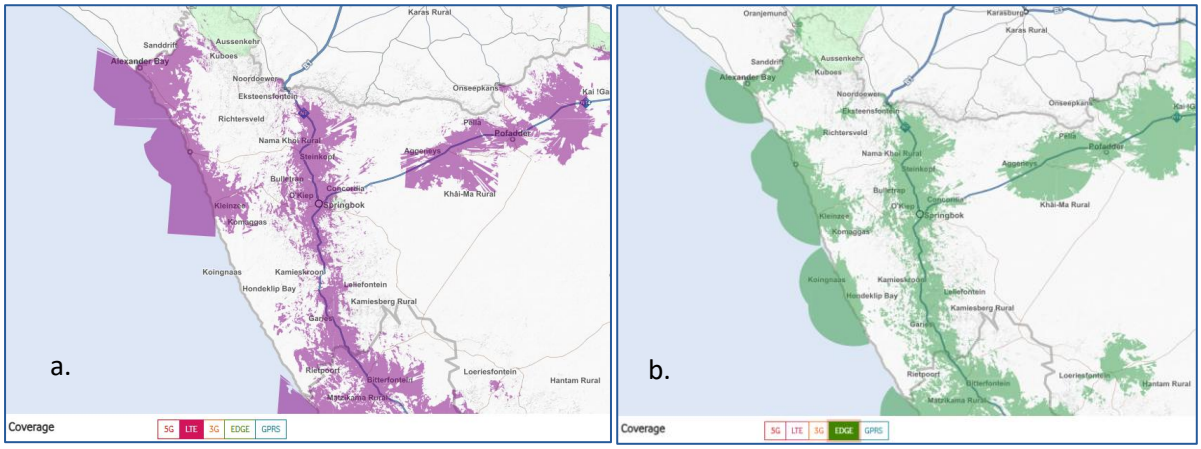


Figure 6-8: Vodacom coverage of LTE (a) and EDGE (b).

Source: (Vodacom, 2024. https://vccoverage.afrigis.co.za)

6.2.3.8 Gas Pipeline

The province does not have established gas or oil pipelines; however, the development of gas pipelines has been identified as an integral part of a future gas economy. Preliminary corridors were established during Operation Phakisa Offshore Oil and Gas in 2014. An SEA was conducted in 2017 to identify and pre-assess environmental sensitivities within suitable gas routing corridors, and, where necessary, to expand the identified electricity power corridors (Department of Environment, Forestry and Fisheries, 2019).

Any future green hydrogen pipeline from Boegoebaai will need to consider the identified corridors and the issues raised in the SEA. In May 2024, WESGRO, NCEDA, Namibia's Environmental Investment Fund, Gasunie, and Climate Fund Managers signed a memorandum of understanding (MoU) to promote the development of green hydrogen infrastructure. This initiative aims to connect South Africa's Western and Northern Cape regions with Namibia's Lüderitz/Windhoek region. As part of the agreement, a collaborative pre-feasibility study was launched to evaluate the viability of constructing a green hydrogen pipeline, forming the Western SADC Green Hydrogen Production Corridor. Completed by the end of 2024, the study analyzed technical, commercial, financial, socio-economic, and operational factors to determine the feasibility of establishing this green hydrogen corridor (WESGRO; NCEDA; GH2 Namibia; Climate Fund Managers; GASUNIE, 2024).

6.2.4 Regional development opportunities

In conducting the regional analysis, it is essential to account for major development initiatives that may influence the broader area. This approach provides a more balanced understanding of the baseline scenario. According to the **Northern Cape Office of the Premier** (Saul, 2024), several key anchor projects are emerging across the province, each with the potential to affect regional resources, elevate skill demands, and impact surrounding settlements.

Central to these developments is the **Northern Cape Industrial Corridor**, which spans from **Vaalharts** on the eastern border and follows the **N14 corridor** from east to west. **Figure 6-9** illustrates the geographic distribution of these initiatives. Notably, several large-scale projects are located outside the SEA region, including the **Kathu Industrial Park**, the **Kathu Housing Project**, and the **Upington Industrial Park**. Within the SEA region, significant investments include the **Namakwa Special Economic Zone (SEZ)** at **Aggeneys** and the **Namakwa Irrigation Scheme**.

Although the **Vioolsdrift Dam** is referenced as a potential development, its progress has stalled due to unresolved disputes between the South African and Namibian Governments, casting uncertainty over its future implementation (located on the lower Orange river is it intended to increase the yield of the Orange River System). In contrast, the **Namakwa SEZ** at Aggeneys is expected to have a substantial impact on regional dynamics, particularly in terms of resource demand, construction materials, workforce housing, and skills development. The SEZ is projected to generate approximately **6,000 direct and indirect jobs** during its initial phase (Modise, 2024).

If these projects are implemented concurrently with developments linked to the **Boegoebaai Port and SEZ**, they may compete for critical resources and skilled labour. This overlap could intensify pressure on regional infrastructure, including roads, water supply, electricity, and housing. Additionally, planning and municipal services may face significant strain if service expansion is not proactively anticipated and coordinated.

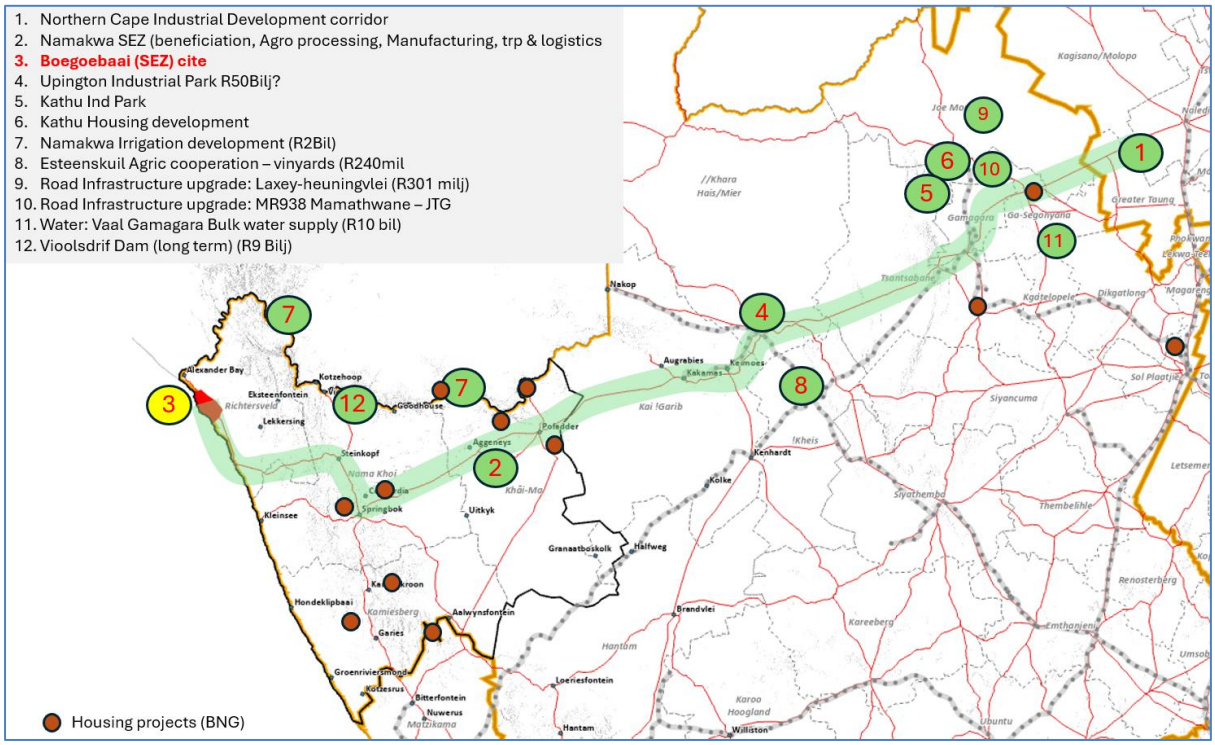


Figure 6-9: Large scale catalytic projects (Northern cape)

Source: (Saul, 2024)

Boegoebaai is proposed as a new deep-water port with associated rail and road infrastructure intended to connect the Northern Cape mining belt to international markets. The regional initiatives along the Northern Cape mining corridor are pertinent to the Boegoebaai development in that they contribute to the underlying demand and the infrastructural backbone that will support and further justify the establishment of both the port and the Special Economic Zone (SEZ). In turn, the port and SEZ are expected to function as the primary export outlet and as a catalyst for the expansion and upscaling of these corridor projects. Projects located outside the immediate study region will influence the settlements and communities in their respective areas, while simultaneously enhancing the overall financial viability of the proposed port. Within the study region, projects such as the Namakwa SEZ, the Namakwa irrigation development, and the Vioolsdrif Dam are anticipated to exert more pronounced effects on the Strategic Environmental Assessment (SEA) area. Settlements in close proximity to these projects, including Aggeneys, Goodhouse, Vioolsdrif and Noordoewer, are expected to experience increased social pressures and to bear certain infrastructure burdens. The specific sites earmarked for project implementation will, in addition, be subject to elevated environmental risks. Other settlements within the region, such as Steinkopf and the Springbok settlement cluster, are also likely to be affected through increased settlement pressures. At the same time, these settlements are expected to benefit from associated capital investments, particularly in the form of enhanced physical and service infrastructure.

6.3 POTENTIAL IMPACTS AND POSSIBLE MANAGEMENT

The development of the new port and SEZ along with its linked infrastructure will result in a myriad of impacts both locally and in the wider region. This section outlines the main planning and infrastructure related impacts likely to arise. In summary these relate to the following themes:

- Spatial development planning, land use management and governance
- Settlement development and service delivery implications, and
- Construction of large economic infrastructure projects.

6.3.1 *Spatial and Development Planning, land use management and governance*

The increased land use applications and infrastructure developments in the region will affect several towns and their municipal governments. The affected Municipalities, the Northern Cape Province, and the National Government need to be prepared to support and guide the Port, SEZ, critical infrastructure components and associated downstream developments.

The proposed development of a new Port with the adjacent SEZ and linked infrastructure elements such as renewable energy resource developments in the region, would require timeous and synchronised planning to ensure that the various phases of the proposed development align within the range of relevant medium-term spatial- and integrated planning instruments (Figure 6-10).

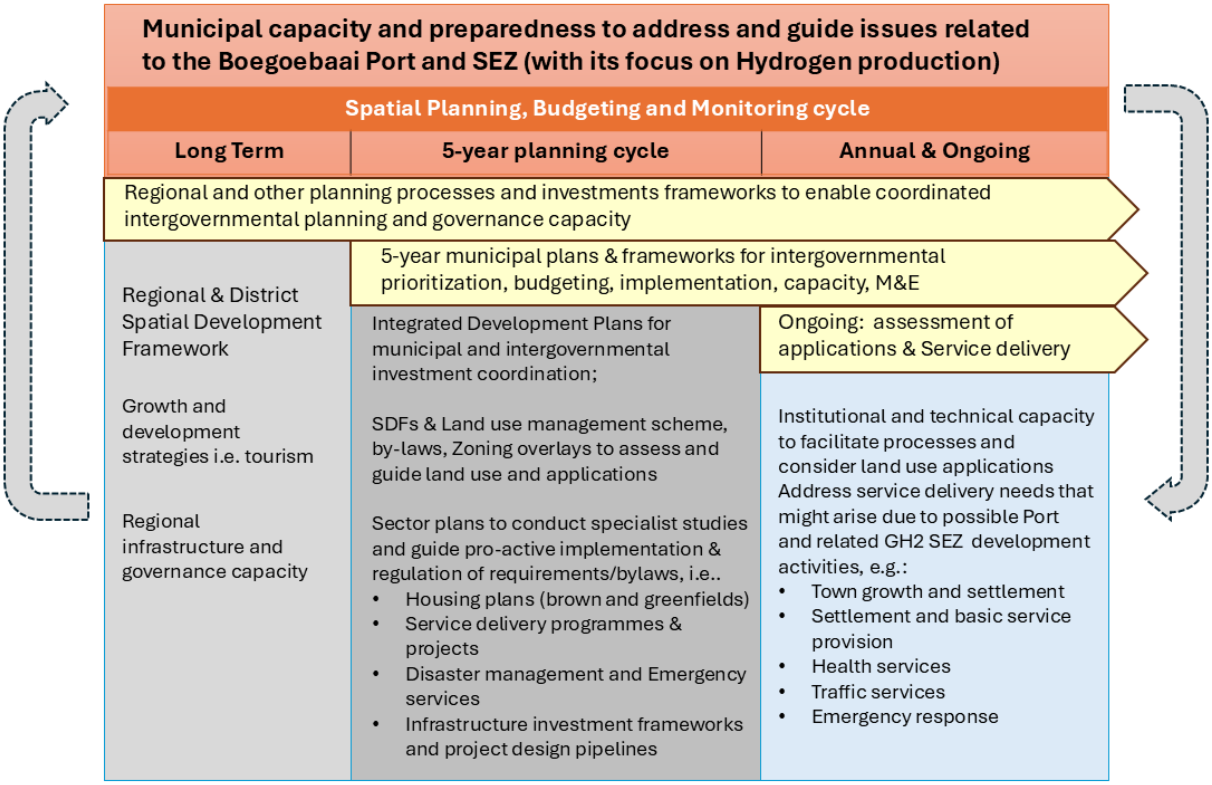


Figure 6-10: Municipal capacity and preparedness to address and guide issues related to the Boegoebaai Port and SEZ.

Source: (Van Hyussteen, et al., 2016, pp. 18-38), adjusted by author.

Spatial planning tools enable municipalities to consider land use applications and prepare for increased service demands from higher traffic, migration, and population growth in towns.

The proposed development of the port and SEZ is expected to positively influence municipal revenues in the region and contribute to the national treasury. However, accommodating these developments will require investments to manage the influx of people employed in various activities directly and indirectly linked to the projects. Given the already stressed settlement areas, investment in multiple infrastructure components will be essential. This investment should focus on fortifying settlements, particularly in the main municipality of Richtersveld, covering essentials such as adequate bulk water supply, sanitation, road systems, electricity, housing projects, and associated social services.

Due to the limited access routes to the port and SEZ, vital roads like the N14, N7, and R382 will need protection to manage increased traffic, primarily from heavy vehicles. Enhancing traffic safety and

mitigating road damage from overloading are pressing issues needing attention. The importance of emergency incident response will grow, not only due to local traffic but also from the movement and parking of heavy freight vehicles passing through towns, necessitating improved traffic management in areas like Springbok, Steinkopf, and Port Nolloth.

Development contributions concerning the infrastructure and service impacts must be evaluated. In certain instances, the organizations responsible for developing the port and SEZ could be liable for regional bulk infrastructure investments. Moreover, the anticipated ongoing land use and development applications associated with the port and SEZ scenarios for small and large hydrogen production will demand additional resources and administrative capacity to handle regulatory processes, straining local authorities further. It's crucial to note that while land use regulatory systems exist in the region, the capacity to effectively implement them daily is limited. Therefore, even minor adjustments to existing resource and land use patterns will create considerable challenges in regulatory processes as well as in environmental and spatial planning in the area.

6.3.1.1 Baseline scenario

As reflected in section 1.6, the region, comprising four local municipalities and the District Municipality, possesses the necessary planning instruments to manage land use and engage in strategic planning. However, the nature of growth and economic development (or decline in certain areas) has resulted in limited planning capacity. Significant planning decisions have been made through a District Municipal Planning Tribunal that convenes quarterly. The financial situation of these municipalities places them in a challenging position—staffing resources are scarce, and currently, no registered professional planners are employed within these municipalities (although two planners in Nama-Khoi Local and Namakwa District Municipalities are in the process of full registration). In the absence of any major development, the existing processes and planning mechanisms will persist. The transition of the town of Alexander Bay is an ongoing endeavour between Alexcor and the Richtersveld Local Municipality, hindered by a lack of municipal resources and the current state of infrastructure in the town. Additionally, 20.6% of households in Richtersveld are deemed indigent and require support, further straining municipal resources.

6.3.1.2 Small Green Hydrogen scenario

As the Port and SEZ developments begin, there will be numerous land use change applications related to the new projects. These include impacted settlements requiring housing, essential infrastructure like water pipelines and power lines, and the establishment of green energy installations. Addressing the significant traffic volumes on the N7, N14, and construction on the R382 will necessitate coordination with local municipalities on services, the development of construction site camps, traffic safety, and land arrangements. Since much of the Richtersveld consists of communal land, the Richtersveld Sida !Hub Communal Property Association will be a key stakeholder in certain spatial planning processes.

The diverse range of developments affecting land use will also require engagement with various authorities, including the Department of Environmental Affairs, the Department of Rural Development and Land Reform, the Department of Energy, the Department of Water Affairs, the Department of Mineral Resources, SANRAL, Transnet, ESKOM, the Department of Trade, Industry and Competition, and the Northern Cape Department of Cooperative Governance, Human Settlement, and Traditional Affairs for the Northern Cape Province.

In the built-up areas of the Richtersveld Municipality, initial planning suggests that towns like Port Nolloth and Alexander Bay will receive significant population increases. Several towns will face land use changes due to expansion, which will present substantial challenges. These rural municipalities are where governmental capacity constraints pose the greatest challenges. Processing land use applications within reasonable timeframes and enforcing and monitoring decisions may be difficult. Currently, a District Municipal Planning Tribunal oversees the planning process, but the anticipated rise in applications and related issues will necessitate enhancements to decision-making mechanisms.

One approach could involve the Namakwa District Municipality taking a more prominent role in regional planning support. Furthermore, the Northern Cape Province could leverage additional capacity to assist

municipalities with land use and development application processes. Over the next 5 to 10 years, a variety of developments are expected to impact the region, with several infrastructure projects occurring simultaneously. This period will see a notable increase in planning activities, requiring added support and capacity. However, some large infrastructure initiatives may not emerge until green hydrogen production and port utilization increase. For significant projects like railways, transmission lines, or pipelines, it is crucial for Provincial and National Government to play a pivotal facilitating role.

6.3.1.3 Large Green Hydrogen scenario

In this scenario, the production of green hydrogen is set to expand significantly. Municipal systems and processes will face considerably increased pressure. The increased scale of development activities is expected to generate a high volume of regulatory applications and service demands across all government levels. Specifically, the ongoing and cumulative rise in land use and development applications will impose a heavy burden on less-equipped municipalities. To sustain robust investment and development trends, it is essential to maintain the planning support mechanisms previously established in the Small Green Hydrogen scenario. Given the expected increase in regulatory applications, settlement expansion, infrastructure corridors and cumulative demands on municipal systems, a threshold-based approach should be adopted. Development approval processes should be sequenced so that large-scale land use applications and associated infrastructure decisions proceed only once minimum planning support capacity, updated land use management arrangements, municipal coordination mechanisms and land access protocols are demonstrably in place. In the absence of such enabling measures, planning pressure should be treated as a strategic constraint rather than only a manageable capacity risk.

This period is anticipated to witness a surge in green hydrogen production alongside higher exports from the port, particularly manganese. As a result, two key infrastructure projects will be necessary: building a rail line from Kenhardt to Boegoebaai and developing pipelines to convey green hydrogen to inland areas. These initiatives will affect municipalities concerning land use applications, servitudes, and support for construction camps. Furthermore, the expansion of green energy projects, particularly wind and solar, will be crucial to meet the increased size and power demands of electrolyser systems, impacting landowners where infrastructure intersects their property.

It is vital to consider the various settlements in the region. Over-investment in one or two towns could jeopardize smaller settlements, prompting residents to move toward the more prosperous ‘growth towns." Therefore, fostering a balanced investment strategy is important to ensure that developments in Boegoebaai and the port do not compromise the vitality of smaller communities. Municipalities and their planning functions must prioritize the preservation of Nama and traditional communities residing in more remote and smaller settlements.

6.3.2 Settlement development and service delivery implications

Within the study area[2] the Richtersveld Municipality is the focal point of a range of developments linked to the port and SEZ and as such, is the primary receiving area. The town of Springbok located at the heart of the study area serves as a Regional Development Anchor where the largest range of social facilities can be accessed. It is also the home of the Namakwa District Municipality. Other towns that provide a rural service centre role are Steinkopf and Port Nolloth. These are also the largest towns in the region housing the largest settlement populations (see Annexure A). Within Khai-Ma and Kamiesberg the largest towns are Pofadder and Garies respectively. The remainder of the region comprise mostly small and dispersed settlements. The towns that have exhibited the largest residential growth over the period 2015-2022 are Springbok, Alexander Bay, Vioolsdrift and Poffadder. In the past mining was a key driver of growth, benefitting towns of Aggeneys, Springbok, and Alexander Bay. Diamond mining, by the ailing state owned Alexcor, has been declining in the Richtersveld Municipality (Mail and Guardian, 2007), leading to a decline in employment opportunities and the local economy. Although the mining town of Alexander Bay is in the process of transfer to the Richtersveld Municipality, some aspects are delaying transfer. Considering both Port Nolloth and Alexander Bay have been identified as the key receiving towns, this has a number of implications including ensuring that these towns can accommodate settlement growth and can provide

[2] Richtersveld, Nama Khoi, Khai-Ma and Kamiesberg municipalities.

social services for a growing population (SRR, 2024). Currently, the town of Alexander Bay is in a deteriorated condition, with public buildings and streets in need of maintenance and repair (see Figure 6-11). This reflects the town's vulnerability and highlights the importance of pre-investment before significant population growth occurs as a result of construction activities and project implementation associated with the proposed port and SEZ.

Figure 6-11: Alexander Bay: condition of infrastructure: a) Abandoned buildings, b) Damaged hospital, c) Decaying streets, d) Rubble in streets.

Source: (Maritz, J., 2024b)

Most of the population residing in the region (89%) live in settlements and towns and according to the 2024 Partner-a-District diagnostic assessment, two in every five people in the Namakwa District live in poverty, further illustrating the current depressed nature of these settlements (DBSA, 2024). This high level of dependence also means that municipalities face increasing pressure for sustainable basic and social service delivery while being burdened with limited human and financial resources. As indicated in Table 6-4, the growth rate in this region varies from settlement to settlement; the overall growth rate is 2.4% per annum (Municipalities of SA, 2024). This still has implications that include a rising demand for housing, access to water, electricity, and sanitation, as well as local amenities (parks, sports and recreation), social services (health care, education, home affairs offices, etc.), and associated facilities.

Planning documents and strategies indicate that new settlement growth should be absorbed into existing settlements and should not lead to the creation of new ones (SRR, 2024) (Erioloba Consulting, 2024). The National Spatial Development Framework stipulates that settlement development should be decoupled from standalone developments such as mining (and industrial) developments – the housing and associated needs should be provided for in existing settlements (Department of Agriculture, Land Reform and Rural Development, and Department of Planning, Monitoring and Evaluation, 2021, p. 121). However, this requires that the most affected settlements be equipped to manage rapid growth when the port and

SEZ developments commence. Although some recent studies identify Port Nolloth and Alexander Bay as the primary affected settlements (SRR, 2024), the settlement choices of new residents moving into the region cannot be entirely anticipated or quantified. A local example of this can be seen in Aggeneys (home of the Namakwa SEZ), where some employees commute from Okiep, Springbok, and other surrounding towns in the Nama Khoi municipality—covering an average distance of approximately 112 km (Thomas, 2024)((Bezuidenhout, 2024)). The anticipated development of the Boegoebaai SEZ may lead to comparable settlement patterns, potentially expanding residential areas beyond Port Nolloth and Alexander Bay. It is essential to acknowledge the settlement-related challenges of towns likely to be recipients of large numbers of new residents. The increase in expected employees linked to the range of new infrastructure will place pressure on the primary receiving settlements (Alexander Bay and Port Nolloth). This would also mean significant land and land-use-related applications and approvals need to be processed timely. Furthermore, this will increase pressure on the current planning governance of the affected municipalities, especially Richtersveld. Table 6-5 provides a set of likely settlement implications for the predefined scenarios. It must be noted that it cannot be assumed that all employees will be accompanied by their families (households) seeking household accommodation.

Table 6-5: Estimated direct settlement implications linked to Port and SEZ (Green Hydrogen Production scenarios)

Scenario	Skills required (From high skills to labourers)[3]	Migration pressures	Town based settlement implications	On-site settlement implications
Baseline Scenario	The Namakwa SEZ would draw in an estimated 6000 direct and indirect jobs (Modise, 2024). Some green energy projects (wind and solar) currently proposed (and not linked to the Boegoebaai SEZ) could both develop - and draw in - skills, especially during construction.	There is limited economic growth in the region with the exception of mining development north of Springbok and at Aggeneys (incl. the Namakwa SEZ), which would generate some jobs in those areas. Otherwise, jobs are limited, and local job creation should be prioritised. In-migration associated with mining can be expected to increase the pressure on housing and service delivery. Main areas of expected (even though limited) growth are settlements around Springbok, Aggeneys and Pofadder.	Rental accommodation is likely to increase in towns such as Springbok (confirmed by interview with local realtor), although the Springbok area has limited new housing developments and growth in property market is slow. Pofadder and Aggeneys are the other towns in which settlement pressure is likely (Bezuidenhout, 2024).	Settlements are likely to be affect by other large-scale developments and projects occurring in the region, notably the Namakwa SEZ and mining developments near Springbok. The towns that are likely to be affected are Aggeneys, Pofadder and the Springbok cluster. Construction camps could be erected at towns or at the infrastructure project sites, with added pressure in nearby towns for housing.
Small Hydrogen Production Scenario	This period represents the start of numerous infrastructure projects, with most resources and additional skills required during the construction phases (2027/8). It is estimated that approximately 4198 to 5638 new direct employees will enter the Richtersveld Local Municipality (estimates calculated in Table 5). Many would not necessarily be permanent residents in the area, due to the temporary nature of the work and limited settlement options. Some water and electricity network infrastructure projects are also likely to commence at this stage to support port and SEZ development. This will	Whilst pressure for job creation would result in preference provided to local residents, some of the skills required might need to be sourced from outside the region, which would likely result in substantial in-migration. Incoming migrants will predominantly be accommodated in existing towns (e.g. Alexander Bay and Port Nolloth). Some infrastructure projects could have temporary construction site camps that relocate as construction proceeds in different areas. In-migration will likely affect the economy of local towns through an increased demand for goods and services. There is also the likelihood of more people entering the region seeking work, which is not necessarily	It is anticipated that the towns impacted would mainly be Alexander Bay and Port Nolloth (SRR, 2024). An increase in the need for rental accommodation could lead to pressure to develop additional housing and/or a rise in property values. Port Nolloth as the larger centre is likely to be the preferred choice for property development. Alexander Bay could be considered to accommodate labourers and be the site for much of the Port and SEZ construction housing. In both these towns' water, electricity and sanitation infrastructure will require expansion (to cater for additional housing and construction demand) and upgrading (to improve existing,	Staff settlement on-site (at the port or at large scale infrastructure developments) is likely to be limited and predominantly comprise of port operators and security personnel. The majority of staff are likely to reside at towns such as Port Nolloth and Alexander Bay. For some infrastructure development projects temporary on-site construction camps could be preferred (example solar and wind projects) during the construction phase (Olivier, 2024). After construction – operational staff are likely to stay at towns such as Port Nolloth or Alexander Bay. Some staff could choose to locate in other settlements such as Springbok, but this may be limited due to distance and/or limited housing and services available (Bezuidenhout, 2024)

[3] The skill number are based on examples / ratios from similar projects. The detail design of the project would detail the numbers more accurately.

Scenario	Skills required (From high skills to labourers)[3]	Migration pressures	Town based settlement implications	On-site settlement implications
	also require skills, but employment is likely to be temporary.	directly associated with the port and SEZ. Generally, immigration is likely to place pressure on towns, especially when that results in informal settlement growth.	often under-capacity or ageing systems).	(Thomas, 2024).
Big Hydrogen production scenario	The extent of infrastructure development is associated with the growth in green energy in the region, including the expansion of desalination, electrolyser and related green hydrogen production components. Once the port and SEZ is established, the expansion of hydrogen related production components will likely generate fewer direct employment opportunities. Job creation could be influenced by an increase in the number of solar and wind projects taking place in the region, as well as the expansion of the gas pipeline and rail construction.	Given that most of the initial construction in the Richtersveld will be completed in the Small Hydrogen Scenario, the projects associated with the expansion to the Big Hydrogen Scenario would likely affect the wider region. Infrastructure projects such as rail and pipelines could cause inmigration into the region.	Growth in green hydrogen production and associated in migration could possibly sustain the housing market in Port Nolloth and Alexander Bay. Alexander Bay is likely to continue to be the preferred location for lower-income housing. Growth in the SEZ industrial park could stimulate higher-income property development in the region, especially in Port Nolloth.	Most of the original developments at the port and SEZ are complete in this scenario, so initial settlement pressure is significantly reduced (Schreiner, et al., 2024). In the Big Hydrogen scenario port operators and security personnel are likely to stay on site. During the construction of associated infrastructure, on-site construction camps could also be established within the broader region. After construction, operational staff will likely reside in towns such as Port Nolloth or Alexander Bay. Some staff could relocate to other settlements such as Springbok, but this is likely to be limited due to distance or a lack of housing availability.

Source: Compiled by Authors.

6.3.2.1 Baseline Scenario

Settlement development in this scenario is limited, with only a few large projects in the region (see Figure 6-9). The Namakwa SEZ will significantly draw in skills and impact the towns of Aggeneys and Poffader. The likelihood of the construction of the Vioolsdrift Dam remains uncertain at this stage; however, it could be a significant project that may affect settlements along the N7, extending from Springbok to Vioolsdrift, including Steinkopf. The Namakwa irrigation project could also influence settlements along the Orange River. With minimal construction and operational job opportunities for the residents of Richtersveldt, incremental growth is expected to continue in towns like Port Nolloth and Alexander Bay. The pressure on local service infrastructure is substantial enough to warrant necessary upgrades in the local municipality. Water supply, waste, and sanitation services require urgent improvements to address the demands of the current population (see Section 6.2.3). Although Alexander Bay will be transferred to the Richtersveld Municipality, without ongoing financial support from Alexcor or the state (e.g., Department of Cooperative Governance and Traditional Affairs), the future of Alexander Bay remains uncertain. Currently, the town exhibits signs of decay and neglect, significantly impacted by the decline of the local mining economy.

Springbok, as the regional anchor town, could experience growth due to the preference of residents working in the region to reside here, given the range of services it provides, which is also stimulated by the evolving mining sector nearby. Other projects that could impact several towns include the revitalisation of Port Nolloth harbour, ongoing regional development of solar and wind plants, the construction of a regional hospital (in Springbok), and the revitalisation of the regional airport (in Springbok).

6.3.2.2 Small Hydrogen Production Scenario

During this phase, numerous initiatives begin to affect land development, including the Port and SEZ industrial estate, alongside green hydrogen-related projects, wind and solar parks, road improvements, and the construction of transmission lines and pipelines. These developments will attract a skilled workforce requiring accommodation: limited onsite lodging at the SEZ and Port necessitates that housing primarily be established in Alexander Bay and Port Nolloth. The skill level of these workers is likely to determine the type of accommodation sought, considering that construction activities are only temporary, with fewer workers seeking property ownership. Those with high skill levels will most likely reside in Port Nolloth or even as far as Springbok, commuting regularly to the area. If Alexander Bay Airport were to be reopened and upgraded to accommodate scheduled commercial flights, it could additionally support the mobility of higher-skilled workers through the implementation of a fly-in fly-out operational model. Accommodation will also be required for less skilled workers, divided between the towns of Port Nolloth and Alexander Bay, given the preference to live as close to the new developments as possible. Additional low-skilled accommodation could be available in construction site camps unless developers prefer to house their workers in the nearest settlement; in this case, towns must ensure they can accommodate these residents.

Past South African experiences, such as in-migration related to developments in various mining towns, echo international boomtown phenomena where large developments draw significant numbers of people, which can strain municipal resources. This could lead to potential informal settlement development and increased service demand, particularly during construction phases. An increase in the demand for (higher end) rental accommodation for specialists associated with multiple infrastructure projects and/or support services could result in rising property values, which may subsequently encourage the conversion of existing housing stock to rental accommodation and guest houses. Uncertainty at the onset of the first phase (Small Green Hydrogen Scenario) could create opportunities for ‘quick wins’ in the property market through estate developments, land use changes, or even illegal sub-letting. Additionally, an increase in land and other resources needed to accommodate township expansion and possible informal settlement upgrades, alongside timely provision of social and basic services, as well as upgrading bulk services capacity (especially regarding water availability and landfill sites), can be anticipated.

A significant proportion of highly skilled professionals and skilled workers would likely commute and primarily utilise rental accommodation. Many local employees and individuals who may have migrated to the area in the ‘hope’ of finding work will probably lack alternative options. The economies of the towns (especially Port Nolloth and Alexander Bay) are likely to experience growth during this period, and the

footprint of urban expansion (both private sector and government) will likely escalate, along with an expected increase in the indigent population associated with migration. This scenario may mean local economies and enterprises utilise the opportunities for growth and diversification, or municipalities may face an unsustainable burden in service delivery and finance. High pressure on municipal service delivery infrastructure is anticipated in this scenario and will persist until financial support is rendered to the municipality for upgrades to water, electricity, and waste infrastructure. It is improbable that these municipalities, particularly the Richtersveld, will be able to finance these expenditures in the absence of additional guaranteed fiscal commitments. Developments, such as the movement of large numbers of heavy vehicles transporting mining products to the port, traversing through the centre of Port Nolloth, could present a point of conflict and possibly raise traffic safety concerns. This could also detract from the perception of Port Nolloth as a coastal tourism destination.

6.3.2.3 Big Hydrogen Production scenario

At this point of the development, port facilities and regional transport networks will be fully operational and attracting substantial public and private sector investment. During this phase it is estimated that once the rail line is operational, the number of heavy vehicles to the Port will decrease, easing the strain on the R382. Once the additional pipelines become operational this will further decrease road-based heavy vehicle transport lessening the need to accommodate drivers staying over.

During this phase the pressure brought about by the construction activities of several simultaneous projects has declined and the region will settle into the operational phases for several infrastructure items. It is the operational employees that are more likely to establish in the region along with their households also requiring a variety of commercial and residential services for daily living. The growth in the development of green energy (wind and solar parks) continues to ensure it meets the energy needs of growing electrolyzer and desalination infrastructure at the SEZ. It is unclear to what extent the residential growth will spill over into towns such as Kuboes and Lekkersing as these towns are small, have limited social facilities and are less accessible by poorly maintained gravel roads. Steinkopf could also grow as a settlement, located on the N7 main road and in closer proximity to Springbok (the regional anchor town). It could potentially offer a place to settle for those seeking more affordable property. The growth in the SEZ and the synchronous economic growth in Port Nolloth, will have implications for informal settlement growth, service demand and associated unintended consequences. This could further impact the demand for water and sanitation, landfill facilities, social facilities, etc. This will place pressure on the Richtersveld Municipality for the delivery of services.

Unless a concerted effort is made to accommodate and train the local population in light of the opportunities offered by the Port and SEZ (particularly the operational phase), some households in towns will likely still be dependent on government grants, and local economies will continue to be largely dependent on the government service sector. This is likely to have spatial implications in the expansion of informal settlements. Skills development within the local population should be undertaken within the areas of solar and wind energy, which are likely to expand during this scenario within the region.

6.3.3 Construction of large economic infrastructure projects

Several large infrastructure projects, some occurring simultaneously, will affect the region. These will include roads, new rail lines, new pipelines, and possibly new electricity transmission lines. Although their construction and composition differ, they are, with the exception of green energy plant projects, all significant linear transport corridors that will require detailed planning, alongside the necessary applications and approvals. They will involve substantial construction over several years, extend across extensive sections of land requiring servitudes, and necessitate large construction teams with a range of skills for implementation. The following section briefly outlines the primary economic infrastructure projects.

6.3.3.1 Pressure on critical national and provincial access roads

A critical component for the port and SEZ development is the access roads to the greenfield site of the proposed project. As these roads will provide the necessary access for various purposes, including freight, construction, and employee access, their condition, design, and function become critical considerations. A recent study has indicated that the Northern Cape, including this region, has significant potential for growth in mining activities (such as zinc, nickel, lead, copper, and cobalt) enhanced by the realisation of Boegoebaai Port. Of particular interest are the roads connecting the Northern Cape mining belt and the proposed Port.

Current access to the site occurs predominantly via national roads, namely the N14, N7, and the R382 (see Figure 6-12). National Road N7, which runs from Cape Town to Namibia, and N14, from Springbok to Upington in the Northern Cape, fall under the South African National Roads Authority (SANRAL). The following table lists the key network between the Northern Cape mines (and large provincial economic centres) and Boegoebaai.

Table 6-6: Road network between Northen Cape Mines and Boegoebaai.

ROUTE (ROAD) - COMMENTS	LENGTH
National Roads (all Class 1 surfaced)	
Sishen to Upington (N14)	230km
Upington to Springbok (N14)	370km
Steinkopf to Port Nolloth (N7)	50km
Provincial Roads (all surfaced)	
Steinkopf to Port Nolloth (R382) – Provincial trunk road	90km
Port Nolloth to Boegoebaai (R382) – Provincial road	60km
Total Main Road network length	**800km**

Source: adapted from (TM consulting and Nelutha, 2019a)

Based largely on the manganese commodity demand and the locality of the Northern Cape Mines, it is envisaged that the first phase of the development of the will result in the transportation of mining ore via vehicular truck transport along the N14/N7/R382 corridor. Currently the Sishen to Saldanha Bay OREX Line, is the only heavy haul rail line that passes through the province. However, this line will eventually reach capacity and require major upgrading. Should the volume of iron ore to Saldanha decline due to possible mine closures, it could open the OREX line to accommodate more manganese for export. Most Northern Cape mining exports currently run through the Sishen to Saldanha line. Manganese is also exported from the Northern Cape via the Port Elizabeth and Ngqura line. Ideally, a large amount of manganese could be exported through the proposed Boegoebaai Port instead. Due to the large weight and long distances required to transport the manganese ore from the mines mentioned, heavy haul carriers are needed. The availability of the new Boegoebaai Port will result in the growth of heavy vehicle volumes, predominantly moving on the N14, N7 and R382.

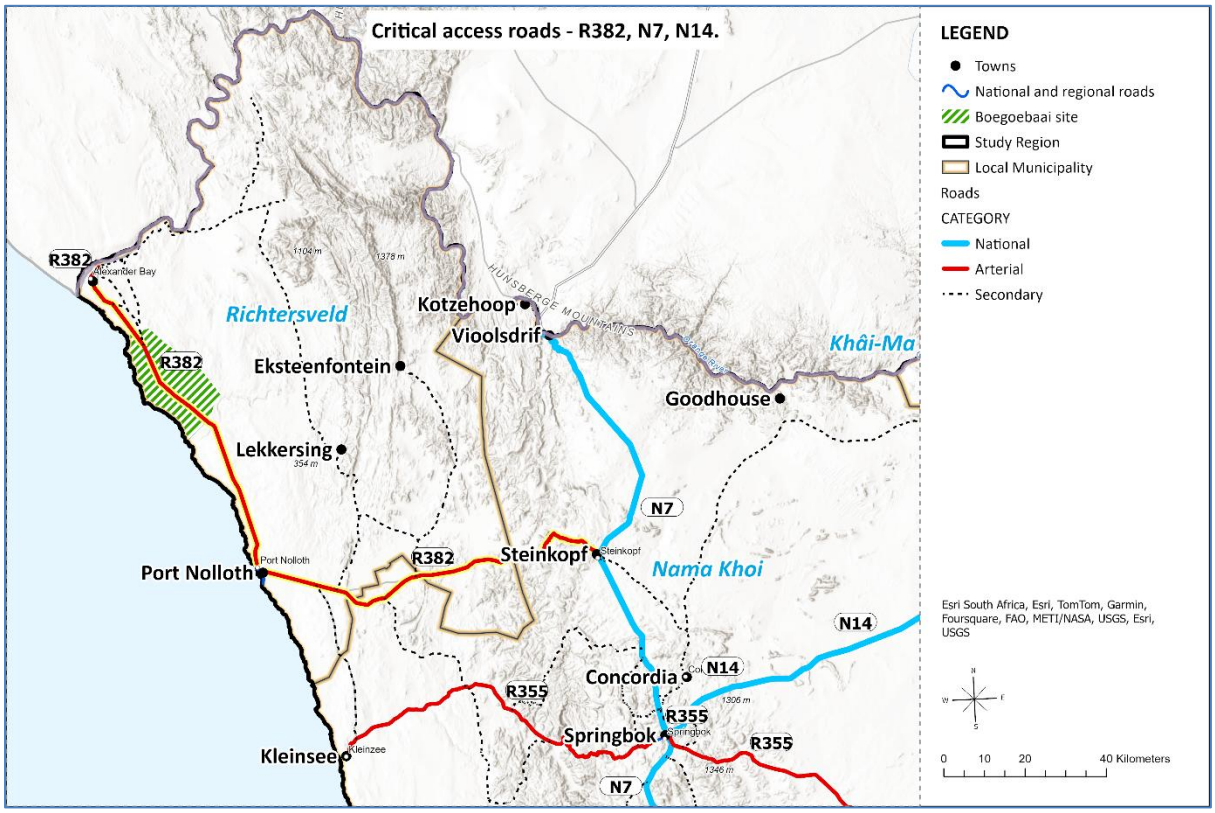


Figure 6-12: Critical current access to proposed Greenfields site.

Source: (Maritz, 2025a)

Information sourced from the South African National Roads Agency indicates that the 2024 road freight volumes on the N14, N7, and R382 were low. The R382 (TR82/1) between Steinkopf (N7) and Port Nolloth (90km), including the Anenous Mountain pass, was initially constructed in 1979 to bituminous standards, over 40 years ago, with likely routine and periodic (re-seal) maintenance interventions. Indications suggest that the road has reached its residual design life and is due for improvements. According to SANRAL, two road engineering consultants were appointed in 2024 to conduct a Road Safety Audit to evaluate the existing road layout and assess the detailed designs for the periodic maintenance of route R382 sections. Whilst fully laden trucks from the mines will be descending the pass to the coast, the return trip to the mines may necessitate the construction of climbing lanes on the steep sections of Anenous Pass. Road R382 between Port Nolloth and Alexander Bay was built in 1991 to class 3 specifications and has reached its design life, requiring rehabilitation and/or reconstruction, alongside Phase 1A of the Port development. It is envisaged that Boegoebaai Port will initially attract freight from the Northern Cape Mines exceeding a total of 6Mtpa (See Table 6-7); and it is assumed that mining commodities will be transported by road from the Northern Cape Mines during the first five years after the Port becomes operational. The road-based commodities transported to the Port are expected to reach 10MTPA by 2035 (TM consulting and Nelutha, 2019a).

Table 6-7: Commodity demand - Boegoebaai (High Case demand)

Cargo Type - Commodity	Volume (Mtpa[4]) 2030[5]	Volume (Mtpa) 2035	Volume (Mtpa) 2050
Dry bulk – iron Ore	0	0	0
Dry Bulk – Manganese	4.5	6.0	9.0
Break bulk – Lead/Zinc	0.7	0.7	0.7
Break bulk – Magnetite	0.3	0.3	0.3
Break bulk - Ilmenite	0.1	0.1	0.5
Liquid bulk – Diesel	1.3	1.37	1.7
Containers – agriculture products	0.15	0.21	0.42
Containers – Salt	0.03	0.03	0.03
Containers – general Cargo	0.75	0.90	1.28
Total	**7.83**	**9.61**	**13.93**

Source: adapted from: (TM consulting and Nelutha, 2019a, p. 18)

This would translate into a large number of heavy vehicles that would significantly impact these roads. During the first year of Port operation, it is estimated that 561 heavy vehicles will visit the Port per day. This is projected to increase to 829 by 2050 (TM consulting and Nelutha, 2019a). This only reflects heavy vehicle traffic on these roads; however, as a shared infrastructure resource, the road also serves tourists, commuters, and other travellers moving between Alexander Bay, Boegoebaai, Port Nolloth, Steinkopf, Springbok, and beyond.

Baseline scenario

When examining the development trends indicated in planning documents (such as SDFs and IDPs), apart from the Namakwa SEZ and possibly the Vioolsdrift Dam, the region shows few significant growth prospects. Should the decline in diamond mining in Alexander Bay persist, unemployment is likely to increase, especially in the Richtersveld Municipality, prompting some skilled workers to look for opportunities in areas like the growing mining sector near Springbok and the Namakwa SEZ's development at Aggeneys. Standard road maintenance will continue, depending on available funding. SANRAL has included the R382 in their network and has hired consultants for ongoing maintenance. This will facilitate access to Port Nolloth from Steinkopf and help those needing to reach the northern areas of Richtersveld. The other roads face challenges due to a lack of funding. Maintaining gravel roads to smaller settlements is already difficult and is expected to remain problematic, given the continued funding shortfalls for regular upkeep. This issue is particularly pronounced in the Richtersveld Municipality, as shown in Figure 6-13, which deters the use of ordinary vehicles on certain gravel roads.

[4] Mtpa = million tons per annum
[5] Ordinally calculated with start date of 2019, adjusted to 2030 and 2035 respectively assuming assumptions remain unchanged.

Figure 6-13: Gravel Road (to Eskteenfontein) where drivers are advised by road alert signs to use a bakkie or 4x4 vehicle.

Source: (Maritz, J., 2024a)

Small Green Hydrogen Scenario

At this stage, construction of the Port will begin, followed by the SEZ, anticipated within the first five to six years (refer to Table 6-13). This development will result in the transportation of equipment, materials, and resources along existing routes, especially the N14, N7, and the R382, which connect major centers and areas beyond the region. The N14 and N7 are established national routes in South Africa, facilitating business, trade, and tourism. Furthermore, the N7 is a vital access point to Namibia. The influx of large construction vehicles may elevate the risk of accidents, material spillage, congestion, and potentially lead to the deterioration of road infrastructure if not managed properly. Within the region, traffic will flow past communities like Springbok and Steinkopf, necessitating solutions for traffic safety. The R382 currently traverses the main streets of Port Nolloth, and the rising heavy vehicle traffic is expected to disrupt the town's tranquil environment, generating noise and air pollution. Accordingly, traffic management and road safety measures along the R382 in Port Nolloth must be prioritized. Beyond the region, the N7 and N14 will facilitate the transport of equipment from Cape Town and along the mining corridor towards Kimberley, and some construction materials may need to be sourced from outside the area.

While green hydrogen production is recognized as the main driver behind Port development, it is important to emphasize that the Port will also function as a significant export hub for regional mining commodities, particularly manganese. Once operational and ready for exports, mining commodities are expected to become key export products. Initially, trucking will be the only method of transporting these commodities. Only after reaching a transport volume exceeding 10 Mtpa will a rail line be established to support the movement of goods to the Port. Projected demand for mining commodities and related truck traffic to the port are shown in Table 6-8. (a single standard heavy bulk mining truck has a payload of 34 tons)

In addition to the initial pressure caused by the various construction activities, the substantial volume of heavy vehicles and other traffic travelling to and from the port will impact road safety (particularly through settlements) and will also lead to increased noise and air pollution. The rise in traffic will also require the implementation of enhanced emergency response and traffic management measures. Due to the significant rise in loads resulting from the high volume of truck traffic, it is recommended that construction of the rail line be initiated earlier than originally planned in the preliminary studies.

Table 6-8: Projected commodity truck traffic to port[6]

Projected commodity mix Truck traffic	Year 0 (2025) - 2030	Year 20 (2045) - 2050
Commodity Demand (Mtpa)	7 128 000	10 528 000
Trucks per annum	204945	302703
Trucks per month	17079	25225
Trucks per day	561	829
Trucks per hour	28	41

Source: adapted from: (TM consulting and Nelutha, 2019a, p. 23)

The R382 linking Steinkopf and Alexander Bay is becoming an increasingly vital shared asset. It is crucial not only for the regional mines but also as the sole road access to the SEZ for hydrogen and related products. Furthermore, it acts as an important access route for employees at the port and SEZ.

Recognizing that the R382 was not designed for high traffic volumes,and considering the significant anticipated heavy vehicle traffic from the mining areas along the N14 (Table 6-9), major construction or reconstruction will be required. The segment of R382 (TR8201) from Steinkopf, past the Anenous mountain pass to Port Nolloth, is in poor condition. Reports by TM Consulting (2019a) indicate that only 18% of the road is in good shape, while the remaining 82% is rated from warning to severe condition and needs strengthening. Rehabilitation or reconstruction of the R382 is critical, requiring a pavement design life of 25 years and an ES30 pavement capable of supporting 30 million E80s over that period. SANRAL has acknowledged the necessity for maintenance along the R382. Given that the road likely has reached its design life and needs rehabilitation, it is unlikely that the existing structure can withstand the anticipated loading due to commodity demands transported to Boegoebaai port by road. Additionally, higher pavement design specifications and specific climbing lanes will be necessary on the Anenous mountain pass between Steinkopf and Port Nolloth.

During this phase, significant deterioration of key national roads (N7 and N14) is not expected as port and SEZ construction begins; however, to manage the increasing and sustained freight flow beyond 2030, greater attention must be directed towards upgrading and rehabilitating these routes. Considering the lengthy timeline required to design and construct the R382 (approximately six years) (TM consulting and Nelutha, 2019a), this may disrupt other construction and trade activities. Demand for water and construction materials will surge during the roadwork period. Some materials will be sourced from outside the region while others locally investigating and approving local borrow pits will be necessary. Temporary site camps for construction workers and stockpiled materials are likely to be established on approved sites (see example in Figure 6-14). This process should involve engaging with landowners and the municipality to secure land and service access. At this point, identifying and permitting approved gravel pits will commence.

Construction-related mitigation for road and corridor development should specify minimum requirements. These include approved traffic management plans; pre-construction road condition surveys; agreements on road damage repair and maintenance responsibility; approved borrow pit and material sourcing arrangements; and municipal service protection measures where construction activity interfaces with local roads, settlements and services. Construction camps associated with road or corridor works should be located on disturbed or low-sensitivity land where practicable, avoid sensitive receptors, provide compliant water supply, sanitation, waste management and stormwater controls, and include clear rehabilitation and closure requirements

[6] Table adjusted from original, start dates.

Figure 6-14: Road site adjacent to road.

Source: (Maritz, J., 2024a)

Other roads: In the Richtersveld, smaller municipal gravel roads connecting communities like Lekkersing, Eksteensfontein, and Khubus could be affected by development. Furthermore, roads accessing the Nama Khoi municipality's Kleinsee and Grootmis are also included. These roads are located within 150 km of the site, and aside from the centres of Alexander Bay, Steinkopf, and Port Nolloth, they serve settlements likely to attract incoming workers looking for accommodation.

Big Green Hydrogen Scenario

At this point in hydrogen production, roughly six to seven years in, the Port is fully operational, and the output of green hydrogen is steadily increasing. Key construction phases for several elements are completed, including the finished R382, which improves access to Port Nolloth, the Port and SEZ, and Alexander Bay. As green hydrogen production and port usage rise, the roads will continue to support increasing volumes of heavy vehicles, particularly on the N14, N7, and R382. Close monitoring and regular maintenance are crucial, with most tasks being outsourced. This phase will also include the construction of a railway line aimed at providing an alternative route for transporting mining commodities from the central and eastern parts of the province, depending on funding availability. If the railway project faces delays, the road network will still handle substantial freight movement to the port. The anticipated rise in traffic will lead to a reduction in the lifespan of these roads, requiring more frequent maintenance, which will necessitate dedicated funding. Monitoring the road system holds great importance due to the high traffic on certain routes. SANRAL is well-prepared to oversee its road network and coordinate necessary maintenance and construction efforts.

6.3.3.2 Proposed rail line

A major consideration for Boegoebaai is its role as a crucial export Port for the Northern Cape Province. The mining sector stands to gain significantly from the development of this new Port. Initially, freight transportation to and from the Port will rely on road transport; however, as freight and export volumes increase, a railway system will be required to alleviate pressure on the roads (TM Consulting and Nelutha, 2019b). The Port's proximity compared to other national ports, along with lower transport costs, would also enhance exports of commodities from various locations within the Northern Cape. In particular, the Aggeneys Mine, located 340 km by road from the Port, will benefit from Boegoebaai's implementation. This mine, part of the Namakwa SEZ, primarily extracts copper, manganese, lead, and zinc. The proposed

railway will connect to the existing rail infrastructure, broadening transport options from other parts of the Province, especially the eastern region. This rail line will link to the Sishen to Saldanha line, facilitating service to mines in that corridor, including Orien Minerals and Kumba Sishen Mine, both found in the Copperton area and focused on zinc and copper production. In the interim, the key transport routes to connect Boegoebaai Port with the Groblershoop area (eastern extent) will be the existing main roads (N14, N7, and R363).

The principal challenges for the rail line's design occur near the Anenous Pass, west of Steinkopf, and along the connection from Steinkopf to the N14. Alignment issues arise from factors such as the terrain, the current road layout, and the mineral types present in the area.

The mining industry is responsible for nearly two-thirds of the commodities traded in the Northern Cape, with around 25 million tons of general freight transported from the region. Once Boegoebaai Port is operational, it is expected to handle a larger volume of commodities, allowing mining operations to increase their capacity. The planned railway will primarily transport manganese from the Hotazel and Aggeneys mines. Until the rail line is functional, heavy vehicles will be the main mode of transport to Boegoebaai Port. Construction of the rail line (based on pre-studies) is also contingent on road freight volumes surpassing 10 MTPA. Until that threshold is reached, the rail line is unlikely to be built.

Careful planning of the alignment, servitude designation, and rail line construction will significantly impact communities along the route and the development landscape in areas adjacent to the corridor. Although the region is sparsely populated, it could influence land development, town expansion, and sustainable regional and community growth.

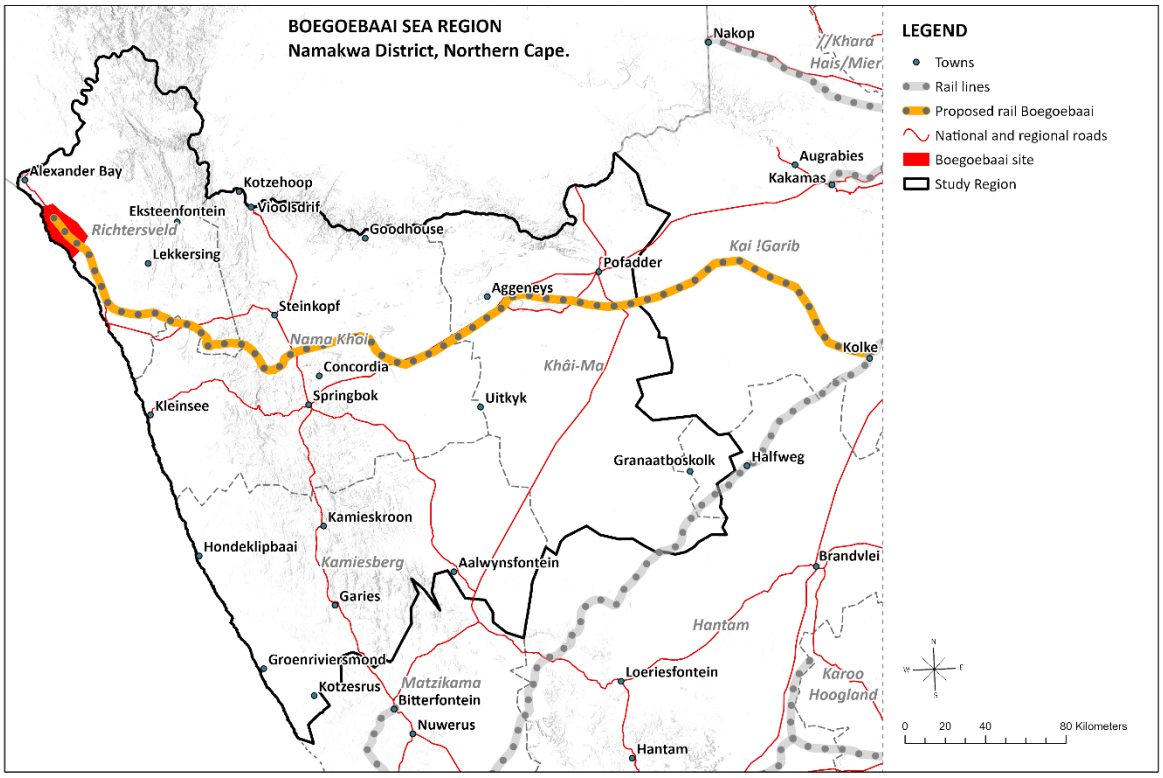


Figure 6-15: Proposed rail line from Kenhardt to Boegoebaai.

Source: (Maritz, 2024c)

Baseline scenario

Due to the lack of development at Boegoebaai, manganese, along with other mining commodities, is mainly transported by rail to Gqeberha, Saldanha Bay, and by road and rail to Durban. In the near future, these operations might also be merged and shifted to the Port of Ngqura. Additionally, the Port of Lüderitz

in Namibia has increased its capacity and is exporting manganese through the Trans-Oranje Corridor. Likewise, other commodities will keep utilizing the ports of Saldanha, Cape Town, and Gqeberha for their import and export needs.

Small Green Hydrogen Scenario

The construction of the Port and the initiation of green hydrogen production are expected to take place around 2028. Once the Port is operational, mining firms will use the new facility to export manganese and other minerals. As discussed in Section 6.3.3.1 about roads, the export of goods, mainly from the mining sector, will primarily rely on road transport until the volume reaches 10 Mtpa. Given the substantial expense of building a rail line, it is improbable that such a line will be developed until this export volume is either met or surpassed.

Big Green Hydrogen Scenario

Typically, a new standard-gauge railway line is justified only when freight traffic volumes exceed 10 Mtpa. Previous studies have predicted this level of traffic may occur by around 2035 (TM consulting and Nelutha, 2019b). To prepare for achieving these freight volumes, essential planning and design studies would have been conducted during the latter part of the Small Green Hydrogen Scenario. The rail line's construction period is anticipated to last 4 to 5 years, excluding planning, design, and tender phases. It is planned to extend approximately 500 km, routing from Boegoebaai Port towards Anenous Pass. The preferred route will intersect the N7 and cross the N14 towards the Sishen to Saldanha railway line (see Figure 6-15). Three bridges are necessary for road-to-rail intersections, along with an additional seven river bridges, all designed with a proposed width of 6 m. The proposal includes four tunnels, with the cut and fill estimated at about 100 to 120 million m^3. At least four crossing loops will be essential for the Boegoebaai Railway, with stations proposed at Aggeneys, Steinkopf, Port Nolloth, and Boegoebaai. The alignment of the proposed rail has been influenced by the existing layout and classifications of surrounding road networks, aiming to minimize road and rail intersections by aligning close to roads for easier maintenance. The main roads considered include R382, N7, and N14. The proximity of various mines in the Northern Cape Province is a significant factor in the rail's design, as it is intended to connect with these mines. Additionally, the existing Sishen to Saldanha rail layout influences the railway's alignment (TM consulting and Nelutha, 2019b).

A land acquisition study is necessary to investigate areas adjacent to the proposed rail alignment. Specialized facilities for storage and maintenance will be required. The maintenance facility at the port will feature a storage yard, cleaning area, inspection zone, and locomotive shop. Empty wagons and trains will be stored in depots for cleaning or servicing, thus, adequate water and power supply from relevant service providers will be essential. A voltage of 50 kV AC overhead catenary is proposed instead of the conventional 25 kV to support heavier loads and increase the distance between transformers. The projected financial costs for the rail line represent a primary risk, estimated to total around ZAR 16 billion.

Other significant risks include:

- The presence of traffic near the rail (on R382, and sections of the N7 and N14)
- Eskom’s capacity to meet energy demands from the rail implementation
- Surrounding ground conditions
- Risks related to environmental authorizations
- Property acquisition and servitude establishment.
- Project cost – affordability.

Constructing a rail line can be intrusive, necessitating land clearance, excavation to create a level surface, soil stabilization to prevent erosion, establishment of a subgrade layer, building the track bed with ballast, and laying cement ties and rails. The width for a single-track measures 6 m, as depicted in Figure 6-16.

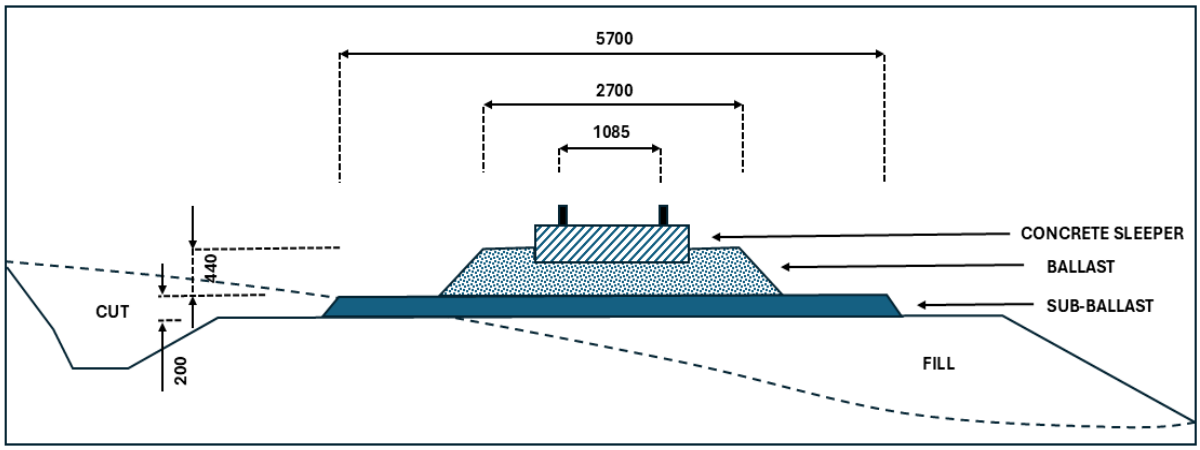


Figure 6-16: Rail Lines structure - cross-section.

Source: adapted from (TM consulting and Nelutha, 2019b).

Land ownership control

There is a clear preference and legal expectation that a Special Economic Zone (SEZ) node should be established on land that the applicant either owns or controls. The South African SEZ legal and regulatory framework requires that the applicant demonstrate ownership or control of the land proposed for designation as a SEZ. If the land is not already owned by the applicant, a clear strategy for acquisition or control must be provided as part of the application process. This is important to ensure that the SEZ entity can effectively manage, develop, and operate the zone without domain-related disputes or uncertainties.

The number of individuals engaged in rail line construction can differ significantly based on factors such as project length, complexity, location, and the degree of technology and automation employed. Typically, constructing a rail line necessitates a varied team of workers with diverse skills, resulting in a total workforce that may range from several hundred to thousands throughout the project's duration. Beyond engineering and technical expertise, a substantial portion of the workforce consists of construction labourers. Many general labourers participate in essential physical tasks, such as land clearing, excavation, grading, and building embankments, often involving hundreds of workers. Additionally, there are specialized teams tasked with placing ballast, installing ties or sleepers, and laying rails, which can range from dozens to hundreds, depending on the project's speed and scale. Furthermore, dozens of heavy equipment operators are also required. In remote locations, labourers are usually housed in construction or field camps.

6.3.3.3 Proposed pipeline corridor

Pipeline development is not a standalone infrastructure project for Boegoebaai; it is part of a broader vision to establish multiple hydrogen hubs along the west coast, including Lüderitz (Namibia), Boegoebaai, and Saldanha Bay. This initiative forms the backbone of the larger hydrogen economy. Initially, the hubs will be developed, and subsequently, they will be interconnected via pipelines. For the pipeline infrastructure to be sustainable, a large hydrogen system must be developed that relies on multiple hubs producing at scale, rather than a single hub. The pipeline is envisioned as a regional and transnational infrastructure that will serve as a system aggregator.

In 2019, a Strategic Environmental Assessment (SEA) detailing a phased strategy for developing a natural gas pipeline network in South Africa was undertaken (Department of Environment, Forestry and Fisheries, 2019). While the Boegoebaai SEA primarily focuses on a hydrogen pipeline, the significant findings (challenges and considerations) from the 2019 SEA offer a solid foundation for considerations relevant to green hydrogen pipeline development. The 2019 SEA clearly states that the construction of any pipeline, whether for natural gas or green hydrogen, will inevitably disrupt people's lives and livelihoods if built near existing or planned communities.

The anticipated disruptions include land use management issues that may render certain land uses unfeasible, as well as complications in tenure management due to the involvement of multiple landowners and municipal authorities. There is also a risk of resettlement and displacement, particularly if the pipeline route extends through densely populated or sensitive regions, which may lead to restrictions on future land development, adversely affecting local economies and service delivery.

To address these challenges, the 2019 SEA cites several actions that can be considered during the planning of pipeline developments. From the perspective of spatial and land use management, it is crucial to locate the pipeline away from densely populated rural settlements and communally owned land. Additionally, negotiations with affected landowners should occur to minimize disruptions and reach amicable compromises. It's acknowledged that pipeline routing must be carried out with the clear intention of minimizing potential displacements and avoiding conflicts with future township development plans (Department of Environment, Forestry and Fisheries, 2019). A hydrogen pipeline would generally fall under hazardous-chemical and pressure-equipment infrastructure, with approvals channelled through the relevant energy, environmental, and safety authorities, and its technical design directed by international or local hydrogen codes and standards. From a safety perspective, hydrogen pipelines are presently regulated under the Occupational Health and Safety Act and its associated regulations, including those relating to Hazardous Chemical Substances, Pressure Equipment, Construction, Explosives, and Major Hazard Installations.

Resettlement and relocation are a last resort, and the chances of this happening should be minimised. However, if relocation is unavoidable, efforts should be made to limit the number of affected individuals, prioritizing routing along existing transmission corridors as a mitigation strategy (Department of Environment, Forestry and Fisheries, 2019).

Moreover, the impacts of pipeline development on property values must be managed carefully, ensuring a transparent and equitable compensation process for any impacted property owners (Department of Environment, Forestry and Fisheries, 2019).

The 2019 SEA also emphasizes the potential effects of pipeline development on communities, advocating for continuous access to public services, roads, and emergency facilities for local communities during the construction phase to mitigate impacts (Department of Environment, Forestry and Fisheries, 2019).

The SEA highlights that disaster preparedness and emergency responses are essential components of pipeline development, recommending thorough risk assessments to mitigate risks of rupture, fire, or leakage. It is advised that pipelines built in “high risk” areas, such as those near communities, include designs aimed at leaking rather than rupturing to prevent catastrophic failures that could harm individuals (Department of Environment, Forestry and Fisheries, 2019).

All these findings should be incorporated into the hydrogen pipeline development in Boegoebaai along the north-to-south corridors (as mentioned in Operation Phakisa, see Figure 6-17) and the west-to-east corridor from Boegoebaai to Prieska (as outlined schematically in the Northern Cape Green Hydrogen Masterplan, Figure 6-18).

A prefeasibility study conducted in 2024 by WESGRO, NCEDA, Namibia’s Environmental Investment Fund, Gasunie, and Climate Fund Managers (2024) indicates that potential environmental impacts can be managed through appropriate mitigation measures, making it feasible to construct a pipeline close to public infrastructure. From a technical standpoint, constructing a predominantly underground pipeline appears feasible, with a 36-inch diameter being the most practical. However, it must be acknowledged that hydrogen and its related land use and planning requirements are currently unclear. A key issue is that hydrogen installations are classified as Major Hazard Installations, necessitating safety distances when planning and implementing such infrastructure. Currently, regulations or guidelines for these installations are insufficient.

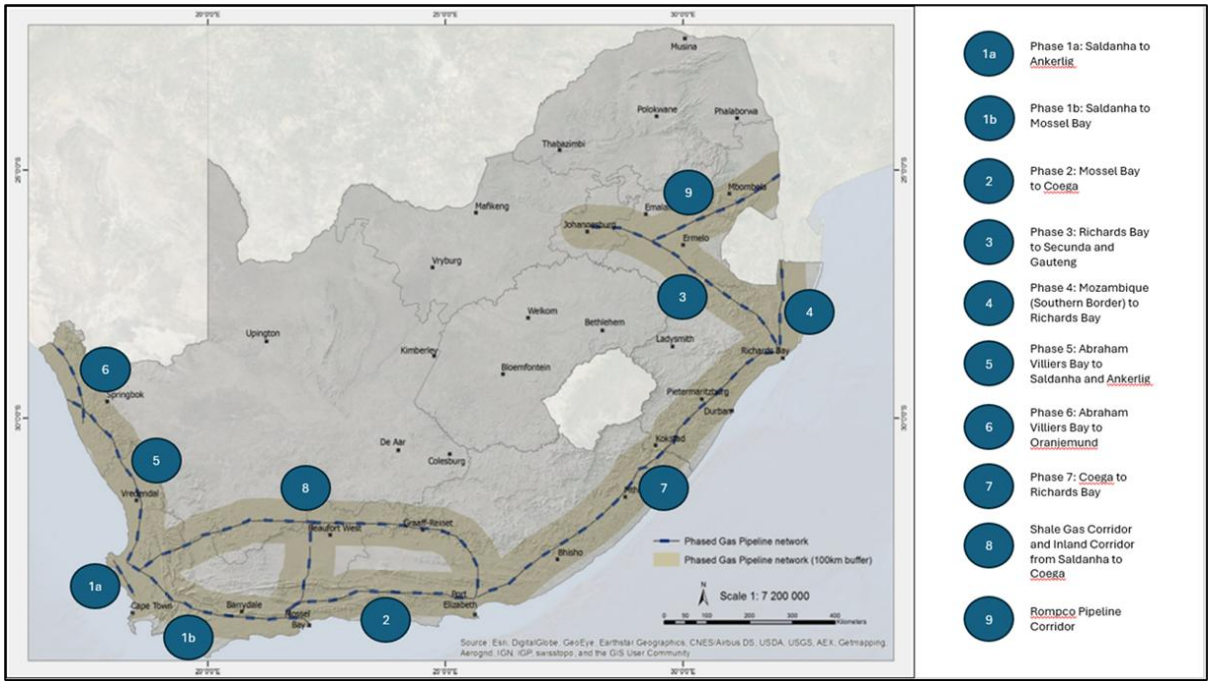


Figure 6-17: Operation Phakisa Phased Corridors including the north-to-south pipeline corridor.

Source: (Department of Environment, Forestry and Fisheries, 2019, p. 10)

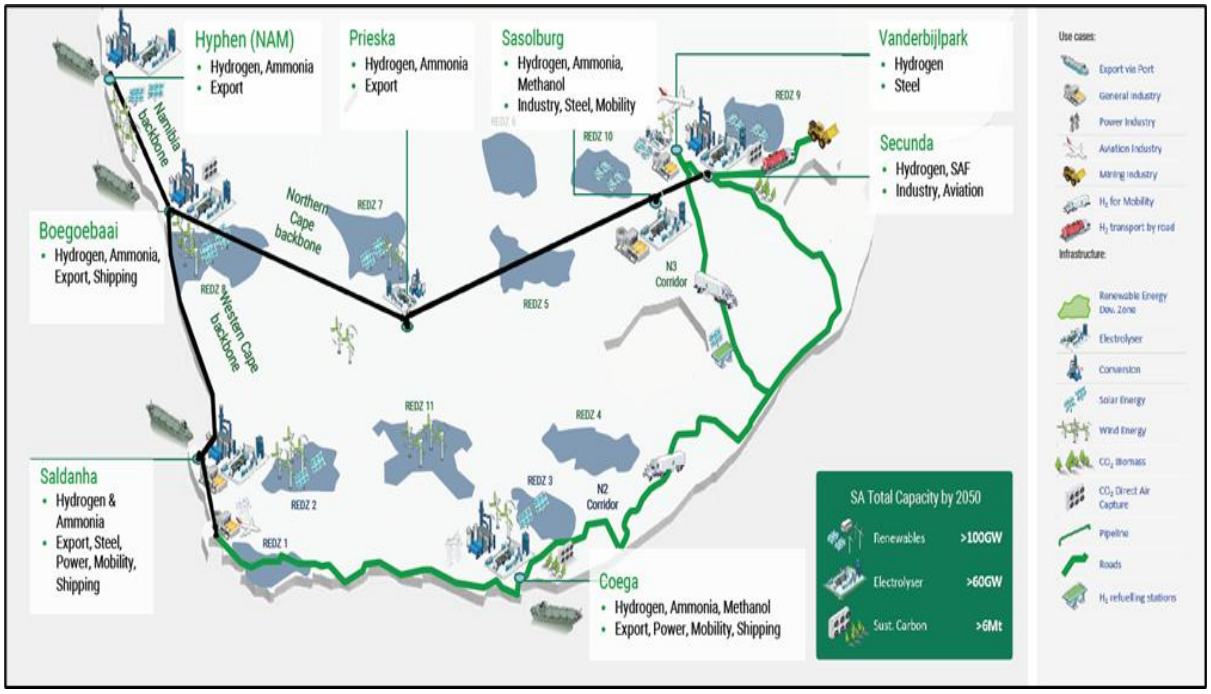


Figure 6-18: Northern Cape Green Hydrogen Masterplan with the envisioned north-south as well as east-to-west green hydrogen pipeline corridors

Source: (NCEDA, 2023)

Pipeline construction is a massive undertaking that requires careful planning and coordination across various sectors. The establishment of construction camps to house workers is crucial for efficiency,

ensuring that key personnel such as welders, inspectors, and medical staff are readily available on-site. In addition to human resources, infrastructure support is essential, local authorities may need to approve and provide services such as water supply, waste management, sewage treatment, and even access to borrow pits for materials. These logistical elements ensure a smooth construction process while minimizing environmental impact. The right-of-way for the pipeline itself, typically spanning 30 to 50 meters (see example Figure 6-19), must be prepared to allow sufficient space for installation, equipment movement, and safety considerations. This path must be carefully planned, considering terrain, existing infrastructure, and environmental factors. It's an intricate process that involves numerous stakeholders, from government departments to private contractors.

Given the length, scale and cumulative implications of linear infrastructure, pipeline routing, right-of-way establishment and construction camp planning should explicitly consider land rights, servitude width, biodiversity fragmentation, heritage sensitivity, road crossings, rehabilitation obligations, worker accommodation, and the capacity of local authorities to support temporary service demands. Minimum requirements for construction camps and servitude processes should therefore be defined in the management guidelines and reflected in project-specific EIAs.

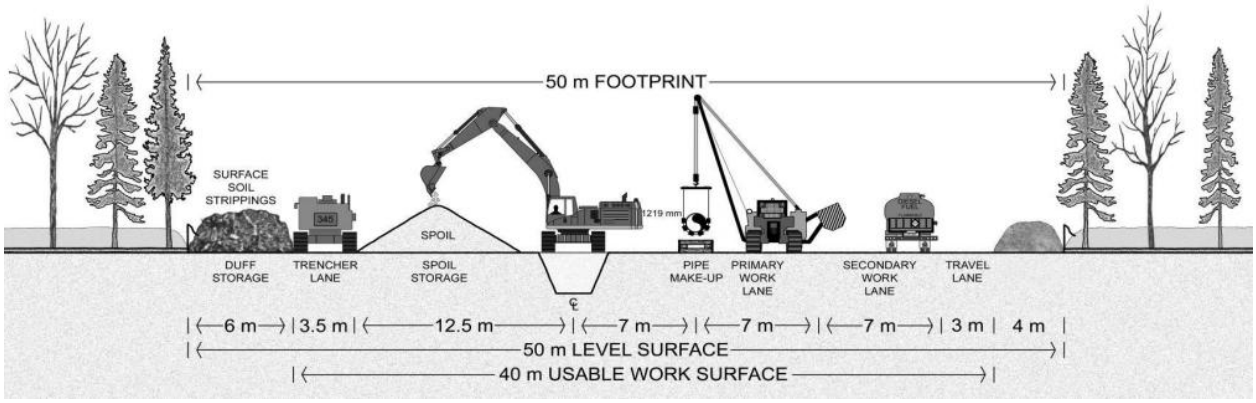


Figure 6-19: Example diagram of pipeline Right of Way and Workspace.

Source: (Ephraim, 2017, p. 7)

Baseline Scenario

The envisioned baseline scenario assumes that the transition to a green hydrogen economy could still progress albeit without Boegoebaai as a contributing hydrogen hub. Other hydrogen developments could still occur under this scenario including the development of the Luderitz and Saldanha hydrogen hubs. The development of a cross-national pipeline could still proceed connecting the Luderitz and Saldanha hubs. It is unclear at this stage what the effect will be on the overall feasibility of developing this pipeline should Boegoebaai not feature in the planning. It could however significantly affect the proposed east-west pipeline which would depend on Boegoebaai hydrogen production.

Although the 2019 Strategic Environmental Assessment (SEA) (Department of Environment, Forestry and Fisheries, 2019) for gas pipeline corridors recognizes the potential for expanding natural gas infrastructure in South Africa, it does not explicitly address the potential for green hydrogen. Nevertheless, the insights and structure provided by the gas SEA that could have potentially been leveraged to inform green hydrogen development, can be explored in the hydrogen scenarios.

Small Green Hydrogen Scenario

In contrast to the baseline scenario, the small green hydrogen scenario marks significant progress toward establishing green hydrogen pipeline infrastructure. Pipeline infrastructure is not a standalone development, but it forms part of a cross-national pipeline connecting the Luderitz–, Boegoebaai- and Saldanha Hydrogen hubs. It also positions the Boegoebaai Port and SEZ as a central hub for hydrogen production and distribution in the Northern Cape. The insights from the 2019 SEA provide a foundational framework for decision-makers to consider vital aspects of a potential green hydrogen pipeline development.

A key infrastructure initiative at this scenario involves the development of a dedicated green hydrogen pipeline along the north-to-south corridor, potentially using the framework established by phases 5 and 6 of Operation Phakisa within the 2019 SEA. This pipeline will connect Boegoebaai and adjacent renewable energy hubs with industrial centers along the West Coast extending to Saldanha and north into Namibia to Luderitz. Moreover, feasibility studies for the proposed west-to-east green hydrogen corridor, as envisioned in the Northern Cape Green Hydrogen masterplan, are set to begin, linking Boegoebaai to the Prieska Power Reserve Project and beyond (eventually leading to Gauteng). This process includes Environmental Impact Assessments (EIAs) to evaluate the ecological costs of the pipeline's development, alongside the acquisition of the essential land and rights-of-way.

The small green hydrogen scenario envisions the acquisition of land rights to facilitate the dedicated green hydrogen pipeline along the north-to-south route. This could potentially benefit from using the existing planning framework established in the 2019 gas pipeline SEA.

This is projected to develop between 2026 and 2035, initially focusing on establishing an electrolysis capacity of 5 GW, bolstered by 10 GW of renewable energy generation.

This small green hydrogen scenario presents economic opportunities by engaging local labour, especially during the construction of pipelines. Some challenges that could affect the construction of the pipelines include a potential shortage of skilled labour, challenges related to land rights (due to appeals and related issues), and environmental considerations regarding pipeline routing.

Strategic environmental management strategies are the proposed mechanisms to mitigate risks linked to biodiversity loss, water resource impacts, and land-use conflicts.

A prefeasibility study conducted in 2024 by WESGRO, NCEDA, Namibia's Environmental Investment Fund, Gasunie, and Climate Fund Managers (2024) identifies two potential routing options (Figure 6-20) for the proposed hydrogen pipeline:

- Scenario 1: This route follows the Namibian coastline, remaining close to previously designated production plots. Its proximity to the ocean facilitates access to seawater, a key resource for desalination.

- Scenario 2: This inland route positions the pipeline centrally between existing production plots and potential new development areas east of Lüderitz. While desalinated water could be supplied via a dedicated pipeline alongside the hydrogen pipeline, further investigation is required to assess feasibility.

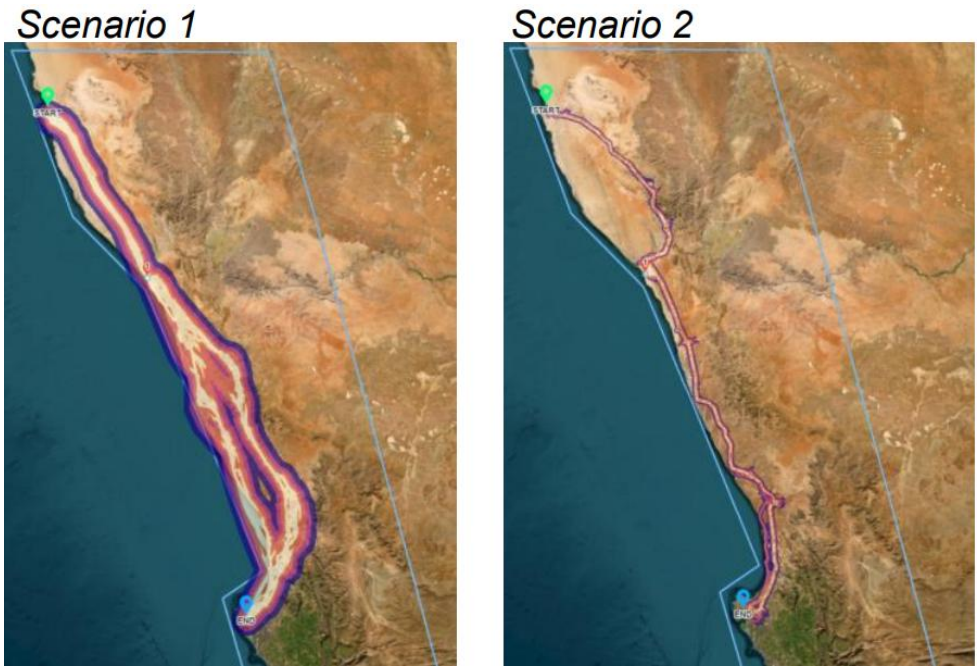


Figure 6-20: Possible pipeline route options.

Source: (WESGRO; NCEDA; GH2 Namibia; Climate Fund Managers; GASUNIE, 2024, p. 25)

Big Green Hydrogen Scenario

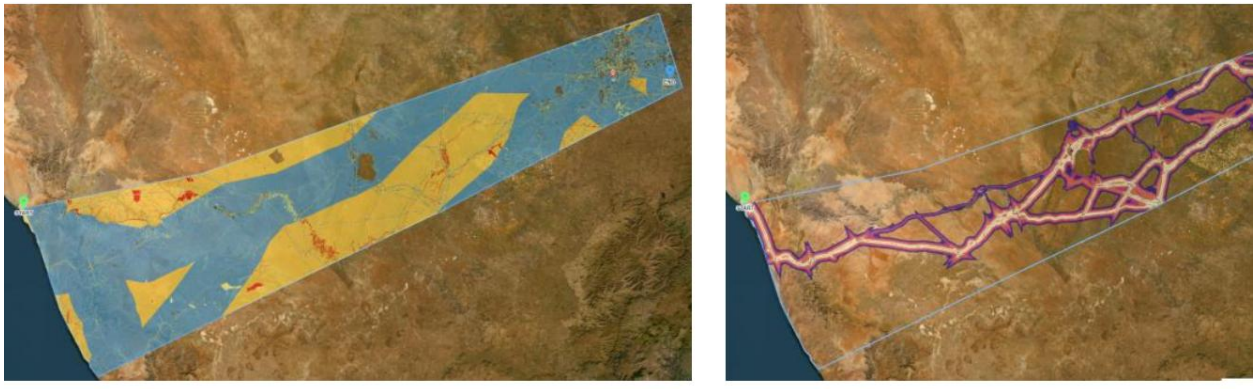
The big green hydrogen scenario envisions the expansion of green energy transmission pipeline network, adding the proposed west-to-east green hydrogen pipeline detailed in the Northern Cape Green Hydrogen Masterplan. This pipeline connects Boegoebaai to the Prieska Power Reserve and beyond to Gauteng, facilitating the direct transmission of green hydrogen to crucial domestic industrial centres, while the north-to-south corridor established in the previous scenario, links Boegoebaai to international markets, including a cross-border pipeline to Namibia.

The big green hydrogen scenario anticipates a fully operational green hydrogen production facility at Boegoebaai by 2050. This scenario envisions increasing electrolysis capacity to 40 GW, bolstered by 80 GW of renewable energy facilities. It envisions significant growth for the Boegoebaai Port and SEZ, with added infrastructure to support the large-scale export of green hydrogen and its derivatives like green ammonia, methanol, and e-kerosene.

The socio-economic advantages of the big green hydrogen scenario include substantial job creation during both the construction and operational phases of dedicated green hydrogen pipelines and associated infrastructure, such as desalination plants and renewable energy facilities.

This scenario could also present a number of environmental and social challenges. These challenges stem from the large-scale construction activities involved, which could impact sensitive ecological regions, including wetlands and critical biodiversity zones. It could also impact nearby settlements in the region (especially during construction). The Gas Pipeline Corridors SEA did not extent along an east-west route, which means that the east-west pipeline will require its own set of environmental assessments.

A prefeasibility study conducted in 2024 by WESGRO, NCEDA, Namibia's Environmental Investment Fund, Gasunie, and Climate Fund Managers considered the likely west-east routing. Key considerations guiding the routing include protected areas, existing land use such as urban areas, and existing infrastructure. These factors create varying levels of spatial resistance: areas alongside gazetted corridors and existing infrastructure are marked in blue, areas depicted in orange indicate lower spatial resistance, while areas marked in red signify high spatial resistance. It is preferable and recommended to route the pipeline within the gazetted corridors and bundle it with existing infrastructure (see Figure 6-21).



Resistance map (blue: corridor, orange light sensitive) Possible routings

Figure 6-21: Possible west-east pipeline routing.

Source: (WESGRO; NCEDA; GH2 Namibia; Climate Fund Managers; GASUNIE, 2024, p. 33)

6.3.3.4 Green Energy Projects

The production of green hydrogen relies heavily on green energy, particularly solar and wind power. The Northern Cape Province is well-positioned, possessing substantial land suitable for both energy sources. Various projects for developing wind and solar farms can be identified in the SEA region (see Figure 6-6, Section 6.2.3.4). The table below outlines the quantity of green energy necessary for hydrogen production as outlined in the Boegoebaai scenarios, beginning at 5GW and increasing to 40GW. To put this in

perspective - South Africa's total domestic electricity generation capacity from all sources in 2024 was 58,09 GW (Africa24, 2024).

Table 6-9: Green Hydrogen production estimations per Scenario

Aspect	Unit	Small Green Hydrogen Scenario	Big Green Hydrogen Scenario	Note/ assumptions
Electrolizer capacity	GW	5	40	Aim of Northern Cape GH Master Plan
RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
RE capacity - solar	***GW***	***6***	***48***	**60 % solar : 40 % wind**
RE footprint - solar	*Ha*	*12000*	*96 000*	0,5MW/ha, footprint
RE facilities - solar	*no of facilities*	*6*	*48*	Clusters of 1 GW facilities
RE capacity - wind	***GW***	***4***	***32***	**60 % solar : 40 % wind**
RE footprint - wind	*Ha*	*4000*	*32 000*	1 MW/ha
RE facilities - wind	*no of facilities*	*3*	*21*	Clusters of 1,5 GW facilities

Source: (Schreiner, et al., 2024, p. 25)

While some land near the proposed port and SEZ is suitable for wind and solar energy production, ***it is unlikely to have enough area for the necessary renewable energy capacity***. Due to the considerable depth of the ocean floor near Boegoebaai, offshore wind energy production is unlikely to be a viable option. Additionally, most of the surrounding land is owned by local communities, which often engage in pastoralist agriculture. As a result, it is improbable that these communities would consent to the development of large wind or solar farms on the available green energy sites. Supporting a 5GW electrolyser requires 10GW of green energy, necessitating a land area of 12000ha for solar and 4000ha for wind. Over time, these requirements will rise to 96000ha for solar and 32000ha for wind. Such large installations should be integrated within the REDZ and Power corridors to facilitate easy grid access for energy transmission. Consequently, it is expected that green energy sites will be developed in the broader region and beyond, with the generated power transmitted to the Boegoebaai site predominantly through ESKOM lines. This strategy also means that the impact of these installations will be spread across a vast area and potentially multiple provinces. To ensure a steady supply of green energy, it is advisable to distribute renewable sources, possibly as far as the Western and Eastern Cape. However, when taking into account ecological constraints—such as protected areas, critical biodiversity zones, and threatened ecosystems—alongside physical limitations like the infrastructural constraints of solar and wind farms, fewer areas remain in the region suitable for these new developments. Annexure E provides the results of the analysis conducted to identify potential green energy production sites in this region.

6.3.3.5 Electricity transmission

The ESKOM Transmission Development Plan (TDP) (ESKOM, 2020) outlines two projects initiated in the past decade to enhance the network and facilitate the evacuation of renewable energy from the area. These projects include the Juno-Gromis 400 kV line and the Gromis-Oranjemond 220 kV line, which was built to a 400 kV specification and became operational in 2018. Additionally, the proposed Gromis-Nama-Aggeneys 400 kV line is set to be commissioned in 2026. This project involves constructing a 400 kV line that connects Gromis Substation to Nama Substation, and Nama Substation to Aggeneys Substation, aiming to evacuate renewable generation within the Namaqualand load network. These lines are depicted on the subsequent map as part of the transmission network. The development of the Port and SEZ will necessitate further additions to the transmission network, requiring new lines to supply power to the site. Figure 6-22 illustrates several new transmission lines, including the Juno-Gromis line and the Gromis-Nama-Groeipunt-Aggeneys-Aries lines, which are crucial for transporting power across the region.

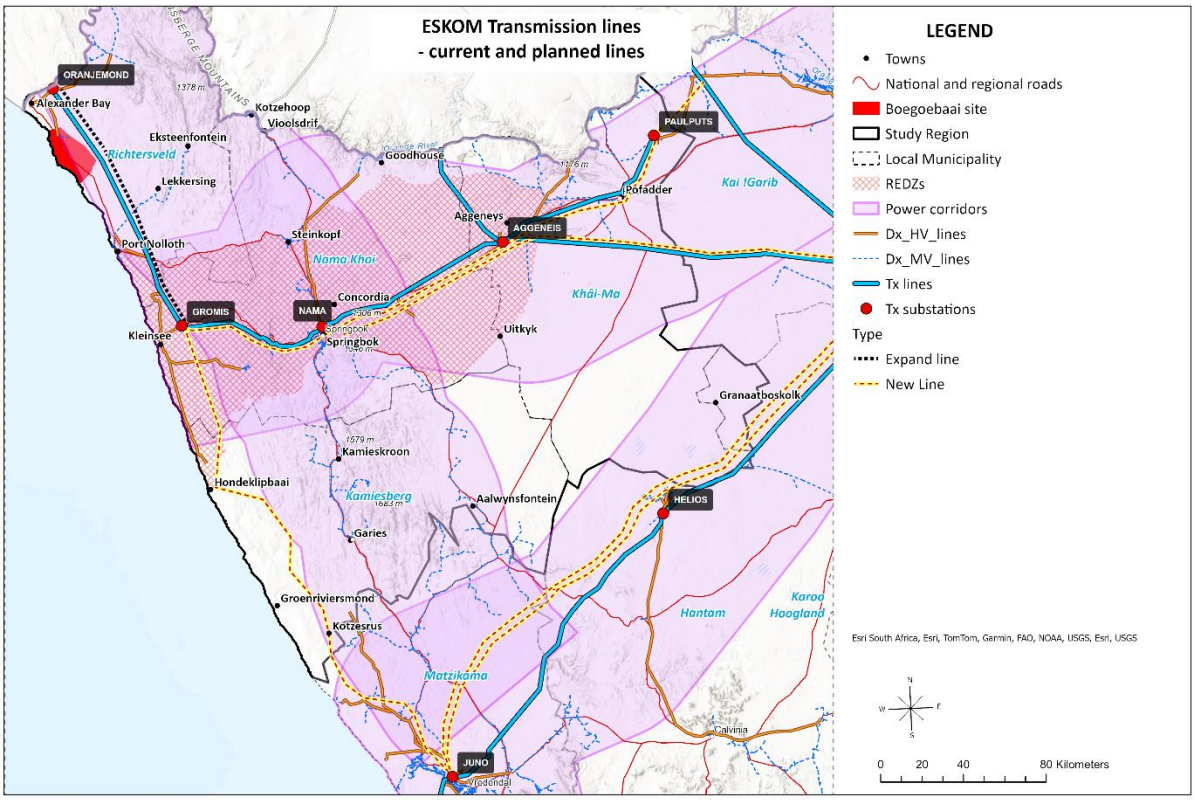


Figure 6-22: ESKOM transmission lines

Source: (Maritz, 2025b)

Prior work has been undertaken initially in 2014 and again in 2019 to undertake Strategic Environmental Assessments (SEAs) for Electricity Grid Infrastructure (EGI) Corridors (Department of Environment, Forestry and Fisheries (b), 2019). The benefit is that developers of large electricity transmission infrastructure that develop within the gazette Strategic Transmission Corridors do not need to undertake a full scoping and EIA process can instead then follow a Basic Assessment Process in Terms of 2014 EIA Regulations (Department of Environment, Forestry and Fisheries (b), 2019). Strategic transmission corridors span much of the region and encompass all current transmission infrastructure. Any new transmission infrastructure expected to be located within these corridors is also included within their coverage. New EGI projects outside these corridors can take between five and ten years to complete. New green energy plants can be operational in a short time, and should new transmission lines be required, this could take longer, placing new power production at risk of not being able to connect the grid. Critically the strategic planning of servitudes needs to be undertaken well in advance of the final planning of power lines. Annexure G lists several activities related to the construction of power lines.

<u>Baseline Scenario</u>

Currently, the region has some green energy applications, but only a few have been implemented. The remoteness of specific areas, along with limited grid infrastructure and environmental considerations, hampers the development of many proposed green energy projects. Consequently, these initiatives will progress but not at the scale necessary for the planned Port and SEZ. Additionally, rising interest in mining north of Springbok increases electricity demand (ESKOM, 2020, p. 77). Therefore, the impact on local towns and settlements, especially in Richtersveld, may be minimal, as growth remains limited and will primarily be felt when green energy projects are approved. Such projects could create jobs, primarily during the construction phase. As mentioned earlier, recent upgrades to transmission lines are also aimed at facilitating the transport of newly generated green energy out of the region.

Small Green Hydrogen Scenario

This scenario requires 10GW of green energy to power a 5GW electrolyser equivalent. Wind and solar power projects near the port and SEZ could provide direct energy to the site (refer to the map in Annexure F). However, if any sites are developed, they likely won't meet the total electricity demand (needing 16000ha). Given that the land surrounding the site belongs to the Richtersveld Sida !Hub Communal Property Association (CPA), it is improbable that they will permit extensive land use due to potential impacts on tourism and their pastoral activities. Additionally, diversifying green energy sources is crucial for ensuring a steady power supply, necessitating the widespread placement of these GE sites across different provinces.

Extra green energy will need to be transmitted via the ESKOM grid to the site. The green energy requirements for Boegoebaai must be considered alongside possible effects on the Government's REIPPP program. However, the SEZ can be directly purchased from independent green energy producers, allowing for power transfer through the ESKOM grid. This enables industrial entities to establish power purchase agreements with IPPs, providing long-term price certainty.

It's recommended that all green energy needs are communicated to ESKOM as soon as possible, impacting their Transmission Development Plan (TDP). According to ESKOM, the TDP plans for a double 765KV line with 400KV interconnectors in the area, which would adequately support initial power needs when combined with direct power production at the site.

Regarding site-specific factors, the land required for solar and wind installations is significant, needing an area of 12000ha for solar and 4000ha for wind. Site location is crucial, particularly about existing grid infrastructure; without it, costly transmission lines would need to be built. The GE site should also be accessible for transporting heavy equipment and construction materials such as solar panels, mounting systems, inverters, wind turbine blades, and tower sections, necessitating the potential development or improvement of access roads, especially if the site is secluded.

It is preferable to house construction workers on-site rather than in regional towns to minimise costs and transportation challenges. The construction phase will see the highest number of personnel on-site. Activities will include land clearing, campsite construction, civil works (like cabling, substations, and foundations), and crucial infrastructure development, particularly road construction. This is especially important for wind farms, where turbine placement varies based on terrain and design, driving the need for roads to facilitate turbine delivery and maintenance. To reduce expenses and environmental impact, road materials are typically sourced from onsite quarries or 'borrow pits'.

Figure 6-23: Example of wind turbine towers with connecting roads (wind turbines in Soetwater in the Northern cape).

Source: (Enel Green Power South Africa, 2024)

Annexure G illustrates the essential skills required for developing a solar energy project. When solar or wind farmland is leased to a developer, it can significantly benefit farmers, rural landowners, and communities facing economic challenges or lacking resources for local development. Additionally, solar and wind farms create job opportunities during both the construction and operational phases, bringing economic advantages to local communities.

These large installations must fit within the REDZ and Power corridors to ensure access to grid infrastructure for transmission. Consequently, it is anticipated that green energy sites will be developed both in the surrounding region and beyond.

Given the extensive scale of wind and solar projects in the area, they hold the potential for socio-economic benefits, including the manufacturing, installation, and maintenance of renewable energy equipment and facilities. Opportunities associated with the green energy sector, particularly supply chains, could be established in the Boegoebaai SEZ, facilitating the execution of green energy projects.

Big Green hydrogen Scenario

In the period following 2035 green hydrogen production is set to increase to reach a capacity of 40GW (estimated by 2050). This increase also requires a concurrent increase in the power delivered to the site. To achieve a 40GW electrolizer capacity 80 GW of green energy is needed at the site. This will result in an increase in the land area required to implement solar and wind production, expanding to 96000 ha for solar and 32000ha for wind respectively. Additional green energy production will need to be developed in the region or beyond, predominantly in the power corridors to reduce grid development costs. Given the objective of not concentrating green energy spatially to ensure constant supply, this would mean such

plants would be developed in locations far from the region, extending to other parts of the Northern Cape and Western Cape (Marais, 2024).

This could potentially have implications for the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) as well as impact on transmission lines. Considering the vast amounts of power consumed at site, the transmission line grid network in this region might not be sufficient to wheel power to the site. Thus, the effects of developing additional green energy plants *will affect the wider region*. The planning and timely extension of ESKOM transmission lines will require advanced planning. Transmission Development Plans need to accommodate the growth in hydrogen production and its increasing energy needs. The planning is especially critical considering the long timelines required for the construction of new transmission lines. Given the time since establishment of initial green energy plants to supply electricity to Boegoebaai GH2, some existing plants could be redeveloped or expanded (considering the use of newer green energy technologies).

6.3.3.6 Port and SEZ site implications

The proposed Boegoebaai Port and SEZ lies at the core of the future industrial development proposals for the region. Apart from its local impacts, the development would also impact the wider region including aspects such as roads, rail, settlements, green energy, employment, etc. It would provide a port to the Northern Cape Province reducing the need to utilise distant national ports. The adjacent SEZ industrial park would extend over an area of about 31000ha when fully developed. The Port, combined with the SEZ, would be significant land use features within the Municipality and as such has implications for municipal planning. The development should be reflected in the Richtersveld Municipality's planning instruments including, for example, the Municipal SDF, IDP and zoning scheme. It is clear when considering the proposed land use components for the SEZ (see Table 6-12), that although the uses are considered 'industrial' the variance in use or feature types requires a more differentiated depiction of land use avoiding single use zoning (Department of Rural Development and Land Reform, 2017). A detailed precinct plan must be established for the development taking cognisance of the layout, land use types allowed as well as ancillary services (Erioloba Consulting, 2024). Table 6-10 highlights the main components for the SEZ divided over two scenarios.

Table 6-10: Development scenarios: SEZ core components.

Aspect	Unit	Small Green Hydrogen Scenario	Big Green Hydrogen Scenario
Electrolyser capacity	GW	5	40
Electrolyser footprint	ha	75	600
GH2 volume	mtpa	0,5	4,0
GH2 storage footprint	ha	250	2 000
Ammonia volume	mtpa	2,8	22,7
Ammonia footprint	ha	57	454
Ammonia storage footprint	ha	28	227
Desalination output volume	Ml/day	36	286
Desalination footprint	ha	7	57
Desalination discharge	Ml/day	48	387
Pipeline intake volume	Ml/day	84	672

Source: (Schreiner, et al., 2024, p. 25)

Baseline Scenario

During this scenario neither the proposed port, nor SEZ development materialise. Limited open pit diamond mining might continue on the proposed site although parts of the terrain have already been mined significantly (see Figure 6-24a). Over time the site will be evacuated and if not rehabilitated, a partially scarred landscape will remain.

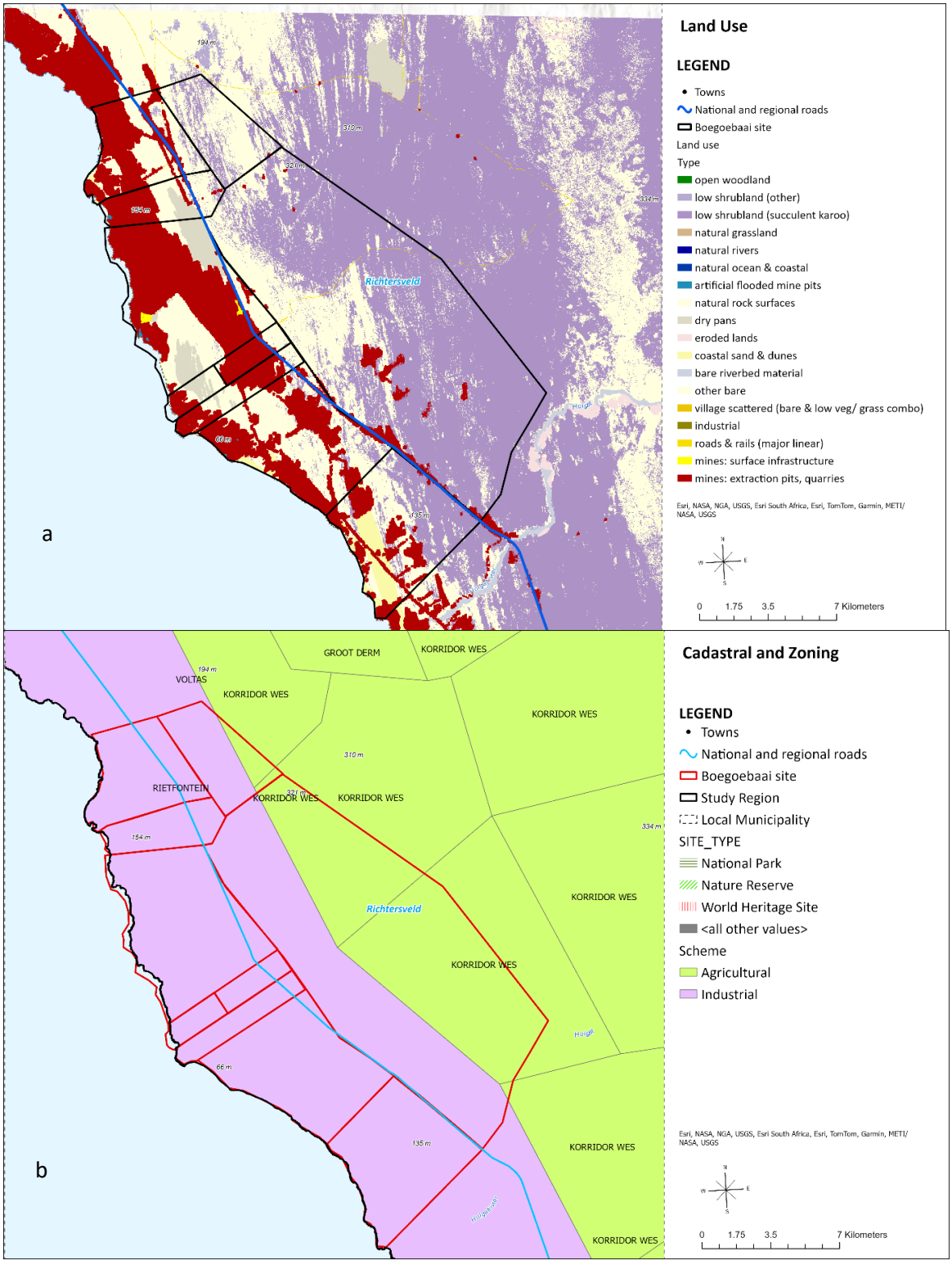


Figure 6-24: Land Use(a) and zoning (b) at site.

Source: (Maritz, 2024d)

Currently the overall land use zoning indicates *industrial* bordered by *agricultural use* (Figure 6-24b). Land use will have to be refined once detailed planning for the SEZ and port has been completed, to reflect a highly structured, phased, mixed-use industrial platform: an industrial cluster anchored in green hydrogen and integrated with the port, internal infrastructure and utilities, environmental conservation areas, and

connecting regional infrastructure. Work Package 1: Strategic Environmental Assessment for the proposed Boegoebaai Port and Special Economic Zone identifies preferred development areas within the SEZ.

The nearby town of Alexander Bay is in decline due to a decrease in diamond mining activities.

Small Green Hydrogen production scenario

Before any development is undertaken a detailed approved precinct plan is required, detailing layout, land uses, services etc. The Port is anticipated to commence first, followed by the phased development of aspects of the SEZ. The Port and SEZ will be the region's focal point of new development. All relevant approvals will, however, be required before construction of any development at the site. During the construction period, the movement of equipment, materials and resources along the N14, N7, and especially the R382 will occur. The interim maintenance work to be carried out by SANRAL will help to maintain the road in the short term only. When considering that the current R382 has not been designed to carry a large number of heavy vehicles regularly, it will eventually be necessary to address the reconstruction of the R382 (TM consulting and Nelutha, 2019a). This will also be beneficial once the port is operational and when large numbers of heavy vehicles transporting manganese to the port commence. A study conducted by Transnet estimated that in year five into port operation, up to 39 trucks per hour will be delivering manganese to the Port (TM consulting and Nelutha, 2019a, p. 23).

Construction material will likely need to be trucked in from the region or areas beyond. Given the size of the Port and the various sections of the SEZ, a significant amount of road construction on site will also be required. Road construction materials will be sourced both commercially and from approved quarries and borrow pits. The identification and permitting of gravel pits will increase during this time, considering the increased need for surfaced roads and road improvements or reconstruction of the R382. Maintaining roads, especially the R382, will be critical to ensure a good level of connectivity to the rest of the region and the towns of Alexander Bay and Port Nolloth.

Considering the range of construction possible during this phase, it is likely that construction site camps will need to be established; however, given the planning objective of not creating new settlements (see the 2024 Richtersveld SDF), careful consideration should be given to where such temporary accommodation should be located. Large temporary settlements would also require water, sanitation, waste disposal, and access to retail and health services. Alexander Bay, as the closest settlement, could serve this purpose; however, the current distressed state of the town signals that before setting up accommodation in Alexander Bay, the infrastructure must be improved. Land use changes and new residential areas will also need to be created in Alexander Bay. Given the financial state of the municipality, it is likely that the key developers of the Port and SEZ will need to invest in Alexander Bay to create a liveable and functioning environment capable of accommodating an influx of primarily temporary workers.

Based on a detailed precinct plan, a more detailed land zoning will be required as well as a change in zoning; the current zoning of some parts of the proposed SEZ is Agriculture. The unique mix of use types within the SEZ will require their respective EIAs and various approvals from relevant authorities. This can include the following:

- **Desalination plant** - Building and commissioning a desalination plant requires various permits and approvals from several State departments. Two key authorisations locally are an **environmental authorisation** in terms of the National Environmental Management (NEMA) Act, No 107 of 1998, and associated EIA regulations, and a **Coastal Waters Discharge Permit** (CWDP), which is issued in terms of the NEMA: Integrated Coastal Management Act, No 24 of 2008, for the discharge of brine generated by a desalination plant into the sea. Separate reports and application processes are required because various government departments or organs of State issue the permits and licences. This will necessitate several detailed, specialist studies, which can be time-consuming. It would take one to two years – potentially more – for all the relevant processes to be completed and permits to be issued (Slater, 2017).

- **Electrolyser plant** – Similarly, the approval and regulation of electrolyser installations generally fall under **the jurisdiction of several regulatory bodies and authorities**, depending on the scope of the

installation. The primary entities involved in approving electrolyser installations include the following: **The Department of Minerals Resources and Energy (DMRE)** is the national government Department responsible for the regulation and development of energy infrastructure, including hydrogen production and the use of electrolysers. **The SABS** is the national standards body which sets and enforces standards for various types of equipment, including electrolysers. Installations must comply with relevant South African National Standards (SANS) to ensure safety and efficiency. **The National Energy Regulator of South Africa** - any large-scale electrolyser installations that are part of the broader energy infrastructure may require NERSA approval. **Local municipalities** may also be involved in permitting and approving electrolyser installations. This is especially relevant for projects involving extensive infrastructure or if local building codes and safety regulations apply. **Department of Environmental Affairs** - Electrolyzer installations, especially large-scale ones, may require an EIA if they are likely to have significant environmental consequences, such as water usage or emissions. The DEA would review the environmental permits and ensure compliance with environmental laws. **The Department of Employment and Labour** ensures that any installation complies with the Occupational Health and Safety (OHS) Act. The large size of the proposed electrolysers might affect the approval process and associated timeframes.

Local municipal bylaws might not sufficiently address electrolyser installations and might require adaptation.

The SEZ and Port will produce wastewater, sewage, and solid waste, which typically form part of municipal systems. Relevant infrastructure needs to be developed to process these items. The institution charged with managing the SEZ will also be responsible for the services within the SEZ.

Large Green Hydrogen Scenario

The initial phase of SEZ development will lay the groundwork for the establishment of components such as water desalination, green hydrogen production and storage, ammonia production and storage and electrolyser installation and implementation. During the later stages, the scale of development will increase as production is ramped up. When new infrastructure - and subsequent SEZ areas - are developed, the standard processes and land use and zoning approvals must be obtained. These expansions will result in periodic construction booms, albeit focussed in particular parts of the overall SEZ.

When hydrogen production reaches larger volumes, the development of pipeline infrastructure to transport the product to Namibia, Saldana Bay and to the eastern part of the province, will become viable. It is assumed that the export of Manganese through the Port is also expected to reach large volumes after the first ten years of operation (first phase). The large amount of mining freight will trigger the introduction of rail as the primary form of transport for mining commodities. Both pipelines and rail lines must be accommodated at the SEZ and Port, respectively.

6.3.4 Estimated project timelines and direct employment

The proposed development of the port and SEZ involves multiple infrastructure components, each requiring dedicated planning, design, construction, and operational activities. Many of these projects will need to be executed simultaneously or in overlapping phases. Several interdependencies exist; for example, while the port will initially focus on exporting manganese, it will also support the export of green hydrogen products. Producing green hydrogen will require the development of solar and wind energy projects, as well as desalination and electrolyser plants.

Additionally, upgrading the R382 is crucial to accommodate the expected surge in freight and other traffic, ensuring efficient access to both the port and SEZ. Table 6-11 provides a high-level overview of the estimated project phases for key infrastructure developments, which in turn is based on project specific assumptions (financing, approvals, labour sourcing and the phasing of projects). The depiction of project timelines and employment is based on available project documentation. While some projects fall within the Richtersveld Municipality, others—such as the proposed rail and pipeline projects—will have a broader regional impact.

It is assumed that some wind and solar plant projects would be developed near the SEZ site, while other projects could occur in the broader region where suitable locational and infrastructural conditions are met, ensuring diversification of green energy resources. The table also indicates that several projects will continue to expand, notably the green energy projects, which must feed into the expanding electrolyser and desalination components. Referencing existing studies, an estimated number of direct construction and operational employment opportunities has been calculated for each project. Due to uncertainties regarding the location of project sites, such as regional green energy (solar and wind) plants, as well as considerations for where construction workers will be accommodated during work in the wider region, estimated direct employment numbers could only be attempted for the Richtersveld Municipality. Furthermore, it remains unclear how many employees might relocate with their families to the region. In some instances, where the region lacks well-developed towns or cities offering various services, the preference may be to work remotely away from their families, especially during temporary construction phases that do not provide long-term employment opportunities beyond these periods. Table 6-12 presents estimates of direct (conservative) employment generated during the construction phases, derived from the available project documentation. Construction is projected to commence three years after the launch of the port and SEZ projects (estimated 2027/28). An estimated 2,618 new employment opportunities would arise around 2028, increasing to 6,538 in 2029. Given the level of skills currently absent in the region, this would attract workers into the area. Direct employment opportunities would fluctuate between 6,538 and 6,336 at the peak of construction activities in the Richtersveld (although some projects would be spread out, and some would migrate away from Richtersveld as rail and pipeline construction progresses into the region). Some of these workers may also bring their families to the region. Following the construction phase and into operations, the number of direct employment opportunities would decline, ranging from 2,026 to 840 (estimates from 2031 onwards), which would more realistically reflect the long-term 'new' residents in the area. Regional and municipal planning strategy documents propose that new incoming residents be primarily accommodated in two towns: Alexander Bay and Port Nolloth. The socio-economic study conducted by SSR (2024), suggested a proportional split between Alexander Bay (35%) and Port Nolloth (65%) in housing these newcomers. This distribution assumes that most individuals will settle in Port Nolloth and Alexander Bay, and that a new "constructors' town" will not be established at the port or SEZ.

Assuming an average household size of 4.3 persons, this would suggest that Alexander Bay could gain between 1,973 direct jobs (resulting in 8,286 people when households are included) at the height of the construction phase, while Port Nolloth could see an increase of between 3,664 direct jobs (yielding 15755 people when households are accounted for). This figure would decline once construction phases are completed and only operational employment remains. It should be emphasized that these figures are derived from preliminary estimates based on pre-study analyses. Comprehensive project planning is required to determine more precise population and household projections; such refined estimates are, in turn, essential for the planning and financing of housing, the design of bulk infrastructure, and the provision of social services.

Some new residents may prefer to live in Springbok, the larger regional centre, rather than in Alexander Bay or Port Nolloth, as it offers a wider range of services, facilities, and amenities. As a result, they may need to commute long distances to the site. Average commuting times of two hours may be further impacted if the road experiences high volumes of heavy vehicle traffic. While smaller towns exist within the Richtersveld, they also have limited facilities and services. Current settlement-related challenges indicate that any significant population growth would require substantial investment to upgrade settlement infrastructure and support its development.

Table 6-11: Timeline for various critical infrastructure items.

Timeline	2025	2026	2027	2028	2029	2030	1st Ship at Berth	2031	2032	2033	2034	2035	2036	2037	Up to 2050	Notes:
Port Landside*[7]	Design		Tender	Construction				*Operation*								Richtersveld focus
External Road*[8]	Design		Tender	Construction				*Operation*								Richtersveld focus
Future Rail*[9]	Pre-planning and Planning		Design					Tender	Construction				*Operation*			Wide regional impact
Future Pipeline Phase 1[10][11]	Pre-planning and Planning	Design	Tender	Construction				Operation								Scenario 1 - Regional impact
Future Pipeline Phase 2								Planning	Design	Tender	Construction			*Operation*		Scenario 2 - Regional impact
Green Energy (S) Direct[12]	Pre-Planning	Planning	Design	Tender	Construction			Operation								Richtersveld focus
Green Energy (W) Direct[13][14]	Pre-Planning	Planning	Design	Tender	Construction			Operation								
Green Energy (Wheel)[15]	Pre-Planning	Planning	Design	Tender	Construction			**Ongoing as separate projects in the region. Linked to Bidding cycle**								Wide regional impact
Electrolizer[16][17]	Pre-Planning	Planning	Design	Tender	Construction			*Operation*					*Planning -expansion*		*Expand Electrolyzer*	Richtersveld focus
Desalination[18]	Pre Planning	Planning	Design	Tender	Construction			*Operation*					*Planning -expansion*		*Expand desalination*	Richtersveld focus

[7] (TM consulting and Nelutha, 2019a)
[8] (TM consulting and Nelutha, 2019a)
[9] (TM consulting and Nelutha, 2019b)
[10] (African Development Bank and SASOL Petroleum, 2002)
[11] (Department of Environment, Forestry and Fisheries, 2019)
[12] (Lochner, Abed, & Antonopoulos, 2022)
[13] (Leguijt, Van den Toorn, Bachaus, & Jongsma, 2021)
[14] (Lochner, Kellerman, Moodley, & Abed, 2021)
[15] (JG Afrika, 2022, p. 16)
[16] (Leguijt, Van den Toorn, Bachaus, & Jongsma, 2021)
[17] (Rhodium Group, 2023)
[18] (CSIR, 2016)

Table 6-12: Employment number for construction and operations - key infrastructure items

Timeline	2025	2026	2027	2028	2029	2030		2031	2032	2033	2034	2035	2036	2037	Up to 2050
Port Landside*	Design		Tender	1738	2078	1656		*1656*	420	420	420	420	420	420	
External Road*	Design		Tender	480	480	480		*20*	*20*	*20*	*20*	*20*	*20*	*20*	
Future Rail*	Pre planning and Planning		Design					Tender	500	500	500	500	*10*	*10*	
Future Pipeline Phase 1	Pre planning and Planning	Design	Tender	400	400	400	1st Ship at Berth	20	20	20	20	20	20	20	
Future Pipeline Phase 2								Planning	Design	Tender	400	400	400	*20*	
Green Energy (S) Direct	Pre-Planning	Planning	Design	Tender	900	900		20	20	20	20	20	20	20	
Green Energy (W) Direct	Pre-Planning	Planning	Design	Tender	680	900		20	20	20	20	20	20	20	
Green Energy (Wheel)[19]	Pre-Planning	Planning	Design	Tender	(900)	(900)		**Ongoing as separate projects in the region. Linked to Bidding cycle**							
Electrolizer	Pre-Planning	Planning	Design	Tender	1000	1000		*300*	*300*	*300*	*300*	*300*	*300*	*300*	*Expand Electrolizer*
Desalination	Pre-Planning	Planning	Design	Tender	100	100		*10*	*10*	*10*	*10*	*10*	*10*	*10*	*Expand desalination*
Employment (some in construction camps)				**2618**	**6538**	**6336**		**2026**	**1310**	**1320**	**1710**	**1710**	**1220**	**840**	

See references in Table 6-13.

Significant construction predominantly affecting Richtersveld LM

Some projects could affect the region, SEZ park growth creating periods of construction boom

[19] Not included in totals.

6.4 RISK ASSESSMENT

SEA risk assessment is conducted at a strategic scale rather than at the detailed level of individual projects. It examines overarching risks and opportunities linked to policies, plans, or programs before specific project designs are developed. This section reflects a risk and opportunity assessment of the key impacts identified. The evaluation in this SEA is mainly measured on the interpretation of the spatial and nonspatial information related to the green hydrogen scenarios specified for this SEA and summarised in this section. The baseline serves as the base against which proposed projects are measured. It must be noted that given the nature of this section, some risks and opportunities are measurable to an extent, and some are qualitative and probabilistic in nature. Examples of similar infrastructure projects implemented elsewhere served as reference cases to help quantify the likely impacts. **Detailed impact can however only be quantified during detailed project planning or impact studies**; this section reflects a summarised compilation of aspects related to several proposed infrastructure items, the likely settlement effects, and the essential planning processes involved. Key risk themes identified include;

- Development planning pressures
- Settlement Infrastructure development and management
- Construction of economic infrastructure

The following table aims to capture the **most relevant measures of risks and examples of potential mitigation measures.**

Table 6-13: Risk & mitigation measures.

Key Risk Area	Measuring Risk - Examples	Risk Mitigation Measures – Examples [Lead and key institutions in brackets]
Development Planning Pressures	• Limited governance capacity for planning, implementation, monitoring, and compliance. • Administrative and technical weaknesses in decision-making processes. • Insufficient involvement of well-capacitated role players in planning and legal processes. • Challenges in securing communal land for development or reaching agreements for its use. • Time and complexity in establishing or expanding servitudes for transport and bulk energy infrastructure. • Volume and technical complexity of applications requiring municipal review and approval (land use change, EIAs, etc.). • Limited intergovernmental and sectoral long-term plans incorporating scenarios and mitigation options. • Inadequate national government investment aligned to local realities and future needs.	• Formulate credible Spatial Development Frameworks (SDFs) to guide development decisions. [Local Municipalities (LM), District Municipality (DM)] • Enact minimum planning bylaws in affected municipalities to close regulatory gaps and enable capacity for enforcement.[Local municipalities] • Review and improve mechanisms for strategic decision-making, negotiating, and management of communal land to support integrated and sustainable development. [DLRRD NC, Traditional councils/communal property associations, affected LMs] • Assess cumulative impacts of land-use changes and related projects at a regional scale to inform sustainable planning. [DLRRD NC, DMs through DDM] • Invest in continuous skills development for municipalities and municipal partners to enhance long-term planning, compliance, development policies, and implementation capacity. [NC COGHSTA with support from SALGA, LG SETA] • Establish region for Regional Development Collaboration and Planning (Examples are Karoo RSDF, Gamagara Mining Corridor Compact approach to activate institutional responses and support capacity. [SALGA, DLRRD NC, four LMs and DM]
Settlement Infrastructure Development and Management	• Existing service delivery backlogs in water, electricity, sanitation, and rising demand. • Shortages in housing and associated expansion of informal settlements. • Limited accessibility of social services and facilities (education, health, sports, waste sites). • High proportion of indigent households. • Elevated unemployment levels.	• Major construction and worker influx should only occur after core water and sanitation upgrades are secured and sustainably operational.[Provincial environmental authority issuing EA; DWS for water use license] • Prioritise housing and service delivery in preferred settlement nodes to manage growth. [LMs and Provincial Human Settlements] • Scale up delivery of housing, infrastructure, and services to meet demand. [LMs, DMs and provincial sector departments]

Key Risk Area	Measuring Risk - Examples	Risk Mitigation Measures – Examples [Lead and key institutions in brackets]
	• Reliance on key investors for regional infrastructure funding. • Constrained municipal financial viability for infrastructure development and maintenance., sports facilities, landfill sites, etc.	• Strengthen municipal financial management, optimise resources, and diversify revenue sources. [LMs, DMs with oversight from National Treasury] • Align bulk services planning to demand within resource and capacity limits, with contingency for surges. [LMs/DMs (bulk services master plans), and DWS/ESKOM/Water boards] • Upgrade and expand social and municipal facilities (education, health, sports, waste management) to meet current and future needs. [LMs/DMs (waste, sports, local roads, community facilities) and provincial departments (health, education, social development)] • Develop applications for co-financed bulk infrastructure [LMs, ISA, Provincial and National Treasury, future Investors]
Construction of Economic Infrastructure (e.g. roads, rail, pipelines, electricity transmission line corridors, and the port and SEZ).	• Heavy vehicle traffic accelerating deterioration of road networks, increasing maintenance needs. • Traffic disruption along the central transport spine to/from the port/SEZ. • Increased road safety risks and incidents, particularly during construction. • Rising road maintenance costs. • Delays in project execution due to regulatory and permitting complexities. • Constraints in acquiring land (private, state, communal) for port, SEZ, and related infrastructure. • Delays in establishing servitudes for rail, electricity transmission, and pipelines. • High construction water demand and delays in water use licensing. • Long-term operational water requirements (e.g., solar plants).	• Implement systematic monitoring of road condition and capacity for proactive maintenance of paved roads such as R382, N7 and N14. [SANRAL (national roads), provincial roads departments, and LMs (local roads)] • Secure sustainable budgets to meet rising maintenance needs.[SANRAL, provincial roads departments, LMs (through their budgets and conditional grants)] • Plan construction camps with municipalities to avoid overburdening local services.[Project proponents and EPC contractors (location, design, funding)] • Assess and strengthen institutional capacity to manage development applications, financing applications, PPPs and licensing efficiently. [DGOC NC COGSTA, Sector departments and LMs] • Simplify and expedite the processes for establishing servitudes for transmission lines and related infrastructure.[National and provincial line departments (DMPR, DFFE, Transport, Eskom/Transnet as SOEs) and DLRRD for land acquisition frameworks]

Key Risk Area	Measuring Risk - Examples	Risk Mitigation Measures – Examples [Lead and key institutions in brackets]
	• Limited availability of construction materials. • Potential delays in electricity infrastructure upgrades to meet port/SEZ requirements. • Additional municipal service demands from construction camps. • High rail construction costs delaying projects and increasing road dependence. • Additional road infrastructure required to access energy and transmission projects.	
Note: This Chapter does not address *onsite* infrastructure development for the port and SEZ.		

6.4.1 Reflecting on risk items

6.4.1.1 Development planning pressures:

Spatial land development planning, land use management, and governance capacity implications: In the area of sustainable development planning and settlement construction and management, there are several key risks associated with the lack of timeous planning and institutional readiness (also see section 7.6). The current mechanisms to process and approve planning applications are not designed to cope with the expected increase in such applications. Should processing of applications linked to the Port and SEZ, settlement development, pipelines, roads, green energy projects be slow and/or be seen as being inconsistent with the principles of fair administration (i.e. fair, open and transparent and without undue delay), there is an increased risk of decisions being challenged (and taken on review), which can significantly harm the commencement of development activities. The capacity constraints with regards to planning could jeopardise the ideals of integration and harmonisation, possibly leading to a lack of social cohesion and social instability in the towns. The lack of long-term environmental and development planning capacity may also result in crisis management, resulting in unsustainable development outcomes. While effective environmental and development planning frameworks are essential, the risk of avoiding unsustainable outcomes can only be avoided if government has the capacity (i.e. funding, human resources, skills) to implement these strategic frameworks and the associated regulatory processes. This must be strengthened within this core region as it is the focus area of several developments. To avoid unfavourable investment conditions especially for local economic development, long-term planning for the identified port and SEZ developments (Scenario 1 and 2) will have to pro-actively consider land use needs and spatial planning implications of, for example, more heavy-vehicle through-traffic affecting towns of Port Nolloth and Steinkopf. The regional development will affect two settlements considerably (Alexander Bay and Port Nolloth), and this could significantly affect housing development and social service provision and place a burden on bulk infrastructure. Smaller settlements need to be protected from unmanaged informal settlement which could place further strain on these communities and endanger local heritage and culture.

Carefully mediating communal land rights for new land development applications: During Apartheid, local people's rights in the region were not acknowledged, and communities were excluded from the use of land and the benefits obtained by others utilising its resources. Corrective measures have ensured land is returned to rightful communities; however, the risk remains that proposed large developments could still exclude the current landowners or not sufficiently benefit them. An historic opportunity currently exists for all stakeholders (including government and the private sector) to demonstrate sensitivity and caring to ensure that the proposed development opportunities provide long term sustainable benefit to the landowners, economically elevating the communities while also protecting local culture and heritage. The area of communal land ownership (CPA in this case) and its use for development is still contested and evolving. Communal land ownership and administration is also a challenge for communities/ community organisations where capacity and institutional readiness can be a challenge (also see section 7.5.4.3.3).

Governmental decision-making will be required around a diverse range of aspects such as: 1) land use change and land development applications for all the port and SEZ project components, 2) the implications of the Port, SEZ (Green Hydrogen components), green energy, pipelines, rail lines on adjacent land uses, 3) the impacts on potential/future spatial development on surrounding areas 4) ensuring the effective involvement of communities, 5) contributions to be paid to municipalities for municipal services, and 6) the possible provision of bulk infrastructure etc. Although many of these aspects, as single stand-alone items, have been addressed in South Africa previously (except for Green Hydrogen), the number and scale of proposed developments that would occur simultaneously is new, especially in this region. The developments will challenge the local aspects of spatial and land use planning legislation, powers and functions of organs of state, provision, maintenance and upgrading of infrastructure, etc.

Appeals processes: Land Use Management Systems of each municipality sets out the appeal process should there be an appeal against a municipal planning tribunal decision. A district municipality may, with the agreement of the local municipalities within the area of such district municipality, establish a Municipal Planning Tribunal to receive and dispose of land development applications and land use applications within the district municipal area (Department of Rural Development and Land Reform (DRDLR) , 2013, p. 44). The Municipal Planning Tribunal handles complaints against a planning decision. An Appeals Authority established in a municipality can decide on an appeal of a decision made by the

Tribunal (Haarhoff, 2022). Municipalities in this region, have technical and professional capacity constraints. The task in supporting these municipalities to be able to process the land use applications that will be needed for the Port and SEZ and all the linked project components as well as settlement growth or boomtown dynamics, is a challenge that must be addressed by provincial governments as a matter of priority. The role of the District Municipality to provide added capacity and planning support should also be considered.

6.4.1.2 Settlement Infrastructure development and management:

Settlement development and service delivery needs: The growth and development of settlements is a normal process that should be sustainable, well planned and executed. Sufficient forward planning would ensure that adequate bulk services are available. Settlement and economic growth in this region have mostly been limited. Going forward, some settlement expansion (Alexander Bay) could be affected by communal land ownership (CPA) and it is likely that infill development should occur first. Alexander Bay might also host a more temporary population due to construction activities at the Port and SEZ. Pre-studies have calculated the estimated social services needed to serve the anticipated (larger) settlement population of both Alexander Bay and Port Nolloth (SRR, 2024). Care must be taken when a portion of the new incoming population is temporary due to construction activity. The key restriction in the development of Alexander Bay is the state of its infrastructure – which needs upgrading to address the needs of the settlements (see 3.3.3). Additionally, the rates and taxes paid by the residents (when Alexander Bay was a mining town costs were much lower than that for the rest of the municipality) could require adjustment which may result in resistance from residents. Port Nolloth is also a town with infrastructure challenges – especially water resources. A new water pipeline from Alexander Bay would solve the problem but funding would be required from, for example, the State or the Port and SEZ developers. Similarly, the town needs to resolve its electricity infrastructure constraints. Further restrictions on the development of settlements are brought about by the availability of financial and management resources to develop and service human settlement expansion. Other large projects in the region such as the Namakwa SEZ should be considered as it would affect other settlements and add to the need for services and bulk infrastructure. Given periods where various projects engage in construction activities, there would be competition for skills and material resources.

6.4.1.3 Construction of economic infrastructure:

Construction materials and resources: The development of the Port and SEZ with its hydrogen production components and desalination plant as well as green energy in the vicinity and beyond in the wider region, will all require substantial construction materials. The following list a few examples of some infrastructure projects and likely construction impacts:

- R382 reconstruction – will require granular graded crushed stone base of 220 500 000m^3, stabilised subbase of 248 000 000m^3 and Asphalt surfacing of 174 195 tonnes (TM consulting and Nelutha, 2019a).

- Unpaved gravel roads will typically require about 1 200 m3 of construction material per layer per kilometre of road and depending on the existing site conditions, anything from one to three layers of material may be required for a new road. Under normal use the upper 150 mm of this material would require replacement every six to ten years.

- Water for road construction - Access to water for construction may be a limiting factor, as typically 84 m^3 (84 000ℓ) per layer per km will be required and needs to be sourced and hauled to site.

- Rail line – the total cut and fill required for the bridges, tunnels and earthworks was calculated to be approximately 100 and 120 million m^3 respectively (TM consulting and Nelutha, 2019b).

Other projects such as solar and wind parks, pipelines as well as all the construction on the SEZ industrial estate will also consume construction materials.

The projected growth in heavy vehicle traffic associated with port and SEZ construction will have a substantial impact on the regional road network, necessitating increased investment in routine maintenance and potentially earlier rehabilitation to ensure safety and serviceability. It is recommended that the rail line be built earlier than initially planned in the preliminary studies, in order to reduce the significant risk posed to the R382 and the towns along its route.

Although for some applications such as roads and rail lines where construction materials will be sourced both commercially and from approved quarries and borrow pits, materials will still have to be brought in from outside the region.

Port and SEZ site Implications: It is likely that the SEZ will be managed and operated by a designated operator or developer (which are either public or private entities) that are responsible for developing, managing, and maintaining the infrastructure and services within the SEZ. The operator is typically in charge of providing essential services such as water, electricity, waste management, roads, telecommunications, and security within the zone. The Richtersveld Local Municipality may still play a role in providing certain public services like emergency services, healthcare, and education that extend beyond the specific needs of SEZ businesses, and which would be located in towns where employees would be housed. The Municipality will also be involved in the broader infrastructure surrounding the SEZ (such as access roads and utilities connecting the SEZ to the surrounding community). Although the appointed SEZ operator is responsible for the planning, construction and supply of infrastructure and utilities within the SEZ (President of the Republic of South Africa, 2014), it still must align to the municipal land use scheme. Given that the responsibility for developing the SEZ lies with the appointed operator or developer, the burden and risk for the Richtersveld Municipality (where capacity constraints would otherwise significantly hamper such items) is reduced.

The proposed Port and SEZ will in essence be a large industrial estate, extending over a large area. As such it will result in a substantial land use change requiring substantial detailed planning. Detailed planning would be the responsibility of the operator or developer. The local municipality hosting the SEZ is generally the primary authority responsible for approving planning and land-use within a spatial development zone. This includes the preparation of zoning schemes, development plans and ensuring that development aligns with the municipal IDP and SDF. A remaining challenge is the land ownership or land control of the SEZ land, which according to the SEZ Act needs to be transferred to the entity governing the SEZ. Unless this is addressed at the start of the initiative, it would hamper all subsequent projects. It is also likely given the capacity constraints at the Richtersveld Municipality (SEZ host) that this issue will be addressed by NCEDA and Transnet, the lead institutions driving the SEZ and Port component respectively.

6.4.2 Reflecting on the core risk themes outlined above, it is evident that institutional and infrastructure upgrades must be implemented before substantial development takes place in the region; otherwise, the overall sustainability of the project could be jeopardized.Measuring risk and opportunity

SEA risk assessment works by systematically evaluating the strategic risks and opportunities associated with proposed policies, plans, or programs before detailed project design occurs. The process typically involves identifying major risk themes relevant to the project (like institutional capacity, settlement services, or infrastructure construction), and assessing each risk by combining consequence (the severity of impact across environmental, social, economic, and institutional dimensions if it occurs) with likelihood (the probability it will actually happen given baseline conditions and proposed mitigation). [20]

[20] Uncertainty, implementation failure and funding gaps are handled qualitatively within the risk-rating logic (and through conservative assumptions),rather than via a separate numeric 'weight', they are built info how likelihood and consequence are judged, and how precautionary the overall assessment is.

6.4.2.1 Defining consequence- and benefit categories

Table 6-13Table 6-14 lists both the positive and negative consequence categories for identified impact themes. It reflects the core elements for each impact theme, measured in extent ranging from 'slight' up to 'extreme', which represents the highest category.

6.4.2.2 Risk and opportunity assessment

Predefined risk and opportunity categories were established by the SEA team and is indicated in Table 6-15 (Schreiner, et al., 2024). Risk or opportunity is reflected for each impact theme and each scenario using these risk and opportunity categories.

Table 6-16 reflects the risks associated with a negative impact. It indicates the main receiving environments and then categorises the **consequence, likelihood and risk** associated with each scenario considering the likely situation before-, and after management actions have been implemented[21].

6.4.2.3 Description of risk themes

Development Planning Pressures

This theme primarily focuses on the municipality's ability to undertake strategic planning and development control. Strategic planning encompasses land use, infrastructure, and land development, as well as key municipal functions, including technical and planning tasks, and the processing of approvals through a district planning tribunal mechanism. It also involves the municipality's capacity to evaluate and process applications, provide decision-making support, and implement necessary changes to planning documents and systems. Additionally, this extends to other government departments or agencies for matters that fall outside the municipal scope.

Settlement infrastructure and service development and management

Towns like Alexander Bay and Port Nolloth have been identified as key receiving areas, expected to experience significant growth and increased pressure to accommodate both temporary and permanent new residents due to proposed projects in the region. Other towns likely to face increased settlement pressures include Steinkopf and the Springbok area. This theme highlights several issues affecting these communities *related to infrastructure development*:

There are significant backlogs in essential infrastructure and services, such as water, electricity, and sanitation services. Moreover, the existing infrastructure may not be adequate to support the anticipated population growth and subsequent expansion. Municipal capacity and available resources to ensure sustainable service delivery are currently insufficient, necessitating external funding or developer contributions for infrastructure development. Additionally, the need to support indigent populations, coupled with limited municipal income, leads to a shortfall in funding, making it difficult to effectively manage settlement growth (also see section 7.6.2).

Construction of (economic) large-scale infrastructure projects

Economic infrastructure encompasses a range of large-scale projects, including new rail lines, electricity transmission lines, hydrogen pipelines, and road improvements and construction. It also covers green energy initiatives and the focused development of the Port and SEZ

Given the similarities between these projects, they face common challenges, such as land acquisition and rights and servitude establishment, as well as the strain on limited road infrastructure (specific routes) needed to transport equipment, materials, people, and other freight to- and from- the region. The

[21] Uncertainty about data, future conditions or implementation is then reflected by: inflating likelihood (because failure is more likely), inflating consequence (because worst-case outcomes cannot be ruled out), or explicitly assigning a more conservative risk class when confidence is low.

construction phase will also increase pressure on essential resources (particularly water) and requires accommodation for temporary workers, often in temporary construction site camps that rely on municipal services. Due to the interconnected nature of these projects, detailed pre-planning and coordination during both the planning and implementation phases are crucial to ensure the successful operation of all infrastructure initiatives.

Table 6-14: Consequence categories.

Theme/receptor	Negative consequence (-)				
	Slight	Moderate	Significant	Drastic	Extreme
1. Development Planning Pressures All LMs; Core focus = Richtersveld municipality.	Slight demand for strategic planning and development control increases pressure on existing capacity. Planning for infrastructure development leads to a slight increase in pressure on the regulatory system, including processes for obtaining rights and permits. Minor delays or inefficiencies in project execution, with no significant cost overruns.	Increasing demand for strategic planning and pressures on the regulatory system i.e. development rights, land availability and permits, results in pressure on multiple municipal and agency functions. Some disruptions to timelines and budgets, requiring additional planning and resource allocation.	Increasing demand for strategic planning and pressures on the development and land management system and processes exceed the capacity of multiple spheres of government and agencies, requiring enhanced planning capacity. Major financial and logistical challenges, resulting in extended delays and requiring large-scale interventions.	Rapidly increasing demand for strategic planning and development control in multiple government and agency spheres overburdens the regulatory system, resulting in delays that cause the loss of investment opportunities. Severe construction setbacks, leading to cascading impacts on project viability and regional infrastructure goals.	Extreme pressure on the strategic planning and development control results in the system's collapse, requiring intervention. Broad-scale development of a rapidly increasing number of infrastructure projects lead to extreme delays in the regulatory process. Total project failure, resulting in economic losses, legal disputes and abandonment of key infrastructure initiatives.
2. Settlement infrastructure and service development and management Esp. Alexander Bay and Port Nolloth, Steinkopf and Springbok-settlement cluster.	Migration can be partially accommodated with only a slight increase in infrastructure and service backlogs.	The increasing number of migrants places more significant pressure on multiple municipal and agency functions, resulting in growing infrastructure and service provision backlogs.	The increase in migration is exceeding municipal and agency capacity to deliver infrastructure services, leading to growing informal settlements.	Rapidly increasing demand for infrastructure and services largely overburdens multiple municipal and agency functions, significantly increasing informal settlement.	Extreme levels of in-migration lead to a severe increase in infrastructure and service backlogs and a rapid expansion of informal settlements.
3. Construction of economic/large-scale infrastructure projects Road-, Rail-, Pipeline-, Transmission corridors, Green energy project, Port	The construction of infrastructure projects leads to a slight increase in pressure on the capacity of existing physical infrastructure and	The increasing construction of infrastructure projects places greater pressure on the capacity of physical infrastructure to	Increasing construction of infrastructure projects results in the capacity of physical infrastructure to accommodate increased settlement and the	The rapid construction of an increasing number of infrastructure projects results in the capacity of physical infrastructure (especially the road,	Broad-scale construction of a rapidly increasing number of infrastructure projects leads to the physical infrastructure (especially the road, water and sanitation

and SEZ.	services to accommodate increased settlement and the movement of people, construction equipment, and materials.	accommodate increased settlement. The movement of people, construction equipment, and materials is becoming increasingly limited.	movement of people, construction equipment, and materials to be exceeded, resulting in delays and increased costs.	water and sanitation networks) to accommodate increased settlement and the movement of people, construction equipment, and materials to be drastically exceeded. The above results in loss of investment due to delays and increased costs.	networks) not being able to accommodate increased settlement and the movement of people, construction equipment, and materials. The above results in significant loss of investment and the termination of projects.
Theme / receptor	**Positive consequence (+)**				
	Slight	**Moderate**	**Significant**	**Drastic**	**Extreme**
1. Settlement Infrastructure Development Especially in Richtersveld (Port Nolloth and Alexander Bay)	Infrastructure backlogs are stabilised and not increased.	Beyond reducing infrastructure backlogs, new investment enables the restoration of existing infrastructure.	Infrastructure backlogs are eradicated. Additional infrastructure for water, electricity, and roads enables some settlement growth.	Infrastructure development enables the considerable expansion of settlements, increasing demand for services and economic investment.	Broad-spectrum investment in settlement infrastructure results in the provision of higher-order facilities. This leads to an increase in population and employment opportunities, which attracts further economic investment and increases municipal income overall.

Table 6-15: Predefined risk/opportunity categories to measure Risk or Opportunity.

RISK (-)		OPPORTUNITY (+)	
VERY LOW	Almost indiscernible negative impact.	Almost indiscernible positive impact.	VERY LOW
LOW	Slight negative impact, limited extent, and short duration, well within tolerance.	Slight positive impact, very localised, well below expectations.	LOW
MODERATE	Substantial impact, but less than major; within tolerance and below limits of acceptable change.	Substantial positive impact, but mostly short term, and spatially limited.	MODERATE
HIGH	Major consequence, approaching tolerance and limits of acceptable change.	Highly desirable impact, major medium to long term positive impacts across a broad range of stakeholders at local or regional scales.	HIGH
VERY HIGH	Extremely negative impact, persistent/long lasting, beyond tolerance and limits of acceptable change.	Highly desired, grandiose long term positive impacts across a broad range of stakeholders at local, regional, national, and/or international scales.	VERY HIGH

Source: (Schreiner, et al., 2024)

Table 6-16: Risk associated with a negative impact.

Negative impact	Scenario	Spatial receiving environment / receptor	Without management			With management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
1. Development Planning Pressure	S0: BASELINE	**Richtersveld** (Primary Receiver)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY LIKELY	VERY LOW
	S1: SMALL GH2		DRASTIC	DEFINITE	VERY HIGH	MODERATE	DEFINITE	MODERATE
	S2: BIG GH2		SIGNIFICANT	DEFINITE	HIGH	MODERATE	DEFINITE	MODERATE
	S0: BASELINE	**Kamiesberg, Nama Khoi, Khai-Ma** (Rest Of Region)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		SIGNIFICANT	MORE LIKELY	HIGH	MODERATE	MORE LIKELY	MODERATE
	S2: BIG GH2		SIGNIFICANT	MORE LIKELY	HIGH	MODERATE	MORE LIKELY	MODERATE
	S0: BASELINE	**District, Province and National** (Incl. Agencies: NCEDA, COGSTA)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		DRASTIC	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		SIGNIFICANT	DEFINITE	HIGH	MODERATE	DEFINITE	MODERATE

Baseline: Given the current low levels of development pressure and limited land use applications, the existing District Municipal Tribunal mechanism is sufficient. A key mitigation would be ensuring that municipalities employ qualified planners to manage ongoing applications effectively.

Small Green Hydrogen Scenario: A significant increase in land use applications is anticipated due to the wide range of developments in the region, with Richtersveld particularly affected. The consequences could be **severe**, as current systems are not equipped to manage a constant high volume of applications. Institutional complexity and the large number of role players will compound the challenge. Additional risks include delays from land ownership disputes, particularly unresolved CPA concerns, which could stall project implementation. A more effective and capacitated planning mechanism must be established to manage the increased workload. Mitigation should also address land-related issues, including the establishment of servitudes required for transport infrastructure.

Big Green Hydrogen scenario: High levels of land use pressure are expected to continue, driven by regional infrastructure such as green energy projects, pipeline expansions, and a new rail line. These developments will trigger land use processes across multiple municipalities. The improved planning mechanisms introduced in the Small Green Hydrogen scenario would remain essential. If not implemented, the consequences could be **severe**; however, with effective mitigation in place, the impact is expected to be **moderate**.

Table continues next page.

Negative impact	Scenario	Spatial receiving environment / receptor	Without management			With management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
2. Settlement Infrastructure Development & Management	S0: BASELINE	**Richtersveld** (Alexander Bay And Port Nolloth)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		EXTREME	VERY LIKELY	VERY HIGH	MODERATE	DEFINITE	HIGH
	S0: BASELINE	**Nama Khoi** (Steinkopf and Springbok Settlement Cluster)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		SIGNIFICANT	MORE LIKELY	HIGH	MODERATE	MORE LIKELY	MODERATE
	S2: BIG GH2		SIGNIFICANT	MORE LIKELY	HIGH	MODERATE	MORE LIKELY	MODERATE
	S0: BASELINE	**Khai-Ma** (Poffadder And Aggeneys)	SIGNIFICANT	LIKELY	HIGH	MODERATE	LIKELY	MODERATE
	S1: SMALL GH2		SIGNIFICANT	LIKELY	HIGH	SLIGHT	LIKELY	MODERATE
	S2: BIG GH2		MODERATE	LIKELY	MODERATE	MODERATE	LIKELY	MODERATE
	S0: BASELINE	**Rest Of Settlements**	SLIGHT	LIKELY	VERY LOW	SLIGHT	LIKELY	VERY LOW
	S1: SMALL GH2		MODERATE	LIKELY	MODERATE	SLIGHT	LIKELY	LOW
	S2: BIG GH2		MODERATE	LIKELY	MODERATE	SLIGHT	LIKELY	LOW

Baseline: At present, pressure on land development and land use applications is low, reflecting modest growth rates and prevailing economic constraints. Current demand is concentrated in Poffadder and Aggeneys (linked to the Namakwa SEZ), and in Springbok, given its regional role and proximity to mining activity.

Small Green Hydrogen Scenario: Extreme pressure is expected due to a wide range of projects and associated construction activities. Construction jobs and the establishment of construction camps, together with increased in-migration, will place significant strain on towns in the Richtersveld, with spillover effects into other settlements if not managed. Additional direct and indirect pressures from port and SEZ-related projects — including energy, roads, pipelines, and associated logistics — will drive settlement and housing demand growth in Port Nolloth and Alexander Bay in particular. With mitigation, the overall consequences are considered moderate.

Big Green Hydrogen Scenario: Settlement pressure will remain high, driven by ongoing regional growth and new energy, rail, and pipeline projects. While the Richtersveld will continue to face significant demand, pressure is likely to shift to other towns as construction activity expands across the region. Additional indirect pressures will arise from housing demand, enterprise development, and informal settlement growth. With appropriate mitigation, the consequences are expected to be moderate.

Table continues next page.

Negative impact	Scenario	Spatial receiving environment / receptor	Without management			With management		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
3. Construction of Economic Infrastructure Projects	S0: BASELINE	1. Port & SEZ	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		DRASTIC	DEFINITE	VERY HIGH	MODERATE	DEFINITE	MODERATE
	S0: BASELINE	2. Road Corridor (focus on R382)	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		SIGNIFICANT	LIKELY	LOW	MODERATE	UNLIKELY	LOW
	S0: BASELINE	3. Pipeline Corridors	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S0: BASELINE	4. Rail Corridor	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S2: BIG GH2		EXTREME	DEFINITE	VERY HIGH	SIGNIFICANT	DEFINITE	HIGH
	S0: BASELINE	5. Transmission Corridors	SLIGHT	VERY LIKELY	VERY LOW	SLIGHT	LIKELY	VERY LOW
	S1: SMALL GH2		DRASTIC	DEFINITE	VERY HIGH	MODERATE	DEFINITE	MODERATE
	S2: BIG GH2		DRASTIC	DEFINITE	VERY HIGH	MODERATE	DEFINITE	MODERATE
	S0: BASELINE	6. Green Energy Projects/ Corridors/Sites	MODERATE	LIKELY	MODERATE	SLIGHT	LIKELY	LOW
	S1: SMALL GH2		EXTREME	DEFINITE	VERY HIGH	SUBSTANTIAL	DEFINITE	HIGH
	S2: BIG GH2		DRASTIC	DEFINITE	VERY HIGH	MODERATE	DEFINITE	Moderate

Baseline: Roads such as the R382, N7, and N14 currently experience low traffic volumes and receive routine maintenance. No rail or pipeline infrastructure is present or anticipated in the near term. Green energy development is likely but at a modest scale, with relatively limited activity in the Richtersveld municipality. Some pre-existing wind and solar projects are possible under the REIPPPP, though continuation remains dependent on private developers. Minor Eskom transmission upgrades are underway to improve electricity access to selected settlements.

Small Green Hydrogen Scenario: A high level of risk is anticipated as multiple linear and energy infrastructure projects commence simultaneously. Alignment planning and the establishment of servitudes for roads, pipelines, and transmission corridors, together with construction activities, will exert wide-ranging effects on settlements and the broader development fabric — especially in the Richtersveld. Key pressures include:

- Materials and resources: high demand for construction materials, borrow pits, and water (including borehole drilling).
- Labour and accommodation: influx of a large construction workforce requiring accommodation, either in settlements or through the establishment of construction camps.
- Land use and permitting: numerous applications and EIAs required for sites, servitudes, and access roads.
- Transport impacts: construction of gravel access roads along all transport corridors (excluding the R382), and gas pipelines aligned to existing road or energy transmission corridors where possible.

Large areas will be affected by infrastructure footprints, with possible conflict over land use (particularly in CPA areas used by pastoralists). Clearing of sites and construction of new roads will add to cumulative pressures. The precise location of renewable energy sites remains uncertain, but diversification strategies suggest projects will extend into the wider region and other provinces.

Big Green Hydrogen Scenario: Infrastructure pressure will remain high with the expansion of pipelines and the introduction of a new rail line. Rail development, in particular, will require extensive land acquisition, servitudes, access roads, and will have significant planning and environmental impacts on the landscape. Increased heavy vehicle traffic will place additional strain on existing roads. Renewable energy projects will continue to expand, though Richtersveld is likely to face less pressure relative to other parts of the region and adjoining provinces. As with the earlier phase, sites will require clearing, new access roads, water abstraction (including boreholes), and the establishment of construction camps. Land use applications and EIAs will continue at scale, supported by new REIPPPP calls to meet large energy requirements.

Table 6-17: Opportunity associated with a positive impact.

Positive impact	Scenario	Spatial receiving environment / receptor	Without management			With management		
			Consequence (+)	Likelihood	Opportunity	Consequence (+)	Likelihood	Opportunity
4. Settlement Infrastructure Development	S0: BASELINE	Port Nolloth and Alexander Bay	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		MODERATE	DEFINITE	MODERATE	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		MODERATE	DEFINITE	MODERATE	SIGNIFICANT	DEFINITE	HIGH
	S0: BASELINE	Steinkopf and Springbok cluster	SLIGHT	VERY UNLIKELY	VERY LOW	SLIGHT	VERY UNLIKELY	VERY LOW
	S1: SMALL GH2		MODERATE	DEFINITE	MODERATE	SIGNIFICANT	DEFINITE	HIGH
	S2: BIG GH2		MODERATE	DEFINITE	MODERATE	SIGNIFICANT	DEFINITE	HIGH
	S0: BASELINE	Pofadder and Aggeneys	MODERATE	MORE LIKELY	MODERATE	SIGNIFICANT	MORE LIKELY	MODERATE
	S1: SMALL GH2		MODERATE	MORE LIKELY	MODERATE	SIGNIFICANT	MORE LIKELY	MODERATE
	S2: BIG GH2		MODERATE	MORE LIKELY	MODERATE	SIGNIFICANT	MORE LIKELY	MODERATE
	S0: BASELINE	Rest of Settlements	SLIGHT	LIKELY	VERY LOW	SLIGHT	LIKELY	VERY LOW
	S1: SMALL GH2		SLIGHT	LIKELY	VERY LOW	SLIGHT	LIKELY	VERY LOW
	S2: BIG GH2		SLIGHT	LIKELY	VERY LOW	SLIGHT	LIKELY	VERY LOW

Baseline: Minimal new development takes place in the region, limiting opportunities to improve or expand settlement infrastructure such as roads, water, sanitation, waste removal, electricity, and social facilities. Some settlements, including Aggeneys and Pofadder, benefit from investment associated with the Namakwa SEZ in their vicinity (unrelated to Boegoebaai). However, most other settlements do not experience significant investment or growth, and infrastructure conditions therefore remain largely unchanged.

Small Green Hydrogen Scenario: The development of the Port and SEZ is anticipated to drive renewed interest and investment in nearby settlements to accommodate both permanent residents and temporary construction workers. Port Nolloth and Alexander Bay will be the key beneficiaries given their proximity to the development site. The resulting demand for services will catalyse infrastructure investment to strengthen these towns and relieve pressure on already strained systems. Additional benefits are expected in Steinkopf and Springbok (and surrounding areas), while Pofadder and Aggeneys continue to gain from the Namakwa SEZ development.

Large Green Hydrogen Scenario: Ongoing investment in the SEZ, Port, new rail and pipeline infrastructure, and expanding green energy projects continue to enhance settlement infrastructure in towns closest to these developments. If investment flows are effectively managed and coordinated, several towns across the region benefit substantially. Settlements located further from the Port and SEZ also experience improvements, albeit on a smaller scale, through broader regional economic spillovers and service investments.

6.5 MANAGEMENT GUIDELINES AND MONITORING REQUIREMENTS

6.5.1 Establishing a planning support unit/function to enhance shared capacity

As mentioned earlier in this section, the capacity and readiness, especially of the four focal local municipalities to deal with implementing a host of infrastructure projects, related land use issues, and the anticipated settlement related implications (planning and services), needs to be enhanced. If not addressed, the affected municipalities are expected to struggle to handle the increased planning needs and regulatory challenges. It is equally important that municipalities ensure compliance with planning regulations (and plans), which implies monitoring and enforcement. Currently, staffing at the four affected municipalities is insufficient to monitor projects and enforce bylaws effectively. The Namakwa District Municipality supports these municipalities, but its capacity is also constrained. The situation is made worse by the vast distances to be covered by officials to visit settlements and projects.

The following are envisioned to address these constraints.

- Communication and information sharing between the affected municipalities (including the Namakwa District) should be enhanced. Several projects cross municipal boundaries, which requires alignment.

- The use of shared geospatial data is also proposed (above).

- Given the newness of some of the proposed developments (unfamiliar to the planners in the region), it would be beneficial to develop the capacity of these and other municipal officials (*mainly focussed on Hydrogen production and Green Energy*).

- Expand the human resource capacity (additional staff, especially registered planners, sharing skills and experience).

- The establishment of a specialised planning unit or relevant mechanism that is responsive to the likely increased planning workload. This could also be the mechanism by which the national and provincial governments can provide support..

- The planning support unit/function is envisaged as a shared capacity mechanism hosted at district and/or provincial level (for example within the Namakwa District Municipality and/or relevant provincial department), with a mandate to support, not replace, municipal planning powers under SPLUMA.

- Such a unit/function would require a dedicated budget and staffing, access to specialist technical support, and clear terms of reference that define its advisory role, coordination functions and reporting lines.

- The land use decision-making authority remains with the Municipal Planning Tribunals and councils as provided for in SPLUMA, and that the support function is intended to strengthen, rather than shift, these statutory roles.

It should be noted that municipal financial constraints currently limit the appointment of additional skilled technical and planning staff. Thus, the cost for providing added support will have to be addressed.

Capacity development, training and empowerment: One of the significant mitigation factors critical to planning, implementation, monitoring and adaptation will be increasing the capacity of the relevant settlement planning, service delivery, integrated planning, and other authorities in the area. Building capacity and expanding the number of planners in municipalities could address this, but this requires resources and may not be done to the extent needed due to funding constraints. It also takes time to ensure the desired results (Figure 6-25).

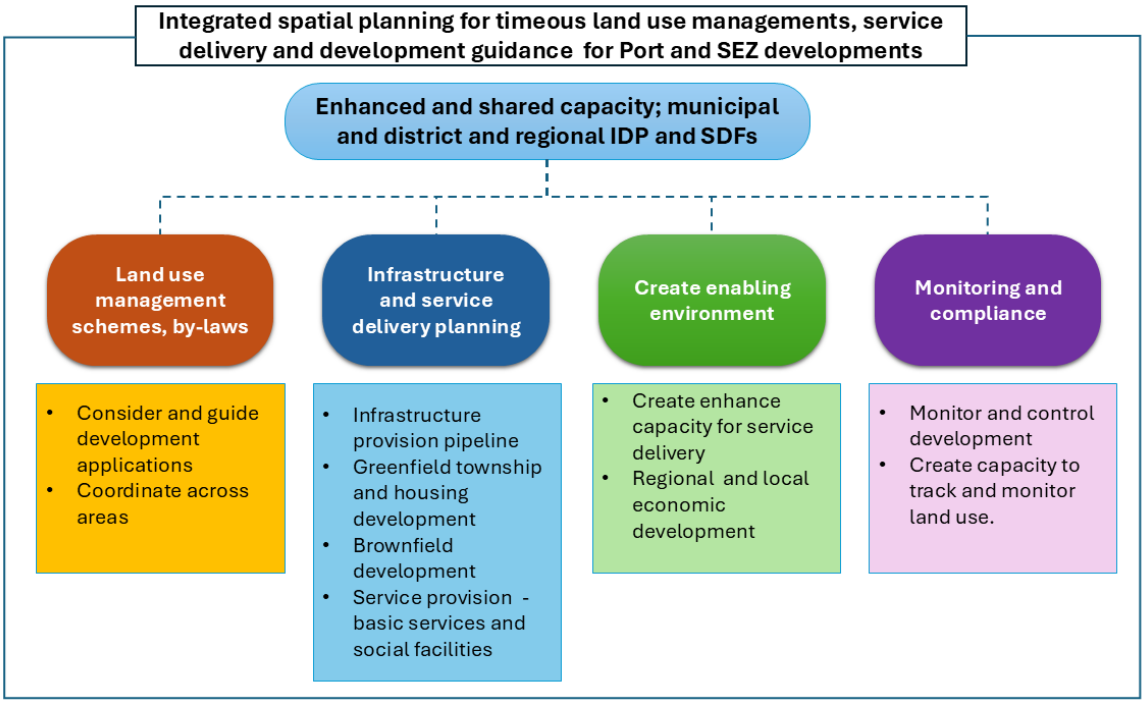


Figure 6-25: Importance of proactive long-term planning instruments and capacity

Source: (Van Hyussteen, et al., 2016, pp. 18-60), modified.

Local planning officials must be capacitated and informed to provide the necessary enabling and regulatory services. Leading investment and/ or development institutions include NCEDA, Transnet, SASOL, SANRAL, ESKOM, Department of Energy, and the DTIC. Their investment is critical to ensure success, and their active participation in the planning activities is of critical importance. The role and support of the South African Local Government Association (SALGA), Department of Rural Development and Land Reform, and Department of Cooperative Government and Traditional Affairs can also aid the planning and development efforts.

Regional specialist capacity: The following will be required:

- Specialist support for baseline studies;
- Specialist studies and dedicated capacity to support SDF and land use management scheme development, with possible appropriate zoning layers for multiple purposes (considering a variety of legal considerations)
- Specialist studies and advice in considering land use applications. There is scope in terms of SPLUMA for a municipality to appoint technical advisers to a municipal or 'shared' planning tribunal to assist with more complex decisionmaking
- Specialist studies to determine relevant development contributions related to the impact on infrastructure and services'
- Specialist support with adaptation of sector plans and strategies
- Monitoring and control, which includes support and control of land use practices, and
- The establishment of a dedicated task team

Precinct plans for the SEZ will be required to detail all developments affecting land uses, the risks involved, and the regulations to be satisfied.

6.5.2 Effective and efficient land use management and regulatory environment

All municipalities in the region have land-use schemes and related procedures for development and land-use applications, in line with SPLUMA. However, limited planning capacity – particularly the small number of registered planners – hampers the effective operation of these systems, especially under conditions of rapid growth. The District Municipal Planning Tribunal, which currently convenes quarterly, is the main mechanism for handling land development applications, but it is unlikely to manage the anticipated surge in applications associated with the port, SEZ and related infrastructure. To reduce these risks and ensure an effective and efficient land use management and regulatory framework, the following minimum conditions should be in place before any major Green Hydrogen-related land development applications are approved.:

- Relevant municipal IDPs and SDFs must be reviewed and revised to integrate the port, SEZ and related infrastructure corridors, and must be formally approved in accordance with the Municipal Systems Act.

- Municipal SPLUMA by-laws, land use schemes and Municipal Planning Tribunals must be fully functional, with meeting schedules, procedures and institutional support that can accommodate the higher volume and complexity of land development applications, ensuring they are processed within reasonable timeframes. A planning support unit/ function is also proposed (section 6.5.1) to expand the planning support functions.

- Existing land use schemes should be broadened and updated, where required, to cater for the complete spectrum of proposed land uses and to promote systematic, periodic review rather than ad hoc amendments.

- Standardised land access and servitude procedures, including those relevant to communal land and CPAs, must be agreed upon by the appropriate spheres of government and affected communities, and then applied consistently across all projects.

- Municipalities should receive support through project-specific planning information: the detailed planning for each major project, and its consequences for municipal functions, must be recorded and communicated in good time so that it aligns with municipal planning and budgeting cycles.

- Suitable GIS-based land use management systems, whether internally managed or supported by external service providers, should be implemented to enable real-time monitoring of land use applications and planning decisions in the core region.

To put these measures into practice, coordinated capacity-building and strengthening of existing planning resources (including more personnel and technical assistance) will be necessary, and governance structures must continue to operate in an open and transparent manner.

6.5.3 Combined planning of Projects

In developing the port and SEZ, numerous large-scale infrastructure projects (such as renewable energy facilities, transmission lines, pipelines, rail links and bulk services) will be designed and rolled out, often with strong interdependencies (for instance, shared access roads and common infrastructure nodes). Taken together, these initiatives affect municipal responsibilities and settlements, and may further burden municipalities whose capacity is already limited. To minimise the risk of piecemeal development and uncontrolled cumulative impacts, integrated planning of these projects should be put into practice through the following measures:

- An intergovernmental project register for all major Boegoebaai-related infrastructure must be created, kept up to date, and used to coordinate project sequencing, routing and scheduling.

- Regular multi-stakeholder planning forums (at least once a year) including affected local municipalities, the Namakwa District Municipality, relevant provincial departments and national SOEs must be held to align project pipelines with municipal IDPs, SDFs and infrastructure plans, and to jointly evaluate cumulative impacts, skills demands and labour requirements.

- Major environmental and land-use authorisations for green hydrogen-related projects should, wherever feasible, be synchronised with IDP/SDF cycles and with each other so that cumulative impacts and infrastructure capacity are addressed in an integrated way.

- Governance frameworks for the port and SEZ should incorporate a balanced mechanism ensuring that municipalities, communities and other affected stakeholders are meaningfully represented, thereby preventing a situation in which key project proponents hold disproportionate decision-making authority (MMSD, 2002).

6.5.4 These tools are intended to translate the idea of integrated planning into practice and to provide a concrete basis for managing cumulative impacts and institutional capacity pressures.Financial support

Pre-studies and recent assessments of the core municipalities show that they lack the financial capacity to clear existing infrastructure backlogs or to fully fund all new infrastructure needed for the port and SEZ, especially in smaller settlements (DBSA, 2024). To ensure strategic feasibility and prevent excessive strain on municipal finances, the following financial conditions are particularly important:

- Key bulk infrastructure needs (notably water, sanitation, electricity and primary access roads) must be clearly identified in municipal and sector infrastructure plans, with indicative funding sources (such as national and provincial grants, SOE investments and/or developer contributions) allocated to each item.

- For any infrastructure that is a prerequisite for major approvals, funding must appear in the relevant Medium-Term Expenditure Frameworks, municipal budgets or in signed finance agreements before any construction-phase approvals proceeds.

- A transparent system for developer contributions and cost-sharing to support municipal and bulk infrastructure must be agreed upon between SEZ governance structures, municipalities and relevant departments, and consistently applied to green hydrogen-related projects.

- Where municipalities are unable to finance required infrastructure, the institution leading the port and SEZ (together with associated partners) should, subject to future agreements, help fund the necessary enabling infrastructure in a way that is consistent with national infrastructure funding and SEZ policy frameworks.

These conditions acknowledge that the mitigation measures and development pathways outlined in this chapter rely on concrete, secured financial commitments, rather than on unfunded expectations.

6.5.5 Sustainable settlements and service delivery

The growth and evolution of settlements is a natural process that should occur in a sustainable, well-planned and properly implemented manner. Adequate forward planning is required to ensure that sufficient bulk services are in place. To date, settlement and economic growth in this region have largely been constrained. In future, certain settlement expansion (for example in Alexander Bay) may be influenced by communal land ownership (CPA), and it is probable that infill development will need to be prioritised. Alexander Bay could also accommodate a more transient population associated with construction activities at the Port and SEZ. Pre-feasibility studies have already estimated the social services required to support the expected larger populations of Alexander Bay and Port Nolloth (SRR, 2024). Caution is necessary when a share of the incoming population is temporary and linked to construction phases.

The primary limitation to Alexander Bay's development is the condition of its infrastructure, which must be upgraded to meet settlement needs. Furthermore, adjustments to property rates and taxes may be necessary (historically, as a mining town, Alexander Bay's costs were substantially lower than those in the rest of the municipality), and this could trigger resistance from residents. Port Nolloth similarly faces

infrastructure constraints, particularly regarding water supply. A new water pipeline from Alexander Bay could resolve these shortages, but would require external funding, for instance from the State or from the Port and SEZ developers. The town also needs to address limitations in its electricity infrastructure.

Additional constraints on settlement development arise from the limited financial and management capacity available to support and maintain human settlement expansion. Other major regional initiatives, such as the Namakwa SEZ, must be taken into account, as they will impact surrounding settlements and increase demand for services and bulk infrastructure. During overlapping construction phases of multiple projects, competition for skilled labour and construction materials is likely to intensify.

In this context, sustainable settlement development for the port and SEZ requires that a set of minimum prerequisites be in place before major construction begins:

- Settlement plans and housing strategies for Alexander Bay and Port Nolloth must be drafted or revised to cater for anticipated population increases linked to construction and operations, including provision for temporary construction workforces and post-construction adjustment.

- Essential bulk and connector infrastructure upgrades for water, sanitation and electricity in Alexander Bay and Port Nolloth must be identified, costed and prioritised, with clearly defined funding sources (such as national grants, provincial programmes, SEZ-related investments or developer contributions) secured before large-scale construction-phase housing is authorised.

- Social infrastructure needs (schools, clinics, policing, waste management and community facilities) associated with peak and long-term population levels must be assessed and built into municipal and sector plans, with explicit responsibilities and funding pathways.

- Measures to prevent unmanaged informal settlement expansion in smaller towns, and to conserve local heritage and cultural landscapes, must be incorporated into municipal settlement and land-use planning strategies.

- For sustainable on-site construction housing and services: where projects intend to accommodate construction workers on or adjacent to project sites, worker housing must be designed to limit resource consumption and associated risks, using environmentally sensitive, sustainable building approaches, alternative technologies, grey-water reuse and, where possible, on-site renewable energy generation. Housing needs and the related demand for services must be evaluated in each project-level EIA, and any dependence on municipal services must be explicitly detailed in project design and backed by formal agreements with the relevant municipalities.

6.5.6 These measures respond directly to the challenges outlined in this chapter and acknowledge that sustainable settlement development in the core area relies on upfront or parallel investment in bulk and social services, rather than reactive interventions once major project construction is already in progress.Pressure on roads for transportation of materials, equipment and freight

Multiple green hydrogen related initiatives including the port, SEZ, pipelines, renewable energy projects and transmission infrastructure, will substantially increase the movement of materials, equipment and freight on regional and local roads, especially the R382, N7 and N14. During the development stages of the port and SEZ – and potentially also nearby green energy sites – the R382 in particular is expected to carry large volumes of heavy vehicles (see Sections 6.3.3.1). If not managed proactively, this could accelerate road wear, heighten accident risks, increase dust and noise, and place additional pressure on emergency and health services in towns such as Steinkopf and Port Nolloth. To address these pressures, the following conditions should guide project approval and roll-out:

- A coordinated freight and construction traffic management plan for Boegoebaai-related developments must be prepared, setting out expected heavy-vehicle volumes, preferred routes, construction traffic time windows and mitigation measures for settlements along the R382, N7 and N14.

- Road sections and intersections most affected by projected heavy-vehicle flows must be prioritised and included in a funded programme for road upgrading and maintenance, with clearly defined responsibilities shared between SANRAL, the provincial roads authority and municipalities.

- Road safety interventions (including traffic-calming measures, signage, law enforcement and, where necessary, bypasses or alternative access arrangements) must be designed for settlements along key freight corridors and incorporated into transport and safety plans.

- The trade-off between continued, long-term reliance on road-based freight and a greater use of rail must be explicitly assessed when considering project approvals and phasing, with explicit attention to cumulative impacts on communities and infrastructure. It is recommended that construction of the proposed rail line be prioritised much sooner, in light of the substantial impacts and risks associated with high truck volumes on regional routes, particularly on the R382.

- The siting and design of construction camps, as well as local access roads to camps, wind and solar plants, pipelines and transmission lines, must account for their proximity to settlements and be governed by conditions that minimise disturbance, dust and safety risks.

- Minimum standards should be established jointly by national regulators and the lead project proponent responsible for worker accommodation and camp management, and all major contractors must adopt formal worker-accommodation plans, apply codes of conduct to minimize tensions with local communities and vulnerable groups, and ensure that camp design explicitly accounts for potential impacts on local water, sanitation and solid-waste systems.

6.6 COLLECTIVELY, THESE MEASURES AIM TO ENSURE THAT TRANSPORT-RELATED IMPACTS ARE HANDLED WITHIN A COORDINATED REGIONAL ROAD AND FREIGHT STRATEGY, RATHER THAN BEING MANAGED ONLY ON A PROJECT-BY-PROJECT BASIS.KNOWLEDGE GAPS

A number of information and planning gaps remain relevant to the implementation of the port, SEZ and associated infrastructure. Not all gaps are of the same strategic significance. Some are material enough to influence the interpretation of this chapter's strategic conclusions and the sequencing of development, while others are more appropriately addressed through subsequent project-level studies, EIAs, detailed design and monitoring. For purposes of decision-making, the gaps identified in this chapter can be grouped into two categories

Gaps material to strategic conclusions and sequencing

These are gaps that could influence whether the development scenarios can realistically be considered strategically manageable in the short to medium term, and they should therefore be addressed as key issues before major approvals are granted and peak development phases begin. These gaps relate to:

- The availability, timing and financing of essential bulk infrastructure upgrades—especially for water, sanitation, electricity and key roads in settlements most directly affected by the port and SEZ;

- The institutional capacity of municipalities and supporting entities to process land development applications, manage cumulative settlement expansion and coordinate infrastructure planning in terms of SPLUMA and related legislation (also see section 7.6.7.1);

- Improved clarity on land access, servitude procedures and governance arrangements in areas under communal land ownership and CPA administration;

- More coherent integrated planning for the sequencing, routing and interdependence of major infrastructure components such as roads, rail, pipelines, transmission networks and renewable energy facilities; and

- A stronger evidence base on likely settlement growth or boomtown dynamics, including the magnitude and duration of construction-related in-migration and its implications for housing, social infrastructure and municipal finances.

Where these matters remain unresolved, the strategic risk profile of the Small and Large Green Hydrogen scenarios should be interpreted cautiously, and the feasibility of proceeding at scale may be reduced.

Gaps to be addressed through project-level studies, EIAs and monitoring

These gaps do not, in themselves, change the overall strategic conclusions of this chapter, but they are crucial for refining impacts, detailed design, and mitigation measures during the next stage of planning. They relate to:

- Precise route alignments and site layouts for individual infrastructure components;
- Project-specific traffic impact assessments, road safety evaluations and construction logistics planning;
- Detailed engineering analyses for bulk and connector services, including operational and maintenance needs;
- Project-specific housing, camp management and worker accommodation strategies;
- Detailed specialist studies and monitoring associated with environmental authorisation processes; and
- Project-specific social impact, emergency response and municipal services management plans.

The difference between these two categories is significant. This SEA does not demand that every uncertainty be fully resolved at the strategic level; however, some enabling conditions must be clarified to a sufficient degree before EIAs or infrastructure approvals can move forward. Specifically, the following issues should ideally be settled, or at least progressed to a stage where they are clearly fundable and implementable, before major development approvals are granted or peak construction periods commence:

- Identification of funded and sequenced bulk infrastructure upgrades for water, sanitation, electricity and key roads;
- Establishment of an operational planning support mechanism and associated municipal support arrangements;
- Agreement on land access and servitude protocols in affected areas, including communal land; and
- Preparation of coordinated settlement and service planning for Alexander Bay, Port Nolloth and other key affected settlements.

These knowledge gaps do not diminish the usefulness of the SEA; however, they show that the strategic acceptability of the proposed development pathways hinges on how well these issues are resolved in intergovernmental planning, funding, and regulatory processes.

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Annexure A – Settlement population projections

The following table lists all settlements in the core region along with the population projections which are based on an average annual structure-based growth rate. Projections undertaken by the CSIR do not reflect the possible effects of scenarios 1 and 2, rather they reflect a baseline with continuing growth based on historic growth rates. Population projections are provided for 2030 and up to 2050. It must however be emphasised that this assumes a settlement trend based on a historic period (2015-2022).

Between 2010 and 2020 the overall population growth averaged 1.19% per annum in the Namakwa District further confirming that this region, in general, has a low overall population and settlement growth rate (Tshani Consulting, 2023, p. 53) (COGTA, 2023, p. 43)

Information discussed in Section 6.2.2 of this report.

Table A1: Settlement growth and projected population.

	Using Residential structures to determine growth[22]			Percentage change between periods		Population Projections based on Settlement growth* rate			
LM and Settlement	**Res Units 2010**	**Res Unit 2015**	**Res Units 2022**	**Perc Change 2015-2022**	**Av Per Annum change 2015-2022 (7)**	**BASE 2022**	**2025**	**2030**	**2050**
Kamiesberg LM	**5001**	**5076**	**5438**	**7.13**	**1.02**	**14970**	**15432**	**16234**	**19883**
Garies	616	622	681	9.49	1.36	3021	3146	3365	4404
Hondeklipbaai	332	332	363	9.34	1.33	803	835	892	1163
Kamassies	109	109	109	0.00	0.00	441	442	443	448
Kamieskroon	310	336	371	10.42	1.49	1437	1502	1617	2173
Karkams	651	656	660	0.61	0.09	2044	2050	2059	2095
Kheis (NC)	216	216	216	0.00	0.00	700	700	700	700
Klipfontein	306	313	325	3.83	0.55	706	718	738	823
Koingnaas*	157	165	317	92.12	13.16	164	170	177	217
Leliefontein	321	324	331	2.16	0.31	912	921	935	994
Lepelsfontein	213	215	219	1.86	0.27	320	322	326	344
Nourivier	219	222	223	0.45	0.06	673	674	676	685
Paulshoek	145	148	152	2.70	0.39	624	631	643	695
Rooifontein (NC)	180	182	183	0.55	0.08	434	435	437	444
Soebatsfontein	103	106	125	17.92	2.56	478	515	585	970
Spoegrivier	177	178	182	2.25	0.32	755	762	774	826
Tweerivier (NC)	93	93	93	0.00	0.00	351	351	351	351
Rest of Kamiesberg	853	859	888	3.38	0.48	1107	1123	1151	1267
Khâi-Ma LM	**4294**	**4414**	**5105**	**15.65**	**2.24**	**8433**	**9011**	**10065**	**15665**
Aggeneys	**648**	**661**	**862**	30.41	4.34	1377	1564	1935	4529
Onseepkans	458	470	508	8.09	1.16	1003	1038	1100	1383
Pella (NC1)	1346	1369	1396	1.97	0.28	1382	1394	1414	1495
Pofadder	973	1025	1269	23.80	3.40	2494	2757	3258	6360
Witbank	112	112	112	0.00	0.00	118	118	118	118
Rest of Khai-Ma	757	777	958	23.29	3.33	2059	2272	2676	5150
Nama Khoi LM	**19288**	**19568**	**20650**	**5.53**	**0.79**	**67204**	**68809**	**71570**	**83767**
Bersig (SPRINGBOK)	3349	3392	3409	0.50	0.07	11440	11465	11506	11672
Bullettrap	267	268	272	1.49	0.21	580	584	590	616
Carolusberg	**400**	**404**	**419**	3.71	0.53	1398	1420	1458	1621

[22] Residential structures based on GeoTerreImage data reflecting residential structures.

	Using Residential structures to determine growth[22]			Percentage change between periods		Population Projections based on Settlement growth* rate			
LM and Settlement	**Res Units 2010**	**Res Unit 2015**	**Res Units 2022**	**Perc Change 2015-2022**	**Av Per Annum change 2015-2022 (7)**	**BASE 2022**	**2025**	**2030**	**2050**
Concordia	2222	2240	2243	0.13	0.02	6959	6962	6969	6996
Goodhouse (NC)	80	80	80	0.00	0.00	233	233	233	233
Kleinzee	432	442	552	24.89	3.56	1036	1151	1371	2757
Komaggas	1227	1239	1270	2.50	0.36	4480	4528	4610	4951
Matjieskloof (SPRINGBOK)	898	902	905	0.33	0.05	2913	2917	2924	2952
Nababeep	1675	1690	1709	1.12	0.16	6758	6790	6845	7068
Nababeep Mine	122	122	122	0.00	0.00	660	660	660	660
Nama Khoi	330	334	343	2.69	0.38	582	588	600	648
Okiep	2373	2420	2439	0.79	0.11	8577	8595	8626	8751
SPRINGBOK	734	761	1160	52.43	7.49	3601	4472	6417	27208
Steinkopf	3388	3420	3571	4.42	0.63	10953	11161	11518	13061
Vioolsdrift*	171	197	422	114.21	16.32	1026	1050	1093	1279
Rest of Nama Khoi	1620	1657	1734	4.65	0.66	6008	6128	6334	7231
Richtersveld LM	**4752**	**5048**	**5667**	**12.26**	**1.75**	**24334**	25636	27961	39572
Alexander Bay*	386	502	892	77.69	11.10	4225	4451	4854	6868
Eksteenfontein	347	351	359	2.28	0.33	957	966	982	1048
Grootderm	4	20	22	10.00	1.43	477	498	534	710
Khubus	436	450	466	3.56	0.51	1779	1806	1852	2050
Lekkersing (NC)	277	283	289	2.12	0.30	669	675	685	728
Port Nolloth	2673	2714	2821	3.94	0.56	11093	11281	11602	12982
Sanddrif	**517**	**559**	**620**	10.91	1.56	3727	3904	4218	5748
Sendelingsdrif	2	51	58	13.73	1.96	655	694	765	1128
Rest of Richtersveld	110	118	140	18.64	2.66	753	814	929	1571
Grand Total	**33391**	**34162**	**36916**	**8.06**	**1.15**	**114940**	**118958**	**125967**	**158386**

Source: Calculated by authors.

'' Winsorisation applied to extreme values – applied local municipal growth rate.*

Annexure B – Gazetted Notice for Namakwa District Municipal Planning Tribunal

PROVINSIALE KOERANT, 27 JUNIE 2016 No. 2023 17

MUNICIPAL NOTICE 31 OF 2016

READINESS OF THE JOINT DISTRICT MUNICIPAL PLANNING TRIBUNAL FOR THE NAMAKWA DISTRICT MUNICIPALITY

Notice is hereby given in terms of the Spatial Planning and Land Use Management Act, 2013 (Act 16 of 2013) that the joint District Municipal Planning Tribunal (DMPT) for the Namakwa District Municipal is ready to commence its operations.

The Namakwa District Municipality and 5 Local Municipalities of the Namakwa District have entered into an agreement to establish a DMPT in terms of Section 34 of the Act.

The following members are appointed as members of the DMPT for a period of one year from the commencement of the agreement. Municipal staff members relate to specific responsibilities at the respective municipalities, of which the post designations may change over time, as well as the incumbents.

TRIBUNAL MEMBERS		
Municipal staff – Job Title	**Position**	**Municipality represented**
Head Infrastructure Head Cooperative Service Head LED/IDP	Members	Richtersveld Municipality
Municipal Manager Head Technical Service Head Cooperative service	Members	Kamiesberg Municipality
Head IDP/LED Housing Head Technical Service Head Section Head Land use and Rental Agreement	Members	Nama Khoi Municipality
Municipal Manager Senior Administrative officer	Members	Khai Ma Municipality
Municipal Manager Senior Administrative officer	Members	Karoo Hoogland Municipality
Additional Members		
C. Geldenhuys	Professional Planner	Khara Hais Municipality
J. du Plessis	Professional Planner	Khara Hais Municipality
E. Julius	Independent Member	Deptartment Economic Development and Tourism
L. Claasen	Legal Officer	Hantam Municipality
J.T. Loubser	Professional Planner	Namakwa District Municipality

Enquiries may be directed to Mr J.T. Loubser at the Namakwa District Municipality during normal office hours by telephone at 027 7128000 or in writing at the address below, or by email at info@namakwa-dm.gov.za

Mr C.J. Fortuin
Municipal manager
Private Bag X20
SPRINGBOK
8240

Annexure C - Project priority list for Water and Sanitation to address constraints

No	Municipality	Project Details	Estimated Cost (Rm)
1.	Nama Khoi	1.1 Installation of Smart Zonal Bulk Water Meters, Pressure Management with AMR functionality.	R 60m
		1.2 Installation of Smart, AMR Pre-Paid Water Meters.	R 80m
		1.3 Upgrading of Oxidation Ponds.	R 148m
2.	Khai-Ma	2.1 Pella: Construction of Bulk Water Reticulation and smart water meters	R 30m
		2.2 Development and Rehabilitation of Wastewater Treatment Facilities	R 150m
		2.3 Construction of Sewage pipelines (reticulation) - Pofadder	R 60m
3.	Richtersveld	3.1 Port Nolloth-Alexander Bay-Lekkersing Bulk Water Supply	R 180m
		3.2 Water Treatment Facilities and Solar Conversion	R 25m
		3.3 Township establishment for 2,000 stands (Boegoe Bay Harbour Project) in Port Nolloth: Township establishment, installation of bulk and reticulation services (water, sanitation, electricity, and roads)	R 342m
4.	Kamiesberg	4.1 Installation of pre-paid water meters in Kamiesberg Municipal area	R 15m
		4.2 Construction of Kharkams Bulk Sewer	R 21m

(DBSA, 2024, p. 22)

Annexure D – Priority road projects

No	Municipality	Project Details	Estimated Cost (Rm)
1.	Nama Khoi	1.1 Springbok - Upgrading of various roads and streets	R 100m
		1.2 Springbok - Upgrading of Stormwater Facilities	R 120m
		1.3 Nababeep - Upgrading of various roads and streets	R 100m
2.	Khai-Ma	2.1 Pofadder Roads Rehabilitation	R 12m
		2.2 Pella rehabilitation (heavy-duty block paving of roads)	R 15m
3.	Richtersveld	3.1 Paving of Gravel Roads - 30km	R 210m
		3.2 Rehabilitation & Maintenance of tarred roads - 47km	R 174m
		3.3 Upgrade gravel road to paving of internal gravel roads - 100km	R 285m
4.	Kamiesberg	4.1 Paving of gravel streets in Garies	R 20m
		4.2 Paving of gravel streets in Kharkams	R 10m

(DBSA, 2024, p. 25)

Annexure E – Analysis to identify potential sites for wind and solar parks.

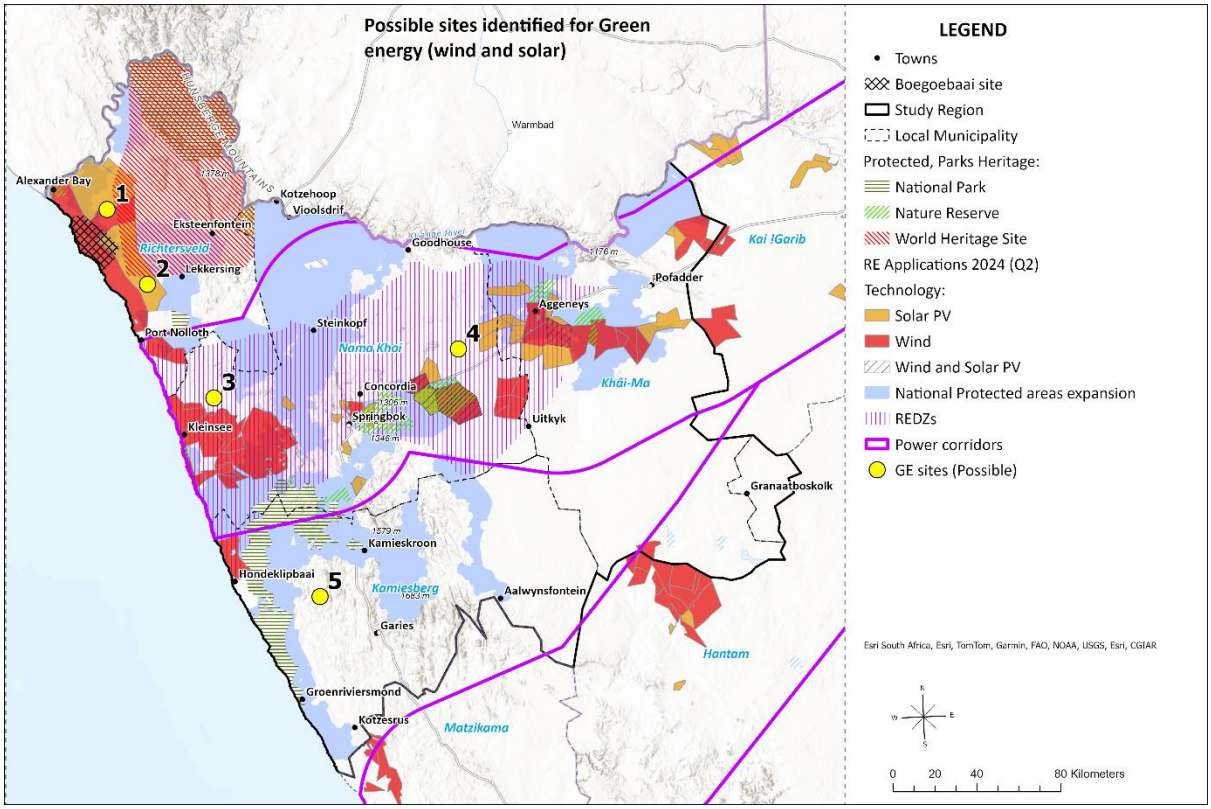

Figure F1: Sites identified for possible green energy developments

Source: (Snyman van der Walt, 2023)

Five sites have been identified through combined geospatial analysis including REIPPP projects, exclusionary factors such as nature reserves, national parks, work heritage area and national protected areas expansion. REDZ and power corridors are also featured. Five sites have been identified with potential for both wind and solar energy generation plants:

1. East of Boegoebaai
2. Between Port Nolloth and Boegoebaai
3. West of Springbok
4. North-East of Springbok
5. North-west of Garies

Annexure F – Services needed to construct the solar energy project.

Below is a list of descriptions for the types of services needed to construct the solar energy project (Soul City Solar, 2024).

MAJOR CONTRACTORS

- **Engineering, Procurement, and Construction (EPC) Contractor** (Like a General Contractor) – Leads the project, safety, and schedule. Manages all subcontractors.
- **Civil/Site Contractor** – Responsible for building roads and grading around module installation.
- **Mechanical / Structural Contractor** – Responsible for driving steel pile foundations, installing tracker/racking system, and installing modules.
- **Electrical Contractor(s)** – Responsible for building the substation, transmission line, underground collection lines between inverter skids, and wiring of the modules.
- **Substation Contractor –** Responsible for the design and construction of the substation including sitework, grading, foundation, and high voltage equipment install.
- **MAJOR Original Equipment Manufacturers (OEM)**
- **Module Supplier** – Responsible for providing site PV modules and coordinating delivery logistics.
- **Tracker / Racking Supplier** – Responsible for providing project tracker / racking system and commissioning motors and moving parts.
- **Inverter Supplier –** Responsible for providing the project inverter skids and start-up of inverters during commissioning.
- **Main Power Transformer Supplier** – Responsible for providing the project MPT(s), dress out, and start-up of MPT(s).

JOBS

Laborers

- Skilled – Skilled labour refers to labour that requires workers who have specialized training or a learned skill-set to perform the work. Activities include fencing, Stormwater Pollution Prevention Plans (SWPPP) installation and maintenance, drain tile repairs, grass and pollinator seeding, vegetative screening, and site security.
- Unskilled – Unskilled labour does not require workers to have special training or skills. Activities include waste management, portable restroom maintenance, and traffic control/flagging.

Civil

- Carpenters – Concrete form work, stairs, decking (for office trailers).
- Surveyors – Site grading and pile layout
- Concrete Finishers – Substation foundation finishing work

- Rod Busters – Tie rebar for substation foundation pours.

- Equipment Operators – Pile drivers, track hoes, bull dozers, motor graders/scrapers, back hoes, track/rubber tire loaders, skid steers, etc.

Mechanical

- Tracker Installer – Assemble and install trackers and racking system based on OEM provided manuals and specs.

- Module Installer – Offload and install PV modules

- Riggers – Align, level, and anchor machinery. Attach loads to rigging to provide support or prepare them for moving, using hand and power tools. Attach pulleys and blocks to fixed overhead structures such as beams, ceilings, and gin pole booms, using bolts and clamps.

Electricians – Read blueprints or technical diagrams. Install and maintain wiring, control, and lighting systems. Inspect electrical components, such as transformers and circuit breakers. Identify electrical problems with a variety of testing devices.

Project Manager – To plan, budget, oversee, and document all aspects of the specific project.

Superintendent – Trade specific – shall be responsible for scheduling, inspections, quality control, and job site safety.

On-Site QA/QC Managers – Inspect, test, and sample materials or assembled parts or products for defects and deviations from specifications.

- Electrical QA/QC Inspectors

- Multi-disciplined QA/QC inspectors

Site Safety Personnel – Ensures that construction workers are following established policies and safety regulations.

Site Project Scheduler – Organize, implement, and maintain scheduling management system supporting identified projects and their plans. Assist to set up tasks and sub-tasks to ensure satisfactory realization of project contract requirements as scheduled.

Craftworkers – On-site creation or reproduction of objects using a variety of techniques.

Post Construction – Operational and Maintenance Jobs

- Facilities Manager – Oversee the daily operations of solar farms. Responsible for ensuring staff are maintaining and operating the equipment and that the solar farm is producing energy as expected.
- Assistant Facilities Manger – Provide technical and sub-contractor support to the Facility Manager for the operations and maintenance of a solar farm. This includes managing the facility's sub-contractors, site maintenance and operation, training, equipment testing, and responding to emergencies.
- Inverter Technician – Responds to inverter faults and outages, supports facility team in maintaining the solar farm operations.
- Remote Operating Control Centre – Monitors and helps control the operation of the solar facility.

MINORITY CONTRACTORS AND MATERIALS SERVICES

- Surveying – As-builts, ALTA survey, road and steel pile layout
- Sanitary Facilities – Port-O-Potty, temporary trailer hook-up
- Road aggregate
- Utility fibre optic cables – Provides internet access for facility
- Trucking – Stone hauling, equipment hauling
- Pipe – PVC, steel, drain tile repair, irrigation repair
- Fuel – Off/On road diesel, gasoline
- Concrete – Off-Site
- Cement stabilization
- Water
- Ice
- Office trailers
- Office supplies
- Electrical service
- Phone/Internet service
- Paving
- Construction material testing
- Engineering services
- Drilling contractors – Substation piers
- Boring contractor – Road and pipe bores
- Dewatering
- Equipment rentals – Lights, generators, tools, equipment
- Trenching

Annexure G – Typical Activities in Powerline Construction

- Erection of camp sites for the Contractor's workforce.
- Servitude gate installation to facilitate access to the servitude.
- Vegetation clearing to facilitate access, construction and the safe operation of the line.
- Establishing of access roads on the servitude where required
- Pegging of tower positions for construction
- Transportation of equipment, materials and personnel to site and stores.
- Installation of foundations for the towers.
- Tower assembly and erection.
- Conductor stringing and regulation.
- Transfer of the line from the Contractor for commissioning.
- Final inspection of the line, commissioning and transfer to the Grid Line and Servitude Manager for operation.
- Rehabilitation of disturbed areas.
- Signing off of all Landowners upon completion of the construction and rehabilitation.
- Transfer of the servitude by the Grid Environmental Manager.
- Operation and maintenance of the line.

CHAPTER 7

Social and Economic Impacts

CHAPTER 7:
Social and Economic Impacts

Integrating Authors:	Prof Doreen Atkinson (Team leader, macro-economics)[1], Hannes Gerber (Agriculture)[2], Prof Andrea Saayman (Tourism)[3], Prof Elmarie Slabbert (Tourism)[3], Dr Stephanie Borchardt (Institutional)[4], Prof Johann Kirsten (Agriculture)[5]

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1 Image: https://pulitzercenter.org/stories/northern-cape-south-africas-emerging-powerhouse

Executive Summary

Overview and study design

1. This chapter is a high-level overview of the likely impacts of the proposed Port, GH2 project and the SEZ. It is not based on original empirical work or community consultation. Instead, it relies on secondary sources, drawn from South Africa and internationally. The chapter will enable top-level decision-makers to understand overarching risks, benefits and possible lines of future enquiry. The SEA process precedes policy decision-making, inputs by interested and affected parties (I&APs), as well as Environmental Impact Studies (EIAs).

2. The study includes three distinct layers of complexity: (a) the Port, the GH2 project and the SEZ; (b) the time period, up to 25 years; and (c) the types of impacts, ranging from *direct* to *indirect* and *interventionist* (corporate social responsibility).

3. For this chapter of the SEA, the goals are:
   (a) *Assess the social sensitivity of local and regional receiving environments*: This is done in terms of the tourism (the most significant growth sector of the region), agriculture and mining sectors, as well as institutions and social cohesion.
   (b) *Classify spatial regions, based on multiple criteria, as being more, or less, suitable for future development*: The study focuses on the Richtersveld jurisdiction (Port Nolloth), Nama Khoi (Springbok), Khai-Ma (Pofadder) and Kamiesberg (Garies), in that order of priority. Richtersveld will host the actual projects, and will be most affected; Springbok will become a key economic hub in the region; Pofadder will be the key town on the SEZ corridor; and Garies (and surrounding towns) are likely to become the main tourist hubs. In all these cases, there will be pressures on transport routes, used by project-based trucks, local residents and tourists; in Richtersveld itself, urban development and housing provision will be crucial, and several infrastructural designs will need to take cognizance of those imperatives.
   (c) *Identify strategic-level constraints, opportunities, cumulative impacts, and strategic management actions*: These will be related to spatial planning, institutional support for municipalities, Corporate Social Investment (CSI) activities, and significantly, public engagement systems.
   (d) *Provide an integrated decision-making framework and suite of tools, to guide project developers, practitioners, and policymakers*: We provide three consultative approaches (PDIA or Problem-driven Iterative Adaptation; FPIC, or Free, Prior and Informed Consent; and a "Green Hydrogen toolbox") which have been developed in other localities and sectors.

4. *The likely macro-economic implications of the Port*
   - Regional impacts: Economic agglomeration near Boegoebaai, as well as along the SEZ Corridor
   - Property values along the coast are likely to increase.
   - Job creation: The lower skills-level jobs can become immediately available to residents of Namaqualand. In the longer-term, training opportunities can be provided to enable career pathing. Skilled Namaqualanders living elsewhere in the country may well return to take up jobs at Boegoebaai. Transport-related jobs will also be created. These jobs are likely to be much better paid than current Namaqualand wage levels, which would therefore stimulate multiplier effects in other sectors.
   - The Transnet CSI programme will encompass numerous sectors, including education, training, enterprise development, and social projects.
   - Business services and multipliers: This will take the form of *direct effects* (e.g. job creation, production, business and household income associated with the operations of the port itself); *indirect effects* (the stimulation of new suppliers of goods and services); and *induced economic*

effects (spending on other sectors as a result of the change in payroll of both directly and indirectly affected businesses). Numerous multiplier causal effects will be set in motion.

- Transport mix: The Port business case envisages a small amount of agriculture and general cargo to be shipped in the early years of the port, and to be phased out later, so that the port becomes a dedicated ore, GH2 and diesel facility. However, in the light of the importance of the port for nearby intensive agricultural projects, as well as a growing number of general industrial and commercial firms that may develop as a result of the Boegoebaai projects, we argue this plan should be reconsidered.
- There are likely to be "boom" impacts, particularly during construction; such impacts can be positive or negative for social and human development indicators. Unlike the closure of mines, there are unlikely to be such drastic "bust" consequences, as construction processes are likely to be lengthy and sustained over time. It is also possible that assertive upskilling efforts can enable construction workers to join the projects as permanent employees.

5. *The likely macro-economic impacts of the Green Hydrogen (GH2) project*
   - Local communities can benefit from grid-related renewable energy at Boegoebaai. Remote communities can benefit from green hydrogen cells as backups to local solar energy plants, which will be much cheaper than extensions to the electricity grid.
   - The GH2 investment may encourage subsidiary industries to relocate themselves near Boegoebaai, thereby promoting investment multipliers in the Namaqualand region.
   - The GH2 project will require a large investment in technical training at school and post-school level in the Namaqualand area, including expanding training at the Springbok TVET college. The training of artisans must be fast-tracked.
   - Local enterprise development can include measures to implement local preferential procurement, where possible; attracting enterprises to Namaqualand; stimulating the creation of new enterprises; and incubating enterprises with specialised skills.
   - The local production of GH2 and ammonia could stimulate local green fertilizer production which can be beneficial for decarbonising intensive agricultural enterprises in the region.
   - Desalination plants for GH2 production can be expanded to provide water for small remote communities near the coastline. New technology has been developed for undersea desalination plants, with greatly reduced energy consumption.
   - Disaster management skills will need to be upscaled significantly in the area, in partnership with Richtersveld LM and Namakwa DM. Additional heavy truck traffic on the roads will also require more intensive disaster management capabilities, including dealing with hazmat situations.
   - Regional partnerships with Government, the private sector, technical institutions and civil society will be required to address regulatory hurdles and promote investment solutions.
   - Procedural justice and "Future proofing" are key principles to ensure that due process and legal requirements are followed, and that any energy stakeholder, when making decisions, will rely on existing best practice in the relevant field.
   - A proactive approach of introducing GH2 to surrounding communities needs to be undertaken.
   - Community engagements must be an ongoing process, and municipalities must be supported to appoint technical staff who can manage local economic development, spatial planning and infrastructural development.

6. *The likely macro-economic impacts of the SEZ:*
   - The Namakwa SEZ, along the N14 corridor, will connect mining hubs like Aggeneys, Sishen and Postmasburg with the proposed Boegoebaai Deep-sea Port. The SEZ is based on the concept of agglomeration economies, i.e. firm-level cost-savings and productivity gains from the spatial concentration of firms and people in economic clusters or cities.
   - This requires the creation of robust regional institutional networks to co-ordinate the activities of the SEZ.
   - The potential negative impacts of ore trucking on the road system, as well as traffic and intensive road-side services, make an imperative case for building a rail network for ore transport, from the

beginning of the project. The revival of Transnet, combined with strong private interest in running rolling stock, should make a business case for a possible **privately owned railway line from Postmasburg to Boegoebaai**. This can transport **copper and zinc** as well. Given that the life span of the manganese mines in the Kalahari is estimated to be over 100 years, this would be a sensible investment. The demand for copper is estimated to increase dramatically in future, due to the growing AI sector.

Social impacts

7. The dynamics of diamond mine closures in the Richtersveld and Kleinzee have created a legacy of unemployment, town deterioration, municipal management challenges, and illegal mining, which will need to be addressed in any future developments.

8. There is a high level of out-migration of young working people, to seek better opportunities in the cities. They may return to Namaqualand if there are new job opportunities.

9. The "boomtown" effect of rapid construction at Boegoebaai may trigger rapid in-migration, which may trigger conflicts with local people, social dysfunctions (e.g. teenage pregnancies) and crime. Timeous interventions can support community solidarity.

10. Health services will be important for a larger population, as well as accidents on the Boegoebaai projects. The decline in HIV/AIDS services, with the closure of the US-funded PEPFAR programme, will lead to increasing AIDS-related treatment requirements. This is an important option for CSI programmes to help to "close the gap" on HIV testing.

Poverty and incomes

11. The new projects at Boegoebaai will cause food and housing prices to increase significantly, and this may place added pressure on poor families. Levels of inequality will increase, between those local people who benefit from these projects, and those who do not get access to jobs, which may lead to new social cleavages and resentment.

12. Richtersveld has a housing backlog of about 160 units, and there is no public money earmarked for housing in Richtersveld at present; the main infrastructure spending priority is water provision, which is extremely challenging in that arid area. Where water is pumped from the Orange River, it is expensive to operate and maintain, placing more pressure on the municipal fiscus.

Tourism

13. The Namakwa District in the Northern Cape includes at least five well-known tourist towns: Springbok, Port Nolloth, Garies, Kamieskroon and Hondeklipbaai. The Northern Cape Provincial Spatial Development Framework refers to the Namaqualand area as the "Ocean, Desert and Flower Cluster". Adventure tourism and agri-tourism and biodiversity form the backbone of Namaqualandland's tourism offerings, and new areas have been identified for protected area status. Several cultural history themes are becoming prominent, including indigenous culture, the Christian missions, museums, the mining history (diamonds and copper), the Okiep-Port Nolloth railway line, shipwrecks, and the Anglo-Boer War. The towns offer a variety of accommodation options, which is a good basis for future development. As recognised in several official strategies, tourism must be promoted as an important sector of Namaqualand's economy. This includes branding, marketing, and tourism training for service providers.

14. Ore trucking is likely to have a major negative impact on tourism, due to heavy and noisy traffic, road safety, air pollution, ore dust, road maintenance delays, intensive road-side services (such as petrol stations and truck stops) that destroy the ambience of the region, and an influx of trucking staff. A railway line for ore trucking will be imperative, to prevent the destruction of decades of investment in tourism, nature conservation and heritage.

15. The Boegoebaai harbour and industrial site can become a tourist destination in its own right, particularly focusing on green energy and shipping displays.

16. Richtersveld is known for its National Park, as well as the World Heritage Site. This celebrates the indigenous Nama culture, as well as the remarkable biodiversity and geology of the lower Orange River area. The Richtersveld CPA is a stakeholder on the communal land, and needs to be consulted on future tourism developments.

17. The Boegoebaai Port and Green Hydrogen may undermine the leisured, rustic, remote atmosphere of Namaqualand. Accommodation and cuisine facilities may be overwhelmed by project staff members. Traffic volumes (particularly ore trucks), crime and lawlessness may detract from the environment of Richtersveld and the highways leading to the Port. Road maintenance and a bypass around Port Nolloth will assist in managing these problems.

18. To prevent encroachment on tourist towns, spatial planning and housing for the Boegoebaai projects should be directed at special-purpose accommodation for employees. Some facilities could be re-purposed for tourism at a later stage. Where possible, guest houses should not be used for project accommodation, as it would squeeze out tourists. Industrial development must be planned away from tourist corridors. Tourist transport may be directed away from the main trucking routes, possibly via Garies and Kamieskroon to the coast, and then northwards to Port Nolloth.

19. The Springbok airport should be upgraded to accommodate scheduled commercial flights, which in turn will enable car rental companies to invest in Springbok. This will benefit employees of the Boegoebaai projects, the SEZ companies, as well as tourists, business people, and medical services.

Agriculture

20. Agriculture in Namaqualand is highly constrained, due to the arid climate and the salinity of the soil. Nevertheless, farming remains close to the heart of many families in the district, for reasons of economic survival, as well as culture, heritage and lifestyle. Agriculture in this region has developed into two distinct sectors: Large-scale, well-capitalised commercial farmers, and small-scale, partially subsistence farmers.

21. The land restitution claim launched by the Richtersveld community was successfully concluded in a landmark court case in 2007, which recognised indigenous communities' rights to ancestral land. The Port has identified CSI opportunities to support agriculture in the district, including infrastructure, marketing, training, smart climate investments, and research stations. The Department of Agriculture envisages an Agri-park at Springbok, and six Farmer Support units in the vicinity. There needs to be ongoing discussions between the Port and agricultural agencies to dovetail their initiatives.

22. The Boegoebaai projects are unlikely to stimulate markets to promote livestock production, because of the dominance of the big retail chains in distribution networks.

23. Large-scale irrigation projects along the Orange River promote economic diversification in the region. Most of this product is exported, making the Boegoebaai Port a very attractive asset. In Richtersveld, 408 ha are under intensive cultivation. These projects are a major source of employment in the district.

24. Farmers in the district will benefit from improved telecommunications and renewable energy (solar, wind and green hydrogen).

25. Farmers will benefit from improved roads – if the roads are maintained well and enlarged sufficiently to accommodate the expected flow of construction trucking. This will enhance local economic development.

26. It is imperative that ore transport is done by railway line, to protect the damage of dust pollution in agriculture and tourism. The European Union's Carbon Border Adjustment Mechanism (CBAM) involves the imposition of a carbon tariff on imported goods, based on the level of embedded emissions in the goods and the carbon price paid by the manufacturers thereof in the country of origin.

27. For irrigation farmers, possible ore dust at the Boegoebaai Port will be a major problem, which would affect the quality of their exports. This will require remedial action to improve trucking and handling systems.

28. Green hydrogen should be marketed to farmers in the district as part of an innovation system of technology use, marketing and distribution.

Mining

29. The Vedanta Zinc mine and its processing facilities near Aggeneys will be a major spur to the regional economy.

30. Copper prices are likely to trend upwards, driven by the demand for copper in green energy projects and in the AI industry. The Transnet SEB study envisages that copper exports will be phased out from Boegoebaai Port, which seems counter-intuitive. A proper study of the copper sector potential should be undertaken. The international literature suggests increasing demand and prices, driven (inter alia) by renewable energy investments. The Boegoebaai port could increase the sustainability of copper exports.

Institutional, political and municipal issues

31. The proposed new multi-faceted project at Boegoebaai will rely heavily on a range of organisational capabilities on the part of municipalities.

32. The new District Development Model (DDM) places District Municipalities as the strategic point of focus in the intergovernmental system, by compiling and guiding the implementation of "One Plans" for their jurisdictions. They must also liaise between local municipalities and provincial or national departments. They should provide advisory and technical services such as infrastructure development, environmental health and district-wide planning.

33. In Nama Khoi (Springbok), two opposition parties, the DA and the Namakwa Civic Movement (NCM) govern in a coalition, which may set a trend for other municipalities in the region. Municipal governance has improved significantly in Nama Khoi LM. Namakwa DM appears to be well-managed. There are significant municipal services and financial problems in other municipalities, particularly regarding water quality and quantity.

34. Nama Khoi LM has a robust public participation approach, using several channels of communication. The other municipalities tend to have difficulties in promoting ward committee functioning.

35. The Boegoebaai projects and the added pressures on road trucking transport will require significant upscaling of disaster management capabilities in Richtersveld, Nama Khoi and Khai-Ma municipalities.

36. Municipal debt and financial shortages are problematic in Richtersveld LM. The municipality's financial system, including revenue flows, will need to be overhauled to improve its cash flow. The Richtersveld municipality's audit findings have highlighted concerns regarding unauthorised, irregular, and fruitless expenditure, which reflects poor governance and compliance with financial regulations.

37. In future planning processes, the diversity of sectors will require new forms of intergovernmental collaboration (national, provincial and municipal), as well as participation of key stakeholders on such

intergovernmental forums. This practice of Collaborative Government can be adapted from international experience.

Public engagement on the Boegoebaai projects

38. There are already concerns that the public engagement process concerning the Port and the GH2 projects have not been effective. This growing controversy highlights the importance of thorough community engagement.

39. The report proposes mechanisms such as the "Green Hydrogen Community Engagement Toolkit" and the "Problem-driven Iterative Process" (PDIA) to set the stage for open-ended and mutually-exploratory discussions. The Richtersveld Community Property Association (CPA) will be an indispensable negotiating partner and possibly an implementation partner as well.

40. A pre-negotiation scoping should be undertaken by a reputable facilitator, to assess the ways in which each party to the discussions will be able to participate.

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CHAPTER 7. SOCIAL AND ECONOMIC IMPACTS

7.1 THE IMPORTANCE OF THE BOEGOEBAAI PORT AND GREEN HYDROGEN COMPLEX

This chapter considers the potential social and economic benefits and risks of one of the largest public-private investments ever proposed for the Northern Cape. The Namakwa District Municipality is poised to play a key role in the country's transition to renewable energy, particularly in the development of green hydrogen. This section examines possible benefits, and the associated risks, particularly in relation to economic sectors, social cohesion, land use, economic inequality, infrastructure, migration, and institutional factors, and provides an overview of the social and environmental impacts that could result from large-scale green hydrogen projects in the region.

There are social, institutional and economic risks associated with these projects, but with adequate effort and collaborative action, many of the potential risks can be overcome, with the requisite research skills and robust institutions.

In this chapter, the term "Namakwa" refers to the Namakwa District Municipality, a political jurisdiction. Interestingly, Namakwa DM includes areas such as Pofadder and Aggeneys, which are actually within the historical "Bushmanland" area to the east of Namaqualand, as typically understood. In this chapter, the term "Namaqualand" refers to a broader historical region, which may include areas in the Western Cape. "Namaqualand" was never clearly defined in the past; it generally refers to the arid western areas, where deserts and spring-time indigenous flowers can be found, and where the Nama people originated historically.

Since the demarcation of municipalities in 1996, statistics are provided on the basis of municipalities, and hence this would be the Namakwa District Municipality, and not Namaqualand as a cultural or ecological region.

7.2 APPROACH TO THE STUDY

This chapter is a high-level overview of the likely impacts of the proposed Port, GH2 project and the SEZ. It is not based on original empirical work or community consultation. Instead, it relies on secondary sources, drawn from South Africa and internationally. The chapter will enable top-level decision-makers to understand overarching risks, benefits and possible lines of future enquiry. The SEA process precedes policy decision-making, inputs by interested and affected parties (EAPs), as well as Environmental Impact Studies (EIAs).

This chapter is intrinsically complex, for three main reasons:

- It combines **three different types of investment**: (a) A harbour, (b) a Green Hydrogen production facility, also associated with Wind and Solar energy generation, and (c) the Strategic Economic Zone (SEZ), which is anchored in the zinc mine near Aggeneys and the transport corridor to Boegoebaai.

- The **time period** covers at least 25 years, with three distinct phases: (a) Construction, (b) early operations of the Port and the GH2 project (both relatively small), and (c) later operations of these projects (at maximum scale). In the case of Green Hydrogen, it is not clear at this stage whether the small-scale level of operations continue into the long-term, or whether it will scale up to a maximum-level.

- There are **three distinct types of impacts** on the economic and social landscape of the receiving environment: (a) Direct impacts, caused by the direct construction and operations activities; including positive impacts, such as economic multipliers, and potentially negative impacts; (b) Indirect impacts, where chains of causality are longer and more complex; and (c) Interventionist impacts, such as Corporate Social Investment (CSI).

This therefore creates a Rubik's cube of potential impacts

There will be a myriad types of interactions, including a whole range of positive or negative unintended or unanticipated consequences. This chapter therefore offers fairly abstract or stylized factors which may function as the main channels of causality, but likely to have many subsidiary spin-offs.

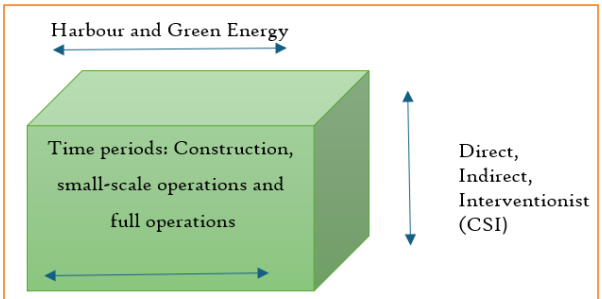

Figure 1: Three-dimensional causal chains

For this chapter, the goals are:

(a) *Assess the social sensitivity of local and regional receiving environments:* This is done in terms of the tourism (the most significant growth sector of the region), agriculture and mining sectors, as well as social development and cohesion.

(b) *Classify spatial regions, based on multiple criteria, as being more, or less, suitable for future development:* The study focuses on the Richtersveld jurisdiction, the Nama Khoi jurisdiction, the Khai-Ma jurisdiction, and the Kamiesberg jurisdiction, in that order of priority. Richtersveld will host the actual projects, and will be most affected; Springbok will become a key economic hub in the region; Pofadder will be the key town on the SEZ corridor; and Garies (and surrounding towns) are likely to become the main tourist hubs. In all these cases, there will be pressures on transport routes, used by project-based trucks, local residents and tourists; in Richtersveld itself, urban development and housing provision will be crucial, and several infrastructural designs will need to take cognizance of those imperatives.

(c) *Identify strategic-level constraints, opportunities, cumulative impacts, and strategic management actions:* These will be related to spatial planning, institutional support for municipalities, CSI activities, and significantly, public engagement systems.

(d) Provide an integrated decision-making framework and suite of tools, to guide project developers, practitioners, and policymakers: We provide three consultative approaches (PDIA or Problem-driven Iterative Adaptation; FPIC, or Free, Prior and Informed Consent; and a "Green Hydrogen toolbox") which have been developed in other localities and sectors.

The financial sustainability of the GH2 project and Port are not addressed directly in this chapter, as they depend on numerous unknowns at this stage. The financial viability of the projets will be determined by investors. If the market conditions are not positive, then investment simply won't happen. However, there are two limits to this argument. Firstly, if the projects have a borderline level of profitability, the aspirant investors may be unwilling to spend significant amounts of money on corporate social responsibility, local empowerment, and training. National government may then decide not to proceed with the projects, since they would have insufficient benefits for the local and regional communities. Secondly, if the project started out as profitable, and then market conditions changed rapidly and unexpectedly, and the projects were to grind to a halt, then significant numbers of people would be left stranded in the Namakwa area. It will be up to National Government policy makers (e.g. DTI, Treasury, Energy) to determine the financial robustness of different bidders' proposals. The National Government will need to determine its own risk appetite on this far-reaching project. It should be remembered that, if the projects fail the test of time, and cease operations, that all three spheres of government will need to contribute to the costs of local upheaval, uncertainty and losses.[2]

[2] This point was include as a response to peer reviewers.

7.3 THE LIKELY IMPACTS OF PORT AND GREEN HYDROGEN PROJECTS

The latter sections of the report will focus on generic themes (economic sectors, social cohesion and institutional design). This section will focus on the proposed Port, GH2 and SEZ initiatives, based on the literature that was developed specifically for these types of investments. Many of the observations in this section will be echoed in the later sections, when a broader context of the "receiving environment" is provided.

The proposed Port and GH2 projects at Boegoebaai fit into at least seven of the Strategic Infrastructure Projects (SIPs), as identified in the *National Infrastructure Plan 2050* (adjusted in 2022):[3]

- SIP 5: Saldanha-Northern Cape development corridor: Integrated rail and port expansion, Back-of-Port industrial capacity (including an IDZ), Strengthening maritime support capacity for oil and gas along the African west coast; expansion of iron ore mining production and beneficiation.
- SIP 8: Support green energy initiatives
- Sip 10: Electricity transmission and distribution; provide access to electricity for all, and support economic development.
- SIP 15: Expanding access to communication technology, extend fibre networks, promote e-government, school and health connectivity
- SIP 17: Regional integration and African co-operation, such as Vioolsdrift Dam on the Orange River, to supply water to the district
- SIP 21: Transport: Road upgrading, small harbours development, Boegoebaai Port and Rail Infrastructure Project. Boegoebaai and the maritime economy is also mentioned in the Industrial Policy Action Plan (IPAP, 2019-2021).

Advanced manufacturing, Green Industries, Rail Transport, and Boatbuilding are also mentioned in the Integrated National Export Strategy (INES) 2030.[4] The proposed Boegoebaai projects are therefore embedded in several top-level Government planning scenarios. This is simultaneously a good thing, as it may then muster the financial and regulatory support required to make a success of it; but it is potentially also a bad thing, as it seems to present local communities with a *fait accompli*, which is difficult to challenge, and which may lead to resistance and resentment. The final section of our report makes proposals for managing this conundrum.

7.3.1 The Port

The Boegoebaai port will be aimed at imports and exports (not passenger traffic), with dry and liquid bulk berths, and multi-purpose terminals. It is unlikely to develop into a "port city" in any real sense of the word, as its main purpose will remain transport (and not broader manufacturing or commerce). It is likely to remain a dedicated bulk transit facility, although complemented by the Green Hydrogen production complex.[5]

Ports typically stimulate regional socio-economic development, which is therefore a key motivator of the Northern Cape's business case for Boegoebaai harbour.[6] This includes creating employment opportunities for people in the Richtersveld jurisdiction, the Namaqualand region, and the province at large. Local economic development can be promoted in strategic towns such as Alexander Bay, which is currently on the verge of closing down completely. The Port will stimulate markets, suppliers, SOEs, and business-related service providers. It will also build skills in the Northern Cape.

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3 Richtersveld LM, *Spatial Development Framework*, 2024, p. 36.
4 Richtersveld LM, *Spatial Development Framework*, 2024, p. 38.
5 However, nothing is cast in stone; in thirty years' time, the local multipliers and technical innovations may indeed lead to the creation of a "port city".
6 Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 30.

7.3.1.1 Regional impacts

The primary purpose of the Boegoebaai Port is a "Pit-to-Port" supply chain project, for export of inland resources and import of a single commodity (diesel). This is an example of the recent rise of seaport terminals that primarily act as transshipment hubs in extensive maritime hub-and-spoke and collection and distribution networks. Increased cargo availability has triggered changes in vessel size and the structure of liner shipping. The new types of port terminals serve large areas or subcontinents, and for trans-shipping at the crossing points of trade lanes. Many of these ports specialise in one function.[7]

Regional impacts of Ports will be felt at the locality level as well as other localities situated further afield. Near the port itself, firms may locate close to the port because they want to benefit from relatively low transportation costs for bulk commodities close to the port. Other firms may consider the agglomeration of firms supplying goods and services to the port as beneficial for their activities, and may therefore locate close to the port. Such agglomeration trends may attract even further rounds of business investment.[8]

Over time, a much larger "region" of influence will develop, with the port and the main product sending areas (Aggeneys, Kathu, Kuruman, Postmasburg) as the extreme poles. Each of these poles are likely to experience additional investments, as the port's beneficial impacts become felt. The delivery routes (train or truck) slowly build points of additional economic concentration along these routes.[9] This creates new forces promoting regionalization, beyond a focus on the port itself, favouring the emergence of transport corridors and logistics ports. This trend will be strongly emphasised by the SEZ at Aggeneys, situated on or near the main transport routes which link the ore fields with the Boegoebaai port.

The lifetime of the mines in Postmasburg and Kalahari appear to be about 30 years, which could be affected in future by market forces. This could impact the long-term viability of the Port.

7.3.1.2 Land ownership and land value

The land earmarked for the Boegoebaai Harbour is owned by the Richtersveld Sida !Hub Communal Property Association (CPA), following a successful land claim. The land is currently used by Alexkor for diamond exploration, in a pooling and sharing joint venture (PSJV) with the Richtersveld Mining Company.

Many ports are constrained by the lack of available land for expansion.[10] The Boegoebaai port will have the advantage of a large area of usable land. The Port will be constructed on undeveloped arid land with a low commercial value, and with little development in the near vicinity. However, this land is owned by the Richtersveld CPA, which will require careful negotiations to the satisfaction of all parties.

The port will increase land values, especially due to subsidiary commercial and industrial developments. The project will thus increase land value prices in the region, such as the surrounding towns of Alexander Bay, Port Nolloth and Springbok.[11] However, increased land prices are always a mixed blessing. While it adds capital value to existing owners, and suggests that investment is taking place for productive purposes, it can also displace local people by pushing land prices beyond their means.

7.3.1.3 Business services and multipliers

The Port will essentially stimulate the transport sector. However, it can also act as a "growth pole" for other industries, such as manufacturing, transport, and logistics.[12] This will indeed be the case if the Boegoebaai port enables the sustainability of the GH2 enterprise.

The Port will have three types of economic impacts:

7 Notteboom and Rodrigue, 2005, Port Regionalisation.
8 Kaufman, *Impact of Ports,* p. 9.
9 Notteboom and Rodrigue, Port Regionalisation (2005).
10 Notteboom and Rodrigue, Port Regionalisation, *Source? ,* p. 3.
11 Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 209.
12 Benacchio and Musso, Ports and Economic impact: *Transporti Europei*, 2001, p. 33.

- **Direct effects**: An increase in job creation, GDP, production, business sales and household income associated with the operations of the port itself;

- **Indirect effects:** Suppliers of goods and services to the new port experience a larger demand, and can expand; this promotes job creation, GDP and household income; and

- **Induced economic effects:** Shifts in spending on food, clothing, housing and other consumer goods and services due to wages in both directly and indirectly affected businesses. This leads to further business growth throughout the economy.

These economic impacts may have complex and possibly destabilising impacts on local communities. Furthermore, the Northern Cape economy is underdeveloped, and impacts in such a context may well be weaker than in a more developed economy. Where services and goods are not available locally, they would have to be shipped in; and there may be barriers to local businesses and workers finding niches in the new Port economy. It is difficult to find studies of similar cases internationally. As a general rule of thumb, the Port authorities should be maximally aware and willing to take innovative steps to bring local economic actors on board.

A large array of specialised categories of service providers will need to service the port, ranging from direct port operators and service activities for shipping agencies to services catering for the needs of crews, government activities in relation to the port, and construction activities. Port operations include freight management (including container repair, freight planning, and cleaning services); freight owners (for mineral and agricultural exporters); transport service providers (mainly by road); and terminal facilities.[13] The agglomeration effects mentioned earlier will stimulate even more diverse business operations.

These chains of business volume increases are called multiplier effects. Multipliers can be triggered by the expenditure of wages, or by port-related businesses, or by the re-spending of tax-payments by various government agencies.[14] The economic effects created by the core function of the port will stimulate *Backward Linkages* (port agencies use goods and services from subcontractors who need other subcontractors). The ratio between backward linkages and the original direct effects is called the "*backward multiplier*". In contrast, the *Forward Linkages* are activities stimulated by the presence of the port. They benefit by having an export facility, e.g. nearby agricultural enterprises, or manufacturers who want to export their goods through the port. The port may also stimulate port tourism and other non-marine economic development, such as real estate agencies. This can provide a significant link with enterprises within the local community.

There is possibly a danger of overstating multiplier effects related to the Port. The Port will not be a "port city", in the classical sense. It will be a dedicated transport facility (combined with GH2 industries), with little chance of becoming a diversified port city. As ports go, it will be largely capital-intensive, focused on the export and import of bulk consumer goods. Given the very low level of development of the Richtersveld and Namaqualand regions, and the highly specific nature of the port itself, the multiplier effects are likely to be much more muted than in a more diverse area such as a typical coastal city. Furthermore, the place of origin of the exported commodities is located far away (the manganese and iron ore fields), which will bring many of the benefits of cost-effective exports to those enterprises and communities.[15]

Nonetheless, over time, the benefits of forward and backward linkages may well bring a trend towards agglomeration at Boegoebaai, which will diversify the business services at the site. This is such a novel project that the agglomeration, multiplier and diversification impacts are actually difficult to tell. Government support programmes can improve the prospects of subsidiary businesses. Probably the single greatest causal factor will be the Port's operators' decision regarding the diversity of products to be handled by the Port, as explained in the following section.

[13] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 42.
[14] Kaufman, *Impact of Ports,* p. 10.
[15] Benacchio, and Musso, Ports and Economic impact, *Transporti Europei*, 2001.

7.3.1.4 Employment

A large share of the jobs, particularly during the Construction phase, will be unskilled and semi-skilled work, ranging from breakwaters, dredging, roads, and rail infrastructure, which are all labour-intensive.

The construction of the port itself is estimated to create a large number of indirect and induced jobs, in addition to the direct jobs that will be created. The port construction can proceed rapidly, unlike the Green Hydrogen industry which will require a great deal of new technology. In the table below, about 7 190 direct jobs will be created in a five-year period (2026-2031). It will stimulate the local, regional and national economy by creating 4 400 indirect jobs (i.e. stimulated in goods and services provided to the port project). In addition, there are likely to be about 16 200 "induced jobs", in industries stimulated by the port:[16]

- **Job creation during Port construction** is estimated as 7 190 direct jobs, 4400 indirect jobs, and 16 200 induced jobs, adding to a total of 27 790 over a five-year period.

- **Job creation during Port operations** is estimated as 420 direct jobs, 586 indirect jobs and 2 350 induced jobs, adding to a total of 3356 over a five-year period.[17] This shows a significant slow-down in employment as the construction phase ends. In effect, the construction phase is likely to cause a "boom-town" effect, which will be explored more fully below.

This may also provide a window of opportunity for local people to enter targeted training programmes, to enable career-pathing. The new job market may also create scope for skilled Namaqualanders, who have left the area in search of better jobs, to return to their region of origin. It is not clear how such jobs would be distributed between men and women, or to youth or people with disabilities. This would depend on proactive management policies.

Total worker income is likely to be around R4.4 billion during the operational phase, which will stimulate local consumer sectors, transport and construction. This is a massive injection into the economy of the Richtersveld, since many local people will find skilled and semi-skilled employment. [18]

The financial impact of the port itself during the construction period will be massive, in terms of total worker income, at about R4,4 billion. However, during the operational phase, worker income will reduce significantly to R0,5 billion.

However, over time, the Port is expected to create jobs and promote economic growth in all sectors of the local economy, and specifically in manufacturing, transport, warehousing and tourism. The Transnet study (2024) expects that development contractors will typically have a core team, often recruited outside Namaqualand, and that most of the construction workers will be sourced local and regionally. For maritime jobs, local people may be trained by the TNPA.[19] The Port will, indirectly, stimulate commercial and financial services, including financial institutions, security services, accommodation, retail, restaurants, health and medical services.

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[16] Transnet, Boegoebaai Port Development Social-Economic Benefit Report, 2024, p. 17.

[17] Jobs would be created in various activities: Handling and berthing of ships; loading and offloading of containers, bulk minerals and liquid fuels, warehousing (including specialised types such as refrigerated, high security, liquid/bulk handling, and storage), general warehousing, road delivery and pickups, shipping line container parks, and specialised services such as export packing. Employment will be created across all levels of skill: General labour (unskilled); drivers, trade hands, motormen, shorehands; tug operations, coxwains, ship steering, seamen, cargo co-ordinators, gantry crane operators, administrative staff, security officers, plumbers, facilities managers, technical officers; occupational health staff; electricians and maintenance personnel; human resources staff; master pilots; senior accountants; harbour master; port manager; port engineer; and information technology. In addition, value-added logistics services will include quality control, packing, goods inspection, insurance, truck stops, parking or staging areas, vehicle maintenance, weiGH2-bridges, container maintenance, fuel supply, information and communication. Northern Cape, *Boegoebaai Port Business Case*, 2020.

[18] Transnet, Boegoebaai Port Development Social-Economic Benefit Report, 2024,, p. 16.

[19] Transnet, 2024, Boegoebaai Port Development SEB report, p. 21.

In addition, there will be jobs created from transportation of commodities. In the early phase (construction), new jobs are estimated between 2 200 and 3 140. By 2050, this is slightly reduced, to between 2 080 and 2 940.[20] ("Jobs" are defined in the Transnet analysis as "workers/employees on-site at any given time).

Ongoing road upgrades and maintenance on the N14, N7 and particularly the R382, will be required, particularly in the light of damages caused by heavily-laden ore trucks.[21] These jobs have not been calculated yet. The fact that current roads were not constructed with such heavy transit in mind, will require sections of the roads to be re-built to different standards.

This makes a strong argument for investment in rail transport of minerals *ab initio.* Furthermore, the European Union's Carbon Border Adjustment Mechanism (CBAM) involves the imposition of a carbon tariff on imported goods, based on the level of embedded emissions in the goods and the carbon price paid by the manufacturers thereof in the country of origin.[22] This means that rail transport will be much more sustainable and internationally acceptable than diesel-fueled road transport.

In particular, the transport of lead and zinc will potentially benefit Namaqualand work-seekers. In the Lead and Zinc sector, around 80 workers will be employed in the short and longer term.

The Transnet report maintains that transport of copper will dwindle from about 40 people in the near term (before 2030), and will phase out completely by 2050. This conclusion should be reconsidered. However, the demand for copper (and its price) is likely to increase in the medium-term, copper-intensive technologies will become more prevalent, including wind turbines, solar panels, electric vehicles and expansion of AI computing centres[23] There are new mining operations in Namaqualand (companies such as Copper 360), and the proposed Port will presumably be a good export site.

The transport of Diesel will create a significant number of jobs (around 230-340 in the short term and 300-400 in the long term), but these are long inter-regional transport systems, which will only partially affect people based in Namaqualand.[24]

This suggests that total employment *(Port and transport),* related to the Port and to transport of commodities, is likely to be:[25]

- **During construction phase (2028):** Between 7 820 and 10 860 jobs (production and transportation)
- **During operations phase (2050):** Between 10 890 and 15 740 jobs.

These jobs are likely to be better paid than current Namaqualand levels. This represents a major injection of revenue into the Namaqualand consumer markets, which will then, inevitably, have multiplier effects in the region. However, the exact availability and uptake of such jobs by local people will remain somewhat indeterminate until the project is rolled out. Stakeholder preferences are likely to be complex, and may change over time. The local ("receiving") community is definitely not homogenous in terms of interests and capacities.

As far as impact on mining is concerned, is concerned, the Transnet study of socio-economic benefits (2024) pointed out anticipated mining employment in various sectors benefiting from the Boegoebaai harbour. Over time, a growing number of jobs will materialise at the Vedanta zinc operations near Aggeneys; this is calculated at 200-250 jobs in the near term, and 150-200 jobs by 2050.[26]

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20 This includes manganese, lead/zinc, magnetite, ilmenite, copper, diesel, green hydrogen products, and containers of mixed goods. Transnet, *Boegoebaai Port Development Social-Economic Benefit Report*, 2024, p. 37.

21 Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 98.

22 https://saiia.org.za/research/understanding-the-carbon-border-adjustment-mechanism-cbam/

23 Soares, AF, Spers, RG, and Jhunior, ROS, Projection of global copper demand in the context of energy transition, *Resources Policy,* vol. 103, April 2025. https://doi.org/10.1016/j.resourpol.2025.105567

24 Transnet, Boegoebaai Port Development Social-Economic Benefit Report, 2024, p. 37.

25 Based on figures in Transnet, *Boegoebaai Port Development SEB Report*, 2024, p. 36.

26 Manganese mining is the largest industry to benefit from mining jobs stimulated. However, it falls just outside the Namakwa region. The benefits of the high levels of wages (between 4 700 and 6 300 for the foreseeable future) will

As regards the Namaqualand region, copper production is likely to employ between 50 and 70 people in the short term (before 2030), but by 2050, those jobs would have fallen away[27]. Lead and Zinc production, from the Vedanta operations, will be about 2 000 in the short and long term. Green Hydrogen production will employ between 100 and 250 people before 2030, but will escalate massively towards 2050, when between 3 750 and 6 000 people will be employed.[28]

7.3.1.5 Proposed Transnet CSI programme

The Transnet Port report has identified the following key issue areas for CSI interventions:[29] Education and training, enterprise development, environmental management, socio-economic and infrastructure development, HIV/AIDS and health care, sports development, and employee volunteering in various projects.

The implementing agency will be the Transnet Foundation, the CSI arm of the Transnet Company. It has several transversal goals:

- Improving communities' access to quality healthcare
- Improve academic outcomes and enable access to meaningful economic opportunities
- Prevent GBV and strengthen community well-being
- Enabling socio-economic transformation by building individuals' capacity, promote community development, and improve livelihoods
- Harnessing the diverse and broad skills and experience of Transnet's workforce for volunteerism initiatives.

All the Transnet CSI programmes will have clear exit plans in place, and will not lead to long-term dependencies.[30]

7.3.1.6 Transport

The Northern Cape mining region will serve as the hinterland for the first phase of Boegoebaai Port. Because of the small size of the Port, it was assumed that a dedicated rail link will not be financially feasible. Hence transport logistics will depend on the use of road vehicles. This will also lead to re-routing some commodities from the distant ports of Saldanha, Cape Town, Durban and Port Elizabeth.[31] Agriculture would only be 1.8% of total commodities shipped.

Boegoebaai will aim to take the smaller minerals (lead, zinc and manganese) from the Sishen-Saldanha line/ This will also benefit the Zinc smelter refinery at Aggeneys. For the foreseeable future, trucks will be used to transport ore to Boegoebaai. This will open up rail transit for more ore to go directly to Saldanha. However, it will bring externality costs for the roads (and communities) in the Boegoebaai area, due to wear and tear of the roads, traffic congestion, and possible traffic accidents. However, this will be made up in benefits flowing from increased trucking jobs, time savings for ore companies in lower inventory holding costs, and

be felt mainly in Postmasburg, Kuruman and Kathu. Transnet, 2024, *Boegoebaai Port Development SEB report,* p, 36.

27 According to the Transnet report. Given the likely increase in demand for copper, this assertion needs to be clarified.

28 Transnet, 2024, Boegoebaai Port Development, SEB report, p. 36.

29 Transnet, 2024, Boegoebaai Port Development, SEB report, p. 72.

30 Preference will be given to non-profit, registered, voluntary and community-based organisations, as well as faith-based organisations, that are well-administered and financially stable. They should have a track record of meeting their stated goals; demonstrate broad community support and involvement; include marginalised groups (such as people living with HIV, youth, women, children, aged, and people with disabilities). They should promote gender equity, and at least 30% of beneficiary support should be women.

31 Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 53.

most notably increased consumer surplus from increased export capacity. The Boegoeberg Port business case argues that this "more than justifies the economic costs incurred."[32]

For the "Low Case" business option, the main focus would be on manganese exports, general cargo, iron ore, and diesel imports.[33] For the "High case", manganese will make up two thirds of shipping. In roughly equal measure, iron ore, diesel imports and general cargo would both be about 7-8%, while agriculture would be at 4.8%.

The agricultural and general cargo numbers were capped due to port capacity, and planned to be phased out at a later stage.[34] This suggestion raises concern, as the port could play a major role in the fortunes of intensive irrigation agricultural schemes in the region. The growing commercial footprint of the region, and the likelihood of further industrialisation of towns such as Springbok, would make an argument for keeping a diversified port. There are significant benefits to be realised form port flexibility and ability to handle a wide range of cargoes, as a general port with a number of different terminals.

The usual arguments for diversification of commodities and inputs will be relevant to bolster the case for continuing a diversified cargo mix, as it will help to reduce dependence on specific commodities and their product or price cycles. The danger is that a sudden reduction in the Port's exports or imports, due to an exogenous "shock" or a decrease in port activities, will have a massive disruptive loss in direct employment.[35] This will have negative multiplier effects throughout the whole region.

7.3.1.7 Community engagement

"Equator principles" are a set of voluntary guidelines adopted by private financial institutions to ensure that large development or construction projects appropriately consider the associated potential impacts on affected communities and the natural environment. [36]

The public participation processes involving stakeholders, and particularly the Richtersveld CPA, need to be robust. Their acceptance of the proposed project will serve as the "social licence" to proceed. The purchase or lease of land for the Port will have to be approved by a majority of members of the CPA.[37]

Port authorities need to cultivate an open and inclusive style of governance, building trusting relationships with surrounding communities: "Port Authorities have to ideally play as 'chairmen' in the roundtables of the decision-making process regarding port planning and development. The meaningful involvement of local communities (which … are among the weaker parts of the port stakeholders) should be considered an important target, in order also to gain … legitimacy of governmental institutions, … which quite often is questioned. Since critical inputs of ports' production functions are supplied from local systems (natural resources, labour and infrastructure), it is therefore a main point that local communities take part in port decisions".[38]

The Port Business case emphasised the importance of engaging with the Richtersveld CPA and community, (a) to understand and address the community's demands timeously, and (b) to control the information relayed to the community regarding the project proposal. The community should be meaningfully engaged regarding the project proposal, thereby creating a meaningful relationship.[39] Community participation proposals for the future are examined in more detail in the final section.

7.3.2 Green hydrogen (GH2)

The South African Green Hydrogen business case depends on the abundance of solar and wind resources, as well as key metals and minerals. South Africa already has access to the proprietary Fischer-Tropsch

[32] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 214.
[33] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 55.
[34] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 57.
[35] Benacchio and Musso, Ports and Economic impact: *Transporti Europei*, 2001, p. 29.
[36] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 136.
[37] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 142.
[38] Benacchio, and Musso, Ports and Economic impact, *Transporti Europei*, 2001, p. 35.
[39] Northern Cape, *Boegoebaai Port Business Case*, 2020, p. 154.

technology developed by SASOL, which is a key advantage. This country has abundant platinum group minerals, a robust financial system, a fairly diverse manufacturing sector, and a large renewable energy programme.

The entire project would include:[40] (a) An electrolyser park, with an anchor investor selected in a bidding process, to construct the facilities at the port; (b) desalination plant; (c) liquid storage facility for green hydrogen and green ammonia, to load export vessels; (d) solar, wind and battery park, and potentially also the production of manganese-based precursor materials for the production of lithium-iron batteries, leveraging on the nearby manganese mines; (e) supplier park for key common components; (f) a "gigafactory" to ramp up the production of electrolysers, using South African intellectual property and expertise.

South Africa does not have much existing gas infrastructure to repurpose, so that many new investments will need to be made. Given long approval times, this may take a significant time period.

At a national scale, the advantages will be:[41]

- Supporting the entire GH2 value chain by manufacturing key inputs for production and use, such as electrolysers and fuel cells (forward linkages), as well as transportation infrastructure such as pipelines and equipment (backward linkages), and use in other sectors, such as agriculture, explosives and steelmaking (production of green fertilizers, explosives and steel)

- The workforce can be pivoted away from fossil-intensive resources towards the GH2 value chain, and thereby promote the Just Transition process, with particular focus on vulnerable groups such as technical and vocational workers, coal miners and surrounding communities, particularly by means of skills transfer and training

- It can support catalytic infrastructure projects, such as the Boegoebaai harbour, which will give the Port a national significance [42]

- Where renewable energy plants are built to support GH2 projects (as in Boegoebaai), those projects can also supply energy into the national grid.

- Co-located production projects, as in mine-haul vehicles in the mineral sector, will have accelerated commercial value due to lower infrastructure and supply chain dependencies, and hence lower cost. This, in turn, will mean that the mining suppliers for the Boegoebaai Port will also benefit from GH2 in their onsite mining operations.

- The DTIC study notes that, to achieve ambitious domestic demand larger than 3mta will require "supportive policies and incentives".

The likely timeline for Green Hydrogen "use case pathways" is as follows:

- In the short term (less than 5 years): Transportation of liquid fuels (by truck)

- In the short to medium term (5-10 years): Pipelines to be built

- In the short term: Energy provision to the grid for grid balancing and short term; this relies on adequate renewable energy being available.

Given the delays in gearing up the industry and the regulatory environment, these time frames should probably be lengthened considerably.

[40] DSI, Hydrogen Society Roadmap for South Africa, 2021, p. 63.
[41] DTIC, Green Hydrogen Commercialisation Strategy, 2023, p. 11.
[42] DTIC, Green Hydrogen Commercialisation Strategy, 2023, p. 112.

The Boegoebaai GH2 project will be led by SASOL. It will occupy 60 000 hectares of land adjacent to the SEZ plant, including the production of green hydrogen and green ammonia. It has the potential to create up to 400 000 tons of green hydrogen per annum. This will position South Africa as a global leader in the green hydrogen economy.[43]

There is an inherent uncertainty in international energy markets. However, there is broadly an international interest in energy diversification, spurred spectacularly by the Iranian war. Research on hydrogen technologies is widespread and ongoing (including in South Africa), and it is likely that this production sector will continue to grow, possibly at an exponential pace. There is general agreement that non-fossil forms of energy are on an upward trajectory over the long term. However, there may be fluctuations in the short term. The proposal to develop a Port alongside the Green Hydrogen project would help to reduce vulnerability to market fluctations, in hydrogen and minerals markets. As always, a global economic collapse remains a risk, due to unforeseen economic or political events.

At this stage, Government is awaiting the SEA in order to make the policy decision whether to proceed with Boegoebaai or not; and this decision will entail a wide range of variables which cannot be assessed at this stage. Only once the opportunities are advertised to secure investment partners, will the project parameters become clear - in the light of the fact that different investor applications will make different project proposals. Another set of variables will affect the potential construction of the port, which will include matters such as mineral exports (markets and prices), potential private sector rail investors, and potential private sector harbour investors. The two sectors (hydrogen and port) may entail different sets of investors, which would then have to be synchronised into one project location. One cannot speculate about these markets at this stage.

With any capital projects, there is a risk that they eventually prove unviable, due to unanticipated factors. They may also not be profitable initially, and then gradually gain traction. The best one can assess, at this stage, is that international energy and mineral markets (particularly iron, manganese, copper and zinc) are likely to grow in future, in the light of factors such as AI, increased defence expenditure, and technologies to mitigate climate change.[44]

The economic business case for GH2, combined with renewable energy at Boegoebaai, will have direct beneficial spin-offs for Namaqualand district as well as the Northern Cape generally. The following sections provide a summary of likely impacts, drawn from South African and international studies.

7.3.2.1 Employment

There is some scepticism about the likely job creation effects of the GH2 initiative, and that only a small segment of the local population may benefit.[45] The fear has been expressed that the focus on 'skilled' labour automatically excludes the majority of residents in the Namakwa District, who lack the necessary qualifications. This concern highlights the risk that local communities may not fully capitalise on the economic opportunities presented by these large-scale renewable energy projects, at least not in the short term. A great deal depends on the window of time, and the use of such available window, for companies to create effective training or re-training opportunities for local people, so that they are able to compete for jobs. A skilling strategy would need to be launched very early in the process.

NCDA anticipates that the first phase of the GH2 project (roughly 10 years) will attract 75 000 workers, in various skills categories:[46] Unskilled labourers (30%), Semi-skilled artisans (20%), Skilled professionals and engineers (10%), skilled artisans (20%), skilled management (20%).

[43] DSI, Hydrogen Society Roadmap for South Africa, 2021, p. 64.
[44] This point was added in response to public reviewer comments.
[45] Hendriks, U. 2022. Some Northern Cape coastal communities oppose multi-billion-rand development projects.
[46] Cited in Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development.

7.3.2.2 Transport

GH2 production can support other catalytic projects, as in the case of Boegoebaai Port, making GH2 and port activities more profitable and sustainable. Locating the GH2 complex at the Port means that it can be geared directly for export in the short term, to areas in the world (such as Europe) where demand opportunities are immediate. The port component of the project concept strengthens the overall business case of GH2 at Boegoebaai. Reciprocally, this strengthens the business case for the port, which in turn can benefit ore and agricultural exports. Additional infrastructure projects will include e-methanol and pipeline infrastructure.

Once a railway line is built, this will create additional jobs at strategic points along the route. However, new railways and roads may well be an obstacle for pastoral farmers moving their livestock, and this will have to be taken into account during route planning.

7.3.2.3 Energy sector

The GH2 complex will entail large-scale renewable electricity expansion in the Namaqualand area, based on the supply to the grid, thereby creating cheaper and more reliable access to electricity in Namaqualand. The planned renewable energy expansion will utilise 240 000 hectares of community-owned land for renewable energy, to support the Green Hydrogen project. The project will require 9GW of renewable energy to do so – about 20% of South Africa's current installed renewable energy capacity. The 30GW wind farm will contribute to reaching this target.[47] The details of such land rental arrangements still need to be clarified, but generally, land-owners (such as the CPAs) are likely to benefit from rental income.

For very remote communities, local solar plants can be combined with hydrogen cells, which supplement energy supply when solar power is unavailable. This would mean that they would not be dependent on long-distance power lines, which require high maintenance, and are unsightly and therefore interfere with tourism "viewsheds".[48]

7.3.2.4 Manufacturing investment

The Boegoebaai SEZ will be an important framework to attract industries that would benefit from GH2 production (backward and forward linkages). In the longer term, industry players can congregate near GH2 production projects to provide inputs and equipment, or to utilise the GH2 itself in production processes; in particular, electricity grid and associated infrastructure, compression and storage equipment, beneficiated products, and logistics. This will strengthen the agglomeration trends mentioned earlier, in relation to the Boegoebaai Port.

Many of these subsidiary industries may benefit from national-level incentives related to green energy, such as credit enhancements, employment incentives, tax breaks and subsidies (e.g. from the IDC), which will therefore benefit investment multipliers in the Namaqualand. Appropriate use of government subsidies will speed up the transition to the hydrogen economy.[49]

However, these benefits will depend on Government streamlining processes of permitting, licencing and authorisation. These approval processes in South Africa are very lengthy, often hindering the implementation of projects. There is a need for a single "one-stop" system to simplify these processes.[50]

To promote the inclusion of local businesses (whether manufacturing, retail or service provision) in the new Green Hydrogen sector, accessible and supportive online portals and help desks should be provided, to ease difficulties of tendering.

47 DSI, Hydrogen Society Roadmap for South Africa, 2021, p. 64.
48 https://www.solarwa.org/hydrogen_energy_storage_a_green_alternative_to_batteries
49 Tetteh, EK et al, Non-carbonaceous and renewable-powered technologies, 2024, p. 13.
50 Pinto and Chege, Regulating Green and Low-Carbon Hydrogen in Africa, 2024, p. 20.

7.3.2.5 Skills development

The NCEDA business case for Green Hydrogen notes that the Northern Cape Government will extend and deepen access to quality education, STEM education in the basic education system, technical education in schools, graduate development and research support. This approach will encompass work skills programmes, including a TVET-to-work transition programme, vocational skills, and SME development support.[51]

Employment and skills training should be promoted at all levels of the GH2 investment, as well as enterprises in the GH2 value chain and related transport services. The TVET college in Springbok can be expanded, and satellite campuses established at Port Nolloth and/or Alexander Bay. SETA funding will be available for training programmes. Relevant skills (ranging from technical training to graduates) will include operations, maintenance, transportation, construction, industrial manufacturing, and energy systems.

The TVET system requires an intersection with the higher education system and the skills development system, to promote access to workplace-based training as well as progression pathways to higher education.[52] There should be synergy between TVET training and later on-the-job training. Several problems with the current TVET system have been identified.[53]

A key shortage in South Africa is training for intermediate or medium-skilled occupations (NQF levels 4-5, equivalent to a matric certificate) that are appropriate for the green economy.[54] The demand of Green Hydrogen plants in the vicinity of Boegoebaai is likely to put upward pressure on demand for such skilled people. Currently, the labour force still remains predominantly low-skilled. The Centres of Specialisation (COS) Programme was launched by Government in 2019, to transform TVET colleges to work closer with industry, and implement a demand-led approach to skills through a dual apprenticeship model. Lecturers should also receive continuing on-the-job exposure to new technologies. Life-learning is becoming the norm. TVET centres should be located in close proximity to the areas of industry demand. In the case of Boegoebaai, it suggests that a TVET branch college should be located in Port Nolloth or Alexander Bay.

The Green Hydrogen Energy TVET Skills Just Transition should provide new, high-quality green jobs in the generation and storage of hydrogen, manufacturing of hydrogen-related products such as fuel cells and electrolysers, beneficiation of minerals, and export of green hydrogen. There will also be jobs in the local manufacture of hydrogen-related products, infrastructure construction, specialised forms of transport. occupational health and safety, disaster management, digital and ICT skills.[55]

Creating a viable TVET system for an industry has a long lead time, estimated 5-10 years, to prepare lecturers, develop curricula, set up work placements, and develop a mutually supportive integrated system between training and industry. A pro-active approach to skills development is crucial.[56] The current inefficiencies and inflexibilities of the TVET system will need to be addressed in the Namaqualand context, possibly by Government and business pressure to identify possible rapid improvements and upscaling.

These recommendations are of major significance for the Boegoebaai Port as well as the GH2 complex. The need for local employment opportunities in Namaqualand is great; and the demand for skilled, trained and train-able young people will be enormous. The real challenge will be to create a pathway for school learners and school leavers into the TVET system, particularly at Springbok.

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51 NCEDA 2023, Northern Cape Green Hydrogen Masterplan, p. 12.

52 SAIIA, The South African Green Hydrogen TVT, 2022, p. 23, 37.

53 Matriculants do not have sufficiently strong technical and mathematical skills; completion rates are low; and training is poorly synchronised with workplace requirements; poor student grant administration; poor integration between occupational programmes and higher-education funded programmes; and poor gender representivity. SAIIA, *The South African Green Hydrogen TVT Ecosystem,* 2022, p. 40.

54 SAIIA, The South African Green Hydrogen TVT Ecosystem, 2022, p. 37.

55 SAIIA, The South African Green Hydrogen TVT Ecosystem, 2022, p. 64.

56 There are already roles in grey hydrogen companies (SASOL, Afrox and Air Liquide) which can be used as the core of the GH2 training industry, spanning process jobs (e.g. operators, controllers, foremen), maintenance positions (machinists, welders, electricians), logistics jobs (forklift drivers, stock control) and support positions (such as lab assistants). The courses at two TVET colleges near SASOL can be extended to other colleges.SAIIA, *The South African Green Hydrogen TVT Ecosystem,* 2022, p. 99.

A TVET college in Port Nolloth will create more opportunities for aspirant technicians. However, ensuring that school leavers are ready for TVET education, and ensuring that the colleges have sufficient experienced lecturers will take a significant lead time.

7.3.2.6 Business development

The Northern Cape plans to implement four types of interventions to support local enterprise supplier development (ESD):[57]

1. **Ring fence enterprises with high local availability and low technical barriers to entry:** Local preferential procurement (e.g. earth moving, fencing and solar panel maintenance)

2. **Incentivise enterprises with high local availability and high technical entry barriers:** Attract national enterprises to Boegoebaai (e.g. civil construction, hydraulic equipment)

3. **Finance enterprises with low local availability and low technical barriers to entry:** Stimulate new enterprises (e.g. platforms and forklift rental, wind tower maintenance)

4. **Incubate enterprises with low local availability and high technical barriers to entry**: Support new enterprises (e.g. desalination components, industrial batteries).

7.3.2.7 Agriculture

GH2 fuel cells can be utilised as backup systems to solar power in commercial agriculture. The production of ammonia from GH2 has multiple benefits. Green Ammonia is the only carbon-free vector that can be scaled up in an economical manner from megawatt hour to terawatt hour, using commercially available technologies. Furthermore, it can be used as both an energy carrier and fertilizer, which has implications for intensive farming. "Green ammonia has the potential to decarbonize the energy sector of Africa and enable low-cost and reliable access to fertilizers".[58] The long history of industrial ammonia synthesis, for over a century, has led to well-established and safe protocols for production, storage and transportation, facilitating its large-scale deployment as an energy carrier.

The market for other forms of hydrogen use in agriculture is still undeveloped, and the cost-benefit calculations for various types of farmers remains unclear. Hydrogen cells would need to compete with other forms of on-farm energy, such as solar. Distribution systems would need to evolve. The use of green hydrogen in agriculture is a tantalising possibility, requiring further technical and economic research in this sector.

7.3.2.8 Urban management spin-offs

Desalination technologies for GH2 production can be expanded to provide water for small remote communities near the coastline. Desalination plants could be oversized to at least 300% of the capacity required for the electrolysis plant alone; the extra CAPEX costs could be carried by the project and built into the hydrogen price, which will not be greatly affected. The extra fresh water supply will enhance the public acceptability of green hydrogen plants. The local water utility can purchase the excess water, paying only for the electricity component, as the capital repayment costs are paid for by the hydrogen business.[59] This will significantly increase the water resilience of local municipalities such as Richtersveld LM, although the transport costs of this water supply may prove to be prohibitive.

Disaster management will be a key aspect of GH2 planning. Hydrogen is tasteless, odourless, non-metallic and highly flammable, and can act hazardously under certain conditions (temperature and pressure) or when mismanaged.[60]. Technical safety standards for hydrogen must be given special consideration and priority, related to storage, handling and transport, as well as adoption of hydrogen fuel cell technology.[61] This will

[57] NCEDA, 2023, Northern Cape Green Hydrogen Masterplan, p. 12.
[58] Sagel et al, Leveraging green ammonia, 2023, p. 14384.
[59] Roos and Wright, *Powerfuels and Green Hydrogen*, 2021, p. 31.
[60] Tetteh, EK et al, Non-carbonaceous and renewable-powered technologies, 2024, p. 13.
[61] Pinto and Chege, Regulating Green and Low-Carbon Hydrogen in Africa, 2024, p. 21.

require a concerted initiative in collaboration with the Richtersveld LM and Namakwa DM, to increase their capabilities regarding disaster management. Additional heavy truck traffic on the roads will also require more sophisticated disaster management, including dealing with hazardous materials.

7.3.2.9 Governance

In addition to national-level partnerships between Government, the private sector, technical institutions and civil society,[62] regional partnerships (e.g. based on the Namakwa SEZ) would be important to address regulatory hurdles and promote positive investment solutions on GH2 investments. "There is a distinct need to involve different actors and systems to generate shared or co-constructed knowledge in pursuit of future energy policies, practices and institutions, where scientific knowledge and lay knowledge can interact and co-operate".[63]

"Energy Justice" is now established as a leading interdisciplinary energy research subject in the past decade. It is a conceptual framework which identifies when and where injustices occur, especially in low-carbon transitions, and how legal frameworks can best address these injustices.[64] It is important to identify potential injustices *before* they occur.

Procedural justice requires public participation and disclosure of information across energy activities and jurisdictions.[65] To ensure transparency and effective public comprehension of choices and trade-offs, all energy components should be treated as part of one system.

"Future proofing" means that, in the future, an energy stakeholder (whether a politician, company director or a civil society representative) can confidently state that, at a specific point in the past, when they had to make a strategic decision, *they relied on existing best practice in the field*.[66] This means that, in future, decision-makers will not be able to rely on their political office to escape charges of contributory negligence on the decisions they made.

7.3.2.10 Community and municipal engagement

Internationally, there have been difficulties in introducing green hydrogen to communities: "The degree of knowledge about green hydrogen in the population is precarious".[67] Familiarity with technology is key. Researchers in Richtersveld have commented on the lack of substantive information on green hydrogen provided in government and SASOL presentations to communities: "According to the community activists, most of the communities who participated left the engagement without knowing what green hydrogen was and how it related to the energy transition". They were therefore did not understand what kind of jobs could be associated with green hydrogen production.[68] Basic information must be provided to community members, in such a way that they are not intimidated by technical information, and are comfortable with asking questions.

The NCEDA strategic plan for Green Hydrogen emphasises the importance of various levels of ongoing community engagement.[69] The topic of community engagement needs to be unpacked into different stages of the value chain. These stages have distinct impacts on people's lives, depending on the local context in which they develop and the processes by which they are introduced.[70] Community engagement must be an ongoing process, with multiple and never-ending iterations, as new stages of the project cycle take place and local people are affected in new ways.

These proposals are expanded in the last section of this chapter.

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62 DTIC, Green Hydrogen Commercialisation Strategy, 2023, p. 71.
63 Vallejos-Romero et al, Green Hydrogen and Social Sciences, 2024, p. 9.
64 Hussein et al, Future-proofing for green hydrogen in the Global South, 2024, p. 345.
65 Hussein et al, Future-proofing for green hydrogen in the Global South, 2024, p. 346.
66 Hussein et al, Future-proofing for green hydrogen in the Global South, 2024, p. 346.
67 Vallejos-Romero et al, Green Hydrogen and Social Sciences, 2024, p. 9.
68 Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 51.
69 NCEDA, 2023, Northern Cape Green Hydrogen Masterplan.
70 Vallejos-Romero et al, Green Hydrogen and Social Sciences, 2024, p. 8.

Municipalities are important institutional avenues in consultation processes. However, their limitations, particularly in rural areas such as Namakwa and Richtersveld, have frequently been pointed out. Richtersveld does not have trained Local Economic Development or spatial planning staff. "While SEZs, REDZs and now EDZs are viewed as economic policy designs that off-set economic development in geographical locations and attract lucrative investments, these grand designs can also be disruptive and abrasive due to the imposing top-down approach in their design and implementation in local host municipalities".[71]

This issue is deeply embedded in the current intergovernmental system in South Africa. Although the ostensible normative underpinning of intergovernmental relations (IGR) is a set of three fairly equal "spheres" of government, national and provincial governments have technical expertise that far outweighs the skills at municipal level. This leads to centralised planning by politicians and technocrats at national government, without the necessary fiscal and institutional support to rural local municipalities – and who will eventually be responsible for local accountability and co-ordination.

This may have material consequences, as the priorities of financial partners and business interests tend become paramount. "Therefore, while industrial development plans in the energy sector are spearheaded by national departments (that is, the Department of Trade and Industry, provincial economic development departments and the Department of Mineral Resources and Energy), they need to be accompanied by support interventions at local government level. This can be achieved through intergovernmental coordination between institutions such as National Treasury, CoGTA, Municipal Infrastructure Support Agency (MISA), Development Bank of Southern Africa (DBSA). The latter institutions should be playing a supportive role to rural municipalities who do not have financial and technical capacity to spatially plan for local government services needed to support industrialisation in their territories".[72]

There is an open question about the degree to which COGTA, at national or provincial level, has been brought into the SEZ, Port and Green Hydrogen planning processes, to assess the technical skills in the relevant municipalities, and to devise and fast-track support programmes. Furthermore, the Port and GH2 projects may need to fund the creation of key posts at municipalities (Richtersveld and Namakwa DM), who can undertake local economic development, spatial planning and infrastructural development.

Although engagement with local communities is generally the main focus of discussions on participation, it is important to expand the topic to work-related engagement, particularly in the renewable energy (RE) sector. A high proportion of jobs in the sector are temporary, migrant, or part-time, often with low unionisation rates. Local residents have little experience with such work-place engagement or trade union-type organisation.[73]

7.3.2.11 Summary

The GH2 complex at Boegoebaai offers major potential benefits to the Namakwa region, in terms of energy generation and use, business development, urban management, and skills development. The real challenge will be to address the institutional and socio-economic difficulties in the Namakwa region, to make the local population willing and able to enter these new economic opportunities.

7.3.3 The SEZ and REDZ concepts

The SEZ programme was introduced in 2014[74] to address the shortcomings of the previous Industrial Development Zone (IDZ) programme. Between 2007 and 2016, the Department of Trade and Industry restructured the IDZs into SEZs, aligning with new economic policies like the New Growth Path and the Industrial Policy Action Plan aimed at promoting growth, job creation, and poverty reduction[75]. This revision

[71] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 21.
[72] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 2
[73] Tunn, J et al, 2024. Green hydrogen transitions deepen socioecological risks.
[74] Department of Trade and Industry: Special Economic Zones Act 16 of 2014.
[75] Namakwa District Municipality. Integrated Development Plan Review 2023/2024. South Africa

also responded to global shifts, such as the formation of BRICS, with the overarching goals of supporting diverse regional development and evolving national priorities.[76]

The Namakwa Special Economic Zone (SEZ), led by the Northern Cape Department of Economic Development and Tourism (NCEDA) in collaboration with the national Department of Trade and Industry (DTI), is positioned as a strategic economic hub in the Northern Cape. [77] The Namakwa SEZ was designated on 21 May 2024, in the Khai-Ma Municipality: "The central thesis is that the SEZ will redress past injustices of mining towns in the province by developing Aggeneys, a purely mining town, into an industrial city that will exist beyond the life of the mine and be an enabler towards the Provincial quest of addressing the cost of doing business in a rural area".[78] The Namakwa SEZ is strategically positioned along the N14 corridor to connect mining hubs like Sishen and Postmasburg with the proposed Boegoebaai Deep-Sea Port. This corridor is expected to enhance bulk commodity transport, positioning the region as a critical logistics hub. The Boegoebaai green hydrogen SEZ is now designated as the Green Hydrogen Development Zone.

The theoretical argument for SEZs is based on the impact of innovation and agglomeration, i.e. the firm-level cost-savings and productivity gains derived from the spatial concentration of firms and people in economic clusters or cities. Alfred Marshall (1920)[79] argued that the clustering of firms reduces transport costs and yields agglomeration economies of scale, typically within one industry. Cost savings are induced by easier movement of goods, labour, and ideas. In addition, the economist Jane Jacobs identified positive agglomeration due to knowledge spillovers *between industries*, which stimulate innovation. Diversity is a key to urban prosperity.[80] The fact that at least three major industries – zinc mining, a port and green hydrogen production – will form the cornerstones of the SEZ, will maximise the number of support industries established in their vicinity. This has a better chance of creating an innovative business ecosystem than if the SEZ was simply built around one industry.

The Aggeneys investment is large and multi-faceted, and has important regional implications: Cumulative direct and indirect jobs: 6 000, with potential impacts up to 21 000 people; requirements for schools, hospitals, social amenities, police stations and human settlements. At this stage, Boegoebaai SEZ is being developed as a satellite node under the Namakwa SEZ licence. The Department of Trade, Industry and Competition (DTIC) and the province have committed R1 billion each for the top structure, with an additional R600 million allocated by the province for bulk infrastructure development. [81]

Numerous criticisms have been made of the efficacy of South African SEZs. The success of IDZ's rely on numerous factors such as the design, location, domestic linkages, incentive packages, financing, development, and management model of the SEZ, and often an already robust economy.[82]

For SEZs to attract foreign investment, they must offer top-tier, globally competitive infrastructure. Previous IDZs in South Africa struggled with inadequate infrastructure, such as water and electricity - hindered their success.[83] SEZs in other African countries have also experienced difficulties in terms of attracting foreign direct investments (FDI) flows and achieving sustainable employment generation. However, there are promising outcomes at the East London and Coega SEZs, involving SME support, technical skills training, shared procurement and recruitment systems.[84]

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76 Department of Trade and Industry (DTI). 2012. Policy on the Development of SEZs, 2010.

77 COGTHA, 2020. Namakwa District Northern Cape: Profile and Analysis District Development Model. Republic of South Africa: Pretoria.

78 Northern Cape Office of the Premier (2023), presentation to National Council of Provinces (NCOP).

79 Marshall, A. (1920). *Principles of Economics*. London: Macmillan.

80 Jacobs, J., 1969. The Economy of Cities. New York: Random House.

81 Special Economic Zone (SEZ), Available: https://www.thedtic.gov.za/sectors-and-services- 2/industrial-development/special-economic-zones/

82 Phiri, M & Manchishi, S 2020. "Special economic zones in Southern Africa", p. 2.

83 Qumba, M.F. 2023. Evaluating South Africa's Special Economic Zones.

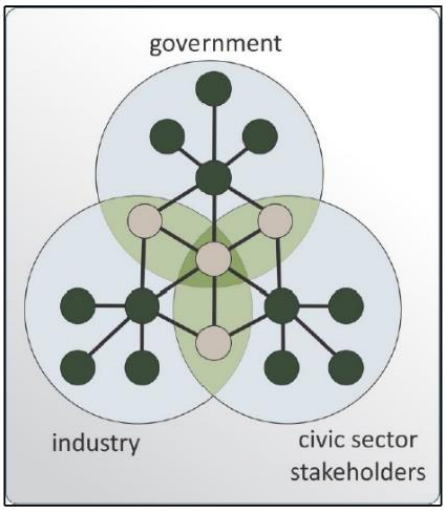
84 **Coega:** 2015/16–2018/19, Over three years, 36% of procurement spend was on small, micro, and medium enterprises (SMMEs), compared to five-year target of 40%; 27,152 persons trained in three years, compared to five-year target of 27,899. **East London:** At East London, proactive collaborative arrangements resulted in localized value chains around existing tenants. The zone procures goods and services for construction and other activities from local suppliers. Labour pooling : Job seekers are required to register their information with the zone via an online database. Job seekers are matched with investors and trained with the right skills required by investors. This has lowered labour search costs for investors. Skills, technology, and knowledge spillovers have been created through

The challenge of creating a new set of regional institutional interfaces should not be underestimated. At a regional level, the Namakwa Special Economic Zone will require an overarching institution to facilitate infrastructure and business development, promote integration with local industry, and fine-tune value chains. Typically, multiple sectoral policy frameworks exist for the same region, complicating efforts to attract investment and ensure sustainable development. High-level and consistent inter-agency coordination are required for these zones to make the region economically viable. [85] There must be a concerted shift towards fostering a more conducive business environment, including tax incentives.[86] This would include streamlined services and regulatory processes, reducing bureaucratic obstacles.[87] There are also potential "twin cities" advantages between the SEZ and nearby Oranjemund in Namibia.[88]

The NCEDA and the Northern Cape Office of the Premier have consistently engaged with the Namakwa District Municipality about the SEZ and REDZ and its relation to the green hydrogen development. However, much of the planning and development of the initiative has thus far been driven by the province with little input from the municipalities. The view has been expressed that the Namakwa DM and Richtersveld LM are merely informed of these developments with no active participation in such assessments.[89] Nevertheless, it is likely that the municipalities' knowledge of these projects will increase over time, enabling them to play a more assertive role. Financial support and capacity building from other spheres of government is essential for the coherent and holistic development of regional industrial and renewable energy projects in SEZs.[90]

The alignment and interactions between stakeholders is so important that it has been described as "governance of future-making", referring to "the coordination of actors, interests and institutions to turn expectations into path creation". "Future-making" leads to "path creation" when alternatives become costly for the decision maker and other actors involved in the governance of future-making, particularly because of sunk costs in the project: "The more expectations are institutionalized, gain collective acceptance and credibility, the more they bind actors, create a governance by expectations, and, eventually, the creation of a new path becomes realistic".

The process of local consensus-building (which is always a lengthy, sustained, iterative process) can be portrayed as a multi-polar network, connected by legitimate sectoral representatives.[91]



Currently, local communities tend to lack the technical knowledge required to engage meaningfully with technicist planners about GH2; this leads to a sense of exclusion, suspicion and resentment.. National governments and international investors should proactively support local and civil-society stakeholders in developing capacities to engage with green-hydrogen futures.[92]

7.4 SOCIAL IMPLICATIONS OF THE PORT AND GH2 PROJECTS

This section analysis the potential social dimensions of these large projects at three levels:

the zone's training facility (science and technology training exceeded targets in 2018). Cited in Phiri, M & Manchishi, S 2020. "Special economic zones in Southern Africa", p. 13.

85 Nzo, M. and Mahibir, M. (2021). Renewable Energy Opportunities in Namakwa, p. 18.
86 Phiri, M & Manchishi, S 2020. "Special economic zones in Southern Africa", p. 19.
87 Qumba, M.F. 2023. Evaluating South Africa's Special Economic Zones.
88 Richtersveld LM, *Spatial Development Framework,* 2024, p. 213..
89 Nzo, M. and Mahibir, M. (2021). Renewable Energy Opportunities in Namakwa, p. 18.
90 Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 38.
91 Boutilier, R.G. and Black, L. 2013. Legitimizing industry and multi-sectoral regulation of cumulative impacts.
92 Klagge, B et al, (2015), Governance of future-making: Green hydrogen in Namibia and South Africa, p. 104244.

- What the local social context offers ("the receiving environment") and the longitudinal trajectories (trends over time)?

- What are the possible impacts of the Port and GH2 complex on the local communities?

- What are the policy-makers' values and goals, and how they can be reconciled with the current social profile of the area as well as the potential impacts of the Port and GH2. To what extent do these projects bolster or undermine such policy goals?

Social impacts are notoriously complex. They are often the product of numerous different interventions simultaneously, such as new inflows of money, new technologies, new institutional systems, and new people. In turn, social impacts stimulate other causal relationships, creating *cumulative* impacts, involving several time frames, social scales, analytical disciplines and unintended consequences.[93] In sum, causal chains are unpredictable and "slippery".

Furthermore, cumulative impacts can result from the aggregation (over time or space) of the impacts of a single activity. Cumulative impacts typically involve multiple actors and causal pathways. The impacts may affect stakeholders in different jurisdictions and involve issues that are legally regulated by multiple institutions; some issues do not fall under any formal regulatory authority at all. South Africa often faces particular challenges regarding the rigidity of sectoral government programmes and regulatory frameworks, so that inter-sectoral and cumulative impacts are seldom recognised or understood.[94] One way of portraying such complexity is to identify "causal pathways". Each pathway could involve several sectors, departments and stakeholders.

"Social transformation and human welfare" is one of the four pillars identified in the Northern Cape strategic plan.[95] This includes basic education, health care, social cohesion and community participation, social protection and safety, sustainable human settlements, and employment and skills development. For these sectors, the proposed Boegoebaai projects could make significant impacts, particularly in relation to skills development and employment. If programme partners undertake corporate social development expenditures, even more beneficial impacts could be achieved. It is likely that this will be mandatory.

However, the Boegoebaai Port and GH2 industry may lead to unintended difficulties related to social cohesion, safety and sustainable human settlements if the project is not designed and implemented carefully. In order to do so, it is important to consider the nature of Namaqualand social development.

7.4.1 Population growth and urbanisation

Population density in Namakwa has always been low, with an average of 1 person per km2. It is the least populated district in the country, although geographically the largest district.[96] The long distance between Namaqualand and the Cape metropolis have always caused the local people to be somewhat isolated from broader developments.

The population of Namaqualand has increased significantly since 1904. The major shift took place between 1930 and 1950, when the population grew rapidly. Another increase took place between 1951 and 1970, probably due to the mining boom, and thereafter increased steadily. [97]

The population of Namakwa DM in general has shown significant spatial shifts in the last 100 years. Population has increased, and become much more urbanised. The rural population was about 13 300 in 1904, increasing to 36 000 in 1980; today, the rural population is only about 3 000 people. By 2011, "non-

93 Franks, et al. 2013. The cumulative dimensions of impact in resource regions.

94 Canter, LW and Ross, B, (2010) State of practice of cumulative effects assessment. A new analytical approach is called 'Cumulative Effects Assessment and Management' (CEAM) within the field of impact assessment analyses complex adaptive systems. It focuses on the *properties of potentially impacted systems, over time*, even though the required information is often not available, and generalisations from other contexts are of limited use.

95 Northern Cape (2020), Office of the Premier, *Strategic Plan 2020-2025,* p. 29; also in the 2024 PGDP Vision 2040 and SOPA Provincial Priorities (see Powerpoint Presentation: NCOP: Three Sphere Planning Session, 2023).

96 Namakwa DM, Draft IDP, 2022-2027.

97 Dunne, J, Regional Development Strategy for Namaqualand, (1986), p. 97.

urban" areas only included about 7.5% of the population. (However, the definitions of "rural" and "urban" are notoriously vague and slippery. Do rural villages count as "rural" or "urban"? Hence generalisations and comparisons are risky). The main point is that there has been a secular trend of people moving from farms and villages to more formal towns, where modern services and jobs are more readily available.

It is possible that some of these remaining rural people will be attracted to unskilled jobs at the Port and GH2 complex. This will mean that the rural-urban ratio of population will become even more urban-oriented.

In contrast, the urban population increased from about 7 000 in 1904 to over 72 000 today (see Appendix A). While some urban migrants retain a foothold in the rural areas (due to part-time livestock farming), the main sources of income for the population are gradually moving from agriculture and mining to service industries such as catering, accommodation and tourism in the major urban centres (see Section E below), as well as relying on social grants.[98] Even though the population remains very poor, there are distinct signs of improvement in the quality of life due to the diversification of the economy.

There is a strong population cluster around Springbok, Okiep and Nababeep, and a secondary node at Port Nolloth (See Appendix A). In four towns (Port Nolloth, Springbok, Pofadder and Garies) there has been a significant long-term increase in population, compared to 1980. Today, these are all significant administrative towns. They have become headquarters of larger municipalities, which encompass several settlements. These municipalities receive funding from central government ("equitable share"), which supports municipal staffing and operations. The rapid expansion of social services (health, education), grants, and jobs in the towns offer much better prospects than living in the remote and arid rural areas. This boosts the local retail sector, and there is some tourism (particularly in Garies, Port Nolloth and Springbok).

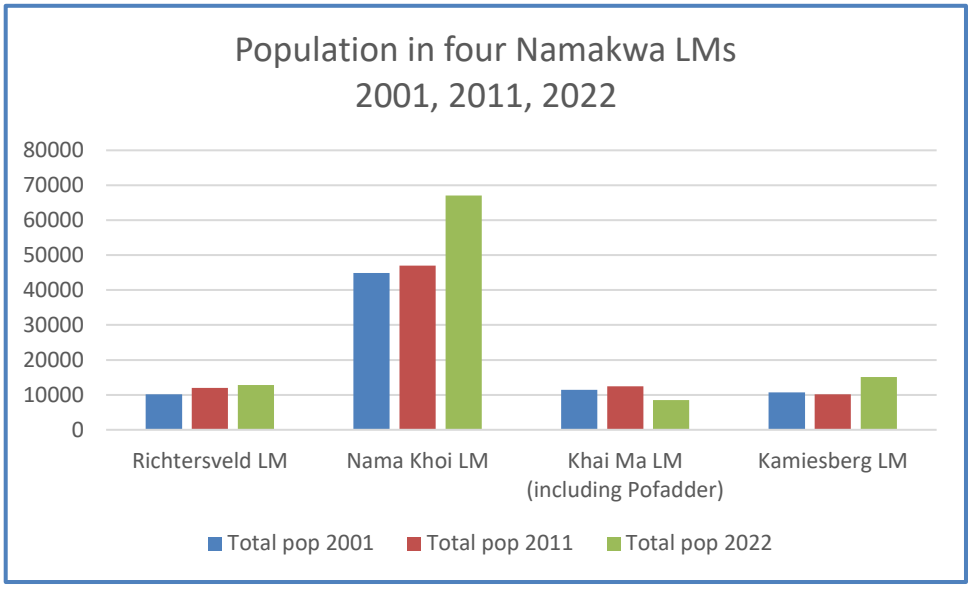
The long-term trend of growing population as well as an increasingly urbanised population has major implications for future development. Urban occupations would be more meaningful and impactful in future, and rural agricultural land may support decreasing numbers of people, and therefore may increasingly become farmed at commercial levels (at least partially replacing subsistence farming). Agriculture would remain important, but a development thrust aimed primarily at urban areas will reduce the population pressure on the land. A great deal would depend on the likelihood of the Port and GH2 project to attract people permanently away from the countryside, as new jobs and skilled opportunities open up.

The population growth rates between 2001 and 2022 show much more dramatic shifts in the latter period (2011-2022) than the earlier period (2001-2011). If the Census statistics are accurate[99], it suggests significant inflows of population into Richtersveld (the largest population percentage increase), while Nama Khoi LM and Kamiesberg LM also had significant percentage increases. Kamiesberg LM turned its trend around from a slight decline to a marked increase. The population in Khai Ma declined, for which we do not have an explanation.

Population shifts in four Namakwa LMs

[98] Hoffman, M.T. and Rohde, R.F. 2007. 'From pastoralism to tourism: The historical impact of changing land use practices in Namaqualand'.

[99] The confusion with the Richtersveld LM population figure raises some doubt generally.



Dependency ratios measure the number of young and elderly people, in relation to working-age people. The figures are relatively balanced, with Kamiesberg LM showing greater pressure on working-age people to support a larger number of non-working people. These figures are relatively stable, with Nama Khoi LM and Kamiesberg showing a healthy movement towards a lower dependency ratio (see Appendix A).

On several social indicators, the four municipalities (surprisingly) perform in very standard ways (See Appendix A, where we used Sol Plaatje Local Municipality (Kimberley) as a point of comparison (using 2011 census figures). This suggests that thirty years of redistributive policies (such as health, education and social grants) have made a significant impact in the erstwhile remote and underdeveloped Namaqualand. On some of the indicators (gender ratio, proportion of elderly in communities, life expectancy, years of schooling, adult literacy rate, HDI), the four Namakwa municipalities are within the same kind of band as Sol Plaatje LM, suggesting that conditions in Namaqualand are not too dissimilar from other localities.

Of significance to the Port and GH2 project is that the proportion of **working age people** in the Namakwa municipalities are higher than that in Sol Plaatje (65%). In Richtersveld it is 71%, and in Nama Khoi and Khai-Ma it is 69%. Only in Kamiesberg is the proportion lower (at 63%), once again indicating a large degree of out-migration of working-age people from towns such as Garies and Kamieskroon, to Vredendal and Cape Town.[100]

The population pyramid of the Namakwa DM shows the relatively small proportion in the under-34 age bracket (See Appendix A for a comparison between the population pyramids of Namakwa, the Northern Cape, and a similarly rural Northern Cape municipality (Pixley ka Seme DM, centered in De Aar. Once again, it suggests out-migration of working-age people with their children.

Not only are these out-migrants the energetic, entrepreneurial and possibly better-schooled members of communities, but they are also the creators of new families. The out-migration of this cohort must act as a dampener on Namakwa DM's current economic performance. On the other hand, the large out-migration of young people from Namakwa DM may mean that these people may wish to return to their place of origin, if new jobs are created by the Port or Green Hydrogen. Furthermore, they may bring technical and business skills and experience with them. Employing this cohort would bolster the Namaqualand economy, but even more importantly, strengthen family and community networks.

[100] One can speculate about causes and effects for out-migration of working age people in Kamiesberg: Since the municipality is located in the south of this study area, and relatively closer to employment centres in the Western Cape, there may be a "pull factor" from outside the region.

The number of indigent households (1129 in Richtersveld, 5334 in Nama Khoi, and 1239 in Khai-Ma) suggest that these households may have one or two members who are unemployed and may be attracted to unskilled or even semi-skilled work at the Port or GH2 project.

The outlying settlements in the Richtersveld LM has shown a slight increase in population in the decade between 2011 and 2021. [101]

Population, Richtersveld settlements, 2011 and 2021

Population distribution

Settlement	2011 population	2021 population
Port Nolloth	5131	5595
Lekkersing	368	401
Eksteenfontein	531	579
Alexander Bay	1745	1903
Grootderm	71	78
Kuboes	955	1041
Sanddrift	1739	1897
Sendelingsdrift	191	208
Richtersveld LM	**10,731**	**11,702**

The impact of mine closures in the Richtersveld, particularly Alexander Bay, and in Kleinzee, are examined in more detail in Section E.

It is likely that the rapid construction phase of the Boegoebaai projects may draw adult men and women from these villages towards the building sites, and that the population in these settlements may decline for a period of 5-10 years. However, it is also likely that people's remuneration will be ploughed back into these settlements, which may experience a period of prosperity and investment based on remittances. During this time, it would be important for the adult workers and work-seekers of these settlements to access training and on-the-job skills development, so that there is not a post-construction slump in these towns. There is already a track record of this phenomenon, in Steinkopf, for example, where mining remittances have been ploughed back into town improvements.

The launch of the construction phase of the Port and GH2 complex is likely to draw many work-seekers and newcomers to the Port area. Once some work-seekers from elsewhere secure jobs and a foothold in the local town, it will encourage other people from their towns of origin to follow suit. A "migration path" may be created, whereby work-seekers from elsewhere steadily migrate to the Port Nolloth area. This is likely to create a bulge in the working-age population, and may create cultural tensions.

It is impossible to quantify the in-migration of people at this stage. The influx can be managed in many different ways (e.g. different kinds of neighbourhood planning and land management systems). These will depend particularly on municipal policies (Richtersveld LM, but probably strongly influenced by the Namakwa DM, as well as provincial sectoral departments. The new situation of a rapid influx of investment capital and new levels of salaries will raise challenges, options and opportunities that the local policy-makers have never experienced before.The important challenge is to ensure that such policy-making will and capability is available to the LM and DM, and that they are presented with clear and relevant policy alternatives. Sectoral specialists will need to provide advice to all levels of government. One key policy choice will be the level of fly-in-fly-out technical staff, or whether family accommodation should be encouraged. International examples offer benefits and challenges of different options; for this reason, the policy-making process must be informed by specialist advice, at a higher level than is currently available in Namakwa.[102]

A related question is the carrying capacity of the land with regards to population. There are at least two dimensions to this question: Environmental carrying capacity and institutional capability. Environmental carrying capacity refers to the level of population which can be supported on available land and water

[101] Richtersveld LM, *Spatial Development framework*, 2024, p. 147.
[102] This point was added as a response to public reviewers.

resources. This, in turn, depends on the way in which people live, and how they make a living. Some livelihoods are more environmentally intensive than others. Agriculture faces real environmental limiting factors, and can support a fairly limited number of people. An industrial strategy can support a much greater number of people, who live in concentrated communities, and whose incomes are generated by the sale of concentrated goods at fairly high prices, which in turn can support higher levels of material welfare. This welfare, in turn, can place more or less pressure on the environment, depending on the policies which are used to manage people's use of the environment (e.g. desalination of water, investment in natural parks, preventing overfishing or hunting for recreation, using large amounts of water for private gardens, etc). Limited resources can support a large number of people, but this puts a premium on management capability, which is strongly emphasised in a later section.[103]

7.4.2 Employment

7.4.2.1 Employment by sector

Historically, the economy of Namaqualand was dominated by agriculture (in terms of lifestyle, but not necessarily value-add), and mining (in terms of regional product and jobs).[104] The economic story of Namaqualand in the last century is about the rise and fall of mining, and the recent rise in government-funded jobs and services. The employment profiles in 1980 and 2023 show the dramatic decline in mining employment (see Appendix A). All the other sectors, except Transport, increased as a share of provincial employment.

In order of magnitude, employment categories in Namakwa District in 2023 were: Government Services (largely funded by intergovernmental transfers, at 28%); Trade, Catering and Accommodation (reflecting tourism activity), at 13%, Agriculture and Mining (both at 13%), Finance and Real Estate (8%), Construction (7%), Manufacturing (4%), and Transport (3%) (See Appendix A for details).

These figures conceal dramatic levels of unemployment in towns such as Kleinzee and Alexander Bay, as well as the Richtersveld generally, due to the closure of De Beers and Alexcor diamond mines. In addition, there is a growing phenomenon of illegal mining (zama-zamas), whose activities will be difficult to regulate in future. Their presence is often associated with vigilantism and crime.[105]

Agricultural employment has grown since 1980, due to the expansion of irrigation agriculture along the Orange River. Because of the aridity and land tenure issues in Namaqualand agricultural employment is still less than the average provincial share. Finance and real estate have grown significantly, suggesting that there is more money in circulation in the province; and manufacturing has managed an uptick.

7.4.2.2 Employment levels

The macro-economic and social indicators for the Northern Cape are currently bleak.[106] The unemployment rate is 32% (compared to the 33.5% level in South Africa); and the Northern Cape has the highest rate of youth who are not employed (around 50%). The expanded definition of the unemployment rate (i.e. including people who have given up looking for work) is 44%.

[103] This point was added as a response to public reviewers.
[104] Mining accounted for 45% of the economically active population in the mid-1980s. Dunne, J, *Regional Development Strategy for Namaqualand,* (1986), p. 98.
[105] A Pretorius and D Blaauw, Kleinzee: Looking for a new dawn amidst the remaining diamond dust; P van der Watt, Alexkor and the Richtersveld community: Unlikely partners to pool, share or profit from joint diamond mining, both in S Matebesi, L Marais and V Nel, 2024, *Local Responses to Mining Closure in South Africa*.
[106] OTP, Memorandum to NCOP, 26 August 2024.

In comparative terms, Namakwa DM performs better than the Province. In 2018, Namakwa District's unemployment rate was 16.5%, which had declined somewhat from 17.8% in 2012 (compared to 28% in JT Gaetsewe, 24% in Pixley ka Seme and 29% in Frances Baard).[107]

In 2022, there were 34 792 employed people in Namakwa District, with over 13 500 people listed as unemployed and still looking for work.[108] (This includes the Hantam and Karoo-Hoogland LM areas as well; these unemployed people in those regions may well also be attracted to job offers at the Boegoebaai Port and GH2 complex).

In the Richtersveld LM, 49% of the population is employed, which is higher than the Namakwa District average of 44%. Of the 4002 employed residents, 573 are in the informal sector. Unemployment figures are high and growing in Richtersveld, due to the downscaling of the mines. High unemployment tends to lead to socio-economic problems such as alcohol and drug abuse, crime, and early pregnancy.[109] Furthermore, the rich diamond deposits along the Orange River and the coast attracts significant informal miners to the area.

On a municipal basis, the National Treasury's Municipal Socio-Economic Profiles (MSEP)[110] provided some interesting findings. Of significance for the Port and the GH2 project would be the people who work in Construction, electricity, water and transport sectors, as these people would have some skills, experience and will to seek work on the new projects (See Appendix A). In these sectors, there are currently about 300 working people Richtersveld, 2 500 in Nama Khoi, 200 in Khai-Ma, and 300 in Kamiesberg. The four municipalities therefore have roughly 3 300 people who have some experience in the key construction, transport and artisan-type trades (electricity and water). This provides at least some pool of people from where the Port and GH2 can recruit workers, and that would stimulate demand for skilled workers in those firms. As noted earlier, Namaqualanders (many with some level of skills) may return from other centres, particularly the Cape metropole, to seek jobs in these new projects.

It is also possible that there may be people with suitable work experience and training who are currently in the category of "discouraged workseekers" and could readily respond to employment demand and new training and re-skilling opportunities.

Employment effects cannot be readily specified at this early stage, since they will depend on public policies (at national, provincial and municipal level), as well as corporate policies on the two projects. At this stage, there is not yet an in-principle government decision to proceed with these projects. Once such decisions are made (with the GH2 and port, respectively), a great deal will depend on the window period involving the creation of consortia and securing of capital. During this window period, government institutions could (and should) be planning rapidly and dynamically for various aspects of the projects, notably fast-tracking training opportunities and land acquisition for real estate expansion (to manage a possible housing boom). A great deal depends on the conditions which government sets for private partners, e.g. the level of local, regional, and national sourcing of skills and supplies. If government agencies let this window go by, and the projects are implemented without adequate government service readiness, the scenarios will look very different. For example, there will be insufficient local skills, and skilled workers may well have to be sourced from elsewhere.[111]

The previous sections outlined the possible employment impacts of the Port and GH2 projects, in both the construction and operations phases. These phases are not hermetically sealed categories. Typically, construction continues well into the operations phase, as new rounds of construction take place. Even in early stages, the inflow of money into the community will stimulate secondary and tertiary rounds of economic activity, ranging from accommodation and catering to vehicle maintenance and childcare. Every aspect of economic activity stimulates the circulation of money (through wages), which stimulates further

[107] Northern Cape, 2019, *Provincial Growth and Development Plan, p.* 77, Quantec data, 2018.
[108] Northern Cape, 2019, *Provincial Growth and Development Plan,* p 77, Quantec data, 2018.
[109] Richtersveld LM, *Spatial Development Framework*, 2024, p. 135.
[110] National Treasury, *Municipal Socio-Economic Profiles*, https://lg.treasury.gov.za/ibi_apps/portal/Municipal_Socio_Economic_Profiles
[111] This point was added as a response to public reviewer comments.

economic activity. Furthermore, rapid on-the-job training and more formal training will be important for both the construction and operations phases. It is likely that employees on construction projects (e.g. doing metalwork) may find jobs in the operations phases. The Construction and Operations phases tend to have reciprocal interactions and impacts.[112]

7.4.3 Household incomes

Historically, people in Namaqualand were desperately poor. Jobs were scarce, poorly paid, and vulnerable to economic cycles. Agriculture offered the only reliable fall-back option, which enabled people to survive. In the 1980s, at least 74% of the coloured population earned less than the national Household Subsistence Level (HSL), and were living in "abject poverty". [113]

By 2019, this high level of poverty had declined to only 22% of the population living below the poverty line.[114] This is a remarkable improvement from the 1980s, although it is still a worrying statistic. It is likely that social grants have played a major role in reducing the worst ravages of poverty.

The monthly income levels in Namakwa District are extremely low, compared to Namakwa DM (R379) and certainly compared to South Africa as a whole (R11 907) (2019 figures; See Appendix A).[115] Average household incomes in Kamiesberg (R378), Khai-Ma (R420), Richtersveld (R528) are very low indeed. Nama Khoi (2 239) is significantly higher than these outlying towns, compared to Sol Plaatjie LM in Kimberley (R10 146), which is almost five times that of Nama Khoi.

However, that does not mean that families in Namaqualand fare particularly poorly on all criteria. The HSRC study of food and nutrition security in the Northern Cape found that a larger proportion of households in Namakwa District were food secure than the Provincial average.[116] This suggests that some of the resources of Namaqualand families may be obtained without paying for it, e.g. pedestrian transport, or producing at least some of food used in the home. In rural areas, there is a great deal of reciprocity amongst community members, exchanging meat and other food in return for services such as transport or herding, without any of this entering the monetized economy.[117]

Having multiple income streams is a crucial support mechanism for poor households. In many cases, livestock owners do not farm primarily for the purpose of commerce or sale of livestock, but rather as a hedge against economic risk, while being prepared to do a range of other activities which may produce a temporary income.[118]

With the arrival of large projects such as the Port and the GH2 industries, there will be a sudden massive injection of cash into the local economy. Many local people will benefit immediately, from jobs or service provision (such as accommodation). Other people will take longer to find a foothold in these projects or in their induced impacts.

Once these projects commence, the cost of living is likely to increase.[119] Inflation tends to have a greater impact on the poor than on more wealthy community members. Local inequality will intensify because of the rising prices of local commodities, notably food, housing, services and strategic items (such as car parts). This affects all local residents, including those who do not earn the higher wages paid by the Boegoebaai companies.[120] Over time, those people involved in the wealth boom can ride out these price increases, or can even benefit from them; other community members tend to experience an erosion of their incomes.

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112 This point was added as a response to public reviewer comments.
113 Dunne, J, 1986, , Regional Development Strategy for Namaqualand, p. 102.
114 COGTA, *Namakwa District Profile*, p. 5. This included the Hantam and Karoo-Hoogland LM areas.
115 National Treasury, MSEP reports, Richtersveld, Nama Khoi, Khai-Ma, Kamiesberg LMs 2024.
116 Mutanga, S et al, National Food and Nutrition Security Survey.
117 Berzborn, S and Schnegg, M, 2007, Vulnerability, social networks, and resilience.
118 Berzborn, S, 2007, The household economy of pastoralists and wage-labourers in the Richtersveld.
119 Chapman, R., et al,. Resource development, local adjustment, and regional policy.
120 Christopherson, S. and Rightor, N. 2011. How shale gas extraction affects drilling localities, p. 359.

Landowners who lease their properties to shale gas companies would gain financial rewards. Inequality will intensify.

7.4.4 Housing and spatial planning

Richtersveld LM will bear the brunt of future housing shortages triggered by the Port or the GE complex.

In Richtersveld LM, there is a backlog of about 160 houses, where the households currently reside in informal dwellings or shacks.[121] About 20% of the Richtersveld population do not have access to piped water. There is a backlog of 602 households making use of pit latrines, bucket systems or composting toilets. About 70 households have no access to phone communication. Compared to other municipalities, this housing backlog does not seem large, but for a municipality so financially constrained as Richtersveld, the need for 160 houses does pose challenges.

In 2024, the Northern Cape Government was planning to build sub-economic homes in the following communities in Namakwa District, but none were earmarked for Richtersveld. Similarly, in the Namakwa Spatial Framework (2023), there was no provision for Richtersveld housing provision. Other towns were identified for housing expansion (see Appendix A). This is not necessarily unfair or unjust, since housing needs may well be greater in other municipalities; but it does suggest that housing expansion in Richtersveld, as a result of the Port or GH2 complex, will have to be done extremely rapidly – to provide for existing needs as well as the influx of employees.

Currently, water supply in several Richtersveld settlements is very constrained. The Namakwa District SDF has proposed a bulk Water Supply refurbishment in Port Nolloth (presumably the boreholes), and replacement of asbestos cement pipes. Several towns draw water directly from the Orange River (Sanddrif, Kuboes, Brandkaros, Beauvallon, Alexander Bay and Port Nolloth). The water is used for household consumption and agricultural activities as well as industrial activities such as diamond mining. Because of the long pumping distance, this water is expensive to provide. Other towns also rely on boreholes (Kuboes, Lekkersing, Eksteenfontein, Port Nolloth, the commonage area of the Richtersveld municipality, and the Richtersveld National Park). Kuboes, in particular, faces challenges, and Port Nolloth has insufficient supply during the holiday season.

Remarkably, in the light of the water shortages, the Richtersveld LM plans to eradicate VIP and UDS toilets, presumably in favour of water-borne sanitation.[122] This will increase the need for wastewater treatment plants. In contrast, the Karoo Regional SDF, sponsored by the Department of Agriculture, Land Reform and Rural Development (DALRRD), argues for dry sanitation.[123] The issue of sanitation technology is typically a very sensitive policy matter. Local municipalities and communities often reject any technologies other than water-borne sewerage, because such technologies are seen to infringe human dignity. However, water-borne sewerage has massive financial and management implications, that such communities cannot afford.

The Transnet Boegoebaai report makes the following housing proposals for housing construction in the Port/GH2 area:[124]

- Housing: Facilitate the development of 1 680 new housing opportunities for construction workers
- 220 new housing opportunities for the permanent Transnet families to live in the area
- Assisting the informal settlement community development in Sanddrift.

This level of housing and infrastructure provision will not be easy or rapid. Housing needs to be considered in the context of spatial planning. Some of the challenges in Namakwa District are: Growing human settlement backlogs; growing informality (due to unmet demand for formal houses); poorly sited informal settlements, often located in high-risk areas, e.g. flood plains, exposed to fire and erosion, or in sensitive environmental areas; lack of spatial transformation and integration with the rest of the urban fabric; delays in tender processes; shortage of serviced stands ; Insufficient funds resulting in certain services (such as

[121] Richtersveld LM, *Spatial Development Plan*, 2024, p. 127.
[122] Richtersveld LM, *Spatial Development Framework*, 2024, p. 182.
[123] DALRRD 2021, Regional Spatial Development Framework, p. 124.
[124] Transnet, Boegoebaai Port Development Social-Economic Benefit Report, 2024, p. 55.

septic tanks) not being installed; and historically, houses were not built up to standard.[125] Consequently, the Namakwa Spatial Framework advocates to prioritise the upgrade of informal areas by expanding basic services such as water, sanitation, electricity and waste removal.

Municipalities have to do urban planning within a new planning framework, the Spatial Planning and Land Use Management Act (SPLUMA) (2013). Every Local Municipality needs to develop a single, integrated Land Use Scheme.[126] Municipalities also have to set up decision-making bodies, called Municipal Tribunals, to consider land use management applications. SPLUMA requires municipalities to determine spatial planning categories in land-use planning. Existing zoning scheme regulations have to be amended or upgraded to include these new concepts. In this context, SPCs A, B and C areas refer primarily to the natural landscape, while SPCs C, D, E and F refer primarily to human-made landscapes.

- SPC A: CORE CONSERVATION AREA.
- SPC B: NATURAL ENVIRONMENT BUFFER AREA.
- SPC C: AGRICULTURAL AREAS.
- SPC D: URBAN AREAS.
- SPC E: INDUSTRIAL AREAS.
- SPC F: SURFACE INFRASTRUCTURE.

In terms of SPLUMA, "Land use management" includes sophisticated new approaches to activities such as land-use changes, e.g. rezoning a property from residential to commercial use; "green fields" development, i.e. on previously undeveloped land; the subdivision and consolidation of land parcels; the upgrading of informal settlements and neglected city centres; public-private partnerships; preventing negative effects on natural habitats, cultural landscapes, and air and water quality; preventing overcrowding and unsafe building construction, and negative impacts on the health and safety of neighbours; efficient infrastructure provision; traffic management; determining property values for purposes of rating, which in turn affects municipal revenue; aesthetic and heritage concerns; and promoting investment. [127]

This kind of planning capacity, involving sophisticated GIS technology, does not currently exist at municipalities, and is likely to become a planning bottleneck. The Department of Land Reform and Rural Development (DLRRD) is assisting the Namakwa DM as well as the Nama Khoi and Richtersveld Local Municipalities to compile the basic research and documentation, possibly in anticipation of rapid development rollout associated with the Boegoebaai Port and GH2 complex. The Richtersveld Land Use System was drafted in 2022, and will form the basis for land use management in the Municipality. A Land Audit has been compiled for the Richtersveld LM, through desktop analysis using a GIS platform.[128] However, for Richtersveld LM to undertake such planning activities in the near future is a daunting prospect. It typically takes years, and skilled staff with local knowledge, to build up such planning capabilities.

In addition, the Namakwa DM Spatial Framework proposes green practices for new projects, These novel techniques are not established in the Namakwa area, and it will be up to designers associated with the Port and GH2 facilities to incorporate these desiderata into their designs.[129]

The Namakwa District Spatial Framework urges Local Municipalities to compile or upgrade their Human Settlement Plans, which would prioritise housing projects in the towns with the most urgent demands. This can then be aligned with the Northern Cape Government's Department of Human Settlements. However, the rapid growth of Port Nolloth, Boegoebaai and Alexander Bay will require these planning processes to be *undertaken at the same time* as building new project premises and immediate requirements such as employee housing.

For the Port and the GH2 complex, there are four possible employment scenarios, with different housing requirements:

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[125] DALRRD, Namakwa Spatial Framework, 2023, p. 96.
[126] DALRRD, *Namakwa Spatial Framework*, 2023, p. 122.
[127] DALRRD, *Namakwa Spatial Framework*, 2023, p. 127-8.
[128] Richtersveld LM, *Spatial Development framework*, 2024, p. 152. It identifies current land uses, environmentally protected areas, arable and non-arable soil potential, traditional authorities and land, land ownersh+ip, mining applications, land reform projects, township establishments, and areas under renewable energy production or licence applications.
[129] Including using rainwater harvesting for indoor use, and minimising water use in buildings; using durable materials and generating less waste; managing indoor temperatures through building design; renewable energy and low carbon technologies for building supplies; solid waste recycling; greywater use for gardens; and solar panels for electricity.

- Recruitment of expatriate and South African professionals, who would stay in local hotels or guest houses. For small towns to absorb such staff, often staying for weeks or even months, would pose massive challenges for local housing provision, with limited available guest houses or hotels. They may be booked out for months or years by construction companies and other specialists. This would squeeze out tourist visitors. [130]

- Some longer-term technical specialists may bring their families and would require rented homes. This may offer a windfall to homeowners, renting out premises at premium prices; this in turn may force out families who were already renting houses. The existing housing shortfall will be exacerbated, with deleterious social consequences for families without adequate accommodation.

- General workers will either continue to live in nearby towns and be transported to work on a daily basis. Alexander Bay is a likely housing centre.

- In-migrants may live in back-yard shanties or informal settlements, placing more strain on water, electricity and other municipal services.

The experience of sudden in-migration linked to large projects (such as mines and ports) is called the "boomtown" phenomenon. Boomtowns are associated with rapid inflows and outflows of investment capital, labour, material and infrastructure. Subsequent "busts" can either be rapid and catastrophic declines (for example, when a mine shuts down), or a slow process of down-scaling, or simply a transition from a construction phase to a less labour-intensive phase of energy production[131] One of the key variables affecting the economic and social future of receiving towns is their ability to promote economic diversification, to act as a hedge against sudden declines.

The main direct impacts are likely to be in the Boegoebaai, Alexander Bay and Port Nolloth areas. This zone is likely to become industrialised, modernised and face heavy traffic and housing pressures. Daily commuting from Port Nolloth and Alexander Bay to Boegoebaai will be intensive. Road traffic from Springbok will be heavy, to transport materials for construction, as well as project staff. More remote communities will experience indirect impacts, such as community members travelling to Boegoebaai, probably on a weekly basis, as well as improved transport systems and social services, due to improved municipal financial resources. [132]

Boomtown dynamics are almost inevitable, and would require an effective multi-sectoral municipal team (with District and provincial support) to manage. There will be a housing shortage. It will be critically important to identify new residential land, and to service it (provide water, electricity, sewerage etc) for new housing construction, to take the pressure of housing demand (as was the case in Kathu, for example). This requires municipal policies and skills regarding land acquisition, servicing, and sales - which the Namakwa District Municipality could assist. Targeted Provincial funding needs to be mobilised in a variety of sectors (housing, transport, health and education), but Government may also require private consortium members to provide key services (such as adequate worker housing and community programmes).[133]

In the context of the Port and GH2 projects, the influx of workers during the construction phase could alter the social fabric of small towns. In addition, the influx of job seekers and logistics traffic strains local municipal infrastructure, which is designed for a smaller population. This leads to skewed housing availability and speculative rental markets. The resulting pressure on existing infrastructure, especially residential water and sewerage systems, requires additional resources for upgrades—resources that underfunded rural municipalities often lack. [134]

[130] However, there may be a beneficial impact: If construction companies sign long-term leases with local guest houses, so that they can be assured of a steady flow of income over several years, they could use this income to add to their accommodation facilities in order to maintain the tourism market. This would add to the local building boom, and create further market distortions, but it would mean that the local economy invests in diversification.

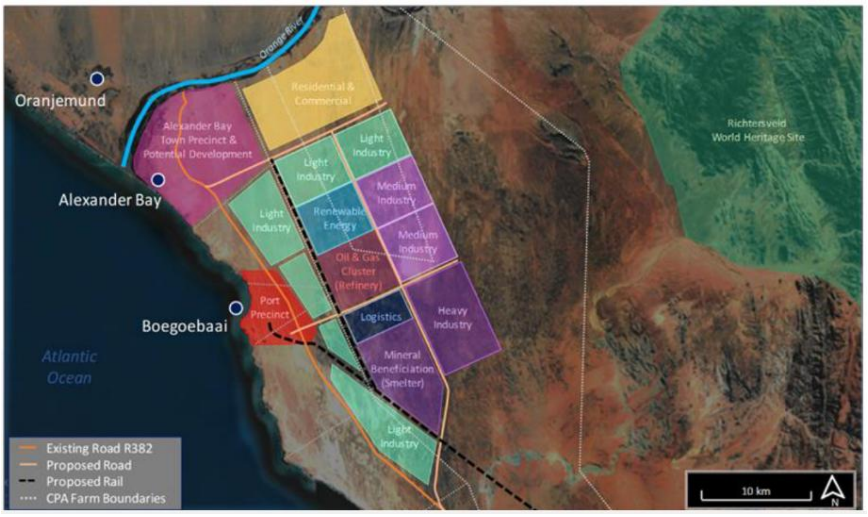
[131] Jacquet, JB, 2009. Energy Boomtowns & Natural Gas, p. 24.

[132] This point was added as a response to public reviewer comments.

[133] This point was included as a response to public reviewer comments.

[134] Wesso, R et al, 2023. Green Hydrogen Community Development Toolkit.

A new "boomtown" area: Intensive housing and industrial developments planned for Alexander Bay and Boegoebaai[135]



The "boom" impacts depend significantly on the speed and scale of industry growth in a given community. A fast pace of development means that more workers will be required per year, with more housing, infrastructure and road usage needs, which will be more difficult for local communities to manage. A slower pace of development will be less disruptive and will extend economic benefits over a longer period of time.[136] Other factors affecting the pressures of a boomtown are the existing housing capacity of a community before a project begins; companies' policies on providing their own staff housing; and the availability of local skills relevant to the operations of the project.

As a result of the inflow of employees, there will be pressure on housing and infrastructure, increases in the cost of living (and subsequent impacts on local poverty levels), and the potential squeezing out of other alternative economic options. Almost all towns in the study area already experience housing backlogs (Alexander Bay is an exception), due to inter-town and farm-town migration trends. Once some work-seekers from elsewhere secure jobs and a foothold in the local town, it will encourage other people from their towns of origin to follow suit. The rise in incomes could lead to a property boom, with increased house prices. This, in turn, could increase municipal revenue from the rates base, in the medium term (houses are re-valued every five to ten years for rating purposes).

Migrant workers who are unable to afford high rental prices resort to living in townships as backyard dwellers or establish informal settlements on private land. Unplanned migration and population growth disrupt the municipality's ability to implement effective spatial planning and secure financing for bulk infrastructure development.[137] Slow Government progress regarding land release for worker housing can create development bottlenecks and delays, due to complex and time-consuming approvals processes. [138] Rapid housing price increases can launch a property construction boom with inflated house prices; however, these entrepreneurs may then face rapid declines in property values once the construction phase tapers off.

Boom towns have far-reaching impacts. Housing shortages and high living costs generate significant economic insecurity, especially among already vulnerable populations and those on low or fixed incomes, including the elderly[139]; with some poorer people becoming subject to homelessness, overcrowding or being forced out of town.[140] As a result of rising housing costs, cheaper housing options such as caravan parks, tents and garages may be sought by long term residents.[141]

With large projects, boomtown dynamics are almost inevitable, and would require an effective multi-sectoral municipal team (with District and Provincial support) to manage. There will be a housing shortage; however,

[135] DALRRD, Spatial Development Framework, 2023, p. 117.
[136] Kelsey, T.W. et al, Economic Impacts of Marcellus Shale in Pennsylvania, p. 13.
[137] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development.
[138] Haslam-McKenzie, F. 2013. Delivering Enduring Benefits from a Gas Development.
[139] Ryser, L. and Halseth, G. 2011, Housing Costs in an Oil and Gas Boom Town.
[140] Ennis, G., Tofa, M. and Finlayson, M. 2014. Open for Business but at What Cost
[141] Chapman, R et al, 2014. Resource development, local adjustment, and regional policy.

it is important to identify new residential land timeously and to service it (provide water, electricity, sewerage etc) for new housing construction, to take the pressure of housing demand (as was the case in Kathu, for example). This requires municipal policies and skills regarding land acquisition, servicing, and sales - which the Namakwa District Municipality could assist. Targeted Provincial funding needs to be mobilised in a variety of sectors (housing, transport, health and education), but Government may also (and should) require private consortium members to provide key services (such as adequate worker housing and community programmes). [142]

The Richtersveld LM (with the support of the Namakwa DM and COGTA) should pro-actively release land for housing, and install infrastructure, so that the project companies can erect housing, or in-migrants can build informal housing if required (in the short-term), or the municipality provide public housing (in the longer-term). Bulk and reticulation infrastructure, such as water, electricity and sewerage infrastructure, as well as local streets and stormwater drainage, must be built rapidly to cope with the additional demand.

7.4.5 Health

Generally, in our study area, the health profile is quite good: The infant mortality rate and under five mortality rate are low; acute malnutrition under five is low; and immunisation rates are generally over 80%.[143]

There will be three major challenges regarding the health impacts of the Port and GH2 complex. The first is the sheer enlargement of the local population; new arrivals will need access to clinics, doctors, and hospital facilities, for illnesses as well as injuries. Port Nolloth already has a hospital, with a fairly diverse range of services.[144] However, barely a year after opening its doors, the Martha Griffiths Hospital had run out of supplies, and appealed to the public for donations.[145] Cash flow problems in the Northern Cape Department of Health had reached critical levels.

Secondly, the new construction and operations staff of the Boegoebaai projects may be vulnerable to accidents, which require more sophisticated levels of trauma treatment.

The third major issue will be the management of HIV/AIDS, particularly in the context of the closure of PEPFAR-related services by the United States. The key to the successful HIV/AIDS management programme has been early detection of cases, so that people can go on treatment before they develop a heavy viral load. This work was done by NGOs in the past, and there is no clear strategy yet for the Government to meet his gap.[146] Without such early interventions, there is the prospect of rising numbers of new HIV cases, more hospital admissions, and inevitably deaths.

The real difficulty in maintaining ART roll-out is called “disengaging from care”, i.e. people dropping out of their ARV maintenance programme. Such “disengagement” is linked to factors like frequent relocations (visiting new clinics), and engaging with an inflexible state healthcare system with long waiting times. Patients may have mental health challenges, lack of family or social support, work commitments, and transportation costs. While people are disengaged from care, they can transmit the virus. In this respect, NGO work had been crucial. Without more assertive government service delivery and encouraging people to re-join treatment programmes, the impact on the population of Namaqualand may well be dire. The longer someone interrupts their treatment and the more times this happens, the more they are at risk of opportunistic infections, severe complications, getting very sick and needing costly hospitalisations. Clinics need to provide friendly, professional services that encourage people to return to and stay on treatment, and

[142] This point was added in response to public reviewer comments.
[143] National Treasury, MSEP reports, 2024.
[144] Including a trauma unit, radiology, dispensary, psychiatric ward, maternity wards and paediatric wards. Consultation rooms will be used for reproductive health services, a psychologist, and dietician. https://www.vukuzenzele.gov.za/new-health-centre-port-nolloth
[145] https://www.news24.com/news24/southafrica/news/its-time-to-help-where-we-can-state-run-northern-cape-hospital-appeals-to-public-for-donations-20231121
[146] Ufrieda Ho, Closing the gap: South Africa’s ambitious strategy to add 1.1 million on life-saving antiretrovirals, *Daily Maverick,* 6 March 2025.

services need to be flexible. These could include more external medicine pick-up points, scripts filled for longer periods, later clinic operating hours, and mobile clinic services.

At least 27 000 people in Namakwa district are already on ART (including 4 228 in Richtersveld; see Appendix A). Every year, around 40 people in Richtersveld join the programme, largely due to proactive HIV-testing services (which are likely to end now). There is a danger that increasing HIV infections and illness may reduce employment of local people on the Boegoebaai projects.

The local Hospital and HIV/AIDS are likely areas where Boegoebaai CSI funding could assist. The Transnet SEB report proposes various interventions to support clinics (see Appendix A). There would also have to be a fast and reliable ambulance service from Alexander Bay to Port Nolloth, or to Springbok, particularly in the light of more working people in the area.

7.4.6 Education, skills and training

By the 1980s, little economic diversification had taken place (away from mining). Employees had gained few skills that were readily marketable for other industries. This reduced their options to obtain employment outside the area. Education options for children were very limited, also restricted by distance and poor roads.[147] In 2019, in contrast, 31% of the people older than 20 years in the Namakwa District had a matric or higher qualification. Many more schools had been established by 2022. Rapid progress had been made.

Yet a significant education deficit still remains: A total of 17% of the population older than 15 years had not completed Grade 7, and are therefore not functionally literate.[148] A large number of young people drop out of the education system between Grade 6 and 9.

About a fifth of the adult population had **matric passes** in 2011, and this has improved to about a quarter of the adults in 2022. (This trend is also reflected in the Namakwa District area as a whole, where matric rates improved from 19% to 26%; see Appendix A for statistics). However, the standard of maths and science teaching is often not adequate to enable learners to qualify for tertiary education, particularly at university level.

A study of over 300 respondents in Port Nolloth found that 27% had completed matric, and 7% had some form of tertiary training, which included useful skills such a boiler makers, motor and diesel mechanics, plumbing and welding.[149]This suggests that there is a reasonable pool of potential employees who can be trained for semi-skilled and technical jobs. However, a different conclusion was drawn by Nzo and Mahabir (2023): "The low levels of education and low skills base (see Appendix A) paints a worrying picture about the ability to attract the requisite skills from local communities in the development of the green hydrogen project".[150] It is not clear what the conclusion should be, faced with such statistics. Much may depend on the age of matriculants, where they live, how mobile they may be, and how desirous they may be for further training.

The Transnet report (2024) proposes several CSI measures in the education sector, including new creches, support for primary and high school learners, assisting in the creation of another high school, and launching a tertiary training facility in Port Nolloth (See Appendix A).

A TVET College (Technical and Vocational Education and Training) operates in Okiep, just north of Springbok. It is part of the Northern Cape TVET system (which also has campuses in Kuruman, Kathu, De Aar, Kimberley, and Upington). There are 27 lecturers and space for 580 students.[151] Hostel accommodation is provided for about 100 students. Bursaries are available from NSFAS. Courses are offered at pre-matric and post-matric levels (see Appendix A for details).

147 Dunne , J (1986), Regional Development Strategy for Namaqualand, p. 95.
148 COGTA, Namakwa District Profile, n.d., p. 5.
149 Fourie and Oppel, *Socio-economic Study*, p. 32.
150 Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 14.
151 https://ncrtvet.com/namaqualand-campus/

The Office of the Premier is spearheading at least two catalytic training projects in Springbok, funded by the Services SETA and the Manufacturing, Engineering and Related Services SETA.[152] These programmes should be expanded to reach all Namaqualand towns.

The Transnet CSI proposals include an agricultural training college in Port Nolloth. While this reflects the importance of agriculture in the area, the urgent need will be for another branch of the Springbok TVET college. This will mean that all students will be assured of a job as soon as they qualify. It will also benefit the industries who would not have to attract suitable staff from far away.

In the meantime, the Namakwa District Municipality and the University of the Western Cape (UWC) have already formalised a Memorandum of Understanding to collaborate on green hydrogen technologies and renewable energy initiatives. The partnership aims to position the Namakwa District as a leading hub for GH2 production, creating employment opportunities and providing specialised training in the sector. It will focus on outreaches at high schools and university students, particularly those pursuing careers in engineering and chemistry.[153] This seems a very promising start, and could serve to launch a TVET branch at Port Nolloth.

7.4.7 Social cohesion and social services

In Transnet's analysis, the potential socio-economic benefits of the Port were flagged as key "public good" benefits of the port. This includes health care, education, stakeholder and youth excursions, environmental programmes, benefiting the aged, early childhood development, employment creation and skills development, and addressing substance abuse and Foetal Alcohol Syndrome.[154] There are already widespread social challenges.

Namaqualand has always been poor. Janeen Dunne described the prevalent psycho-social problems in Namaqualand in the 1980s: Low aspirations; apathy; conservatism; community divisions and envy, which inhibit innovation; the Apartheid legacy of inadequate financial capital for housing, farming and businesses; inadequate housing supply; limited local government revenue streams; weak agricultural markets and limited farm production; churches hampered by low financial resources and long distances; and municipalities staffed by people with limited skills.[155] In the last forty years, there have been some improvements, due to social grants, tourism developments, and improved government services.

Particularly in the urban areas, there is widespread dependence on social grants. There is also social decay, and abuse of drugs and alcohol. This creates many social ills, especially amongst the youth, including teenage pregnancies. Recreation centres, after-school and youth care centres, rehabilitation centres and other forms of social support will be required to enable communities to make use of new opportunities.[156]

This general picture may appear rather dismal, but the local population is also resilient. There are strong social norms, particularly on the communal lands. While many analysts point to the "tragedy of the commons" phenomenon, where individual self-interest undermines collective management of common resources, there are indeed strong principles which resource users adhere to, such as birthright access to grazing resources, access to stock-posts, and access to water points.[157] Significantly, the Port Nolloth area is generally listed as a relatively safe area.[158] In the ten-year period between 2008 and 2018, overall crime decreased at an average annual rate of 2% in the Namakwa District Municipality.[159] Due to a lack of

[152] Northern Cape, Office of the Premier, Memorandum to NCOP. Services SETA focuses on sectors such as personal care; real estate; communication and marketing; management and business; labour (employment agencies); cleaning and hiring (office machinery), equipment and rental leasing; renting of construction or demolishing equipment with operators; renting of personal and household goods; function and catering equipment hire; truck and plant hire. MERSETA focuses on metals, auto, tyres, plastics and components manufacturing.
[153] Box, H. 2023. Namakwa District Municipality and UWC sign Green Hydrogen MOU.
[154] Transnet (2024), , Boegoebaai Port Development Socio-economic Studies: SEB Report, p. 7.
[155] Dunne (1986), J, Regional Development Strategy for Namaqualand, p. 180-197.
[156] Nama Khoi LM, *Spatial Development Framework*, 2025, p. 87.
[157] Allsopp, N et al, Environmental perceptions and practices of livestock keepers on the Namaqualand Commons challenge conventional rangeland management.
[158] Northern Cape, 2022, Provincial Spatial Development Framework, p. 49.
[159] COGTA, *Namakwa District Profile*, n.d., p. 17.

research, the patterns of social cohesion in Namaqualand, particularly in the urban areas, are not well understood.

The "boomtown" scenario has already been used to describe the experience of small towns when large projects are located in the vicinity.[160] The social challenges potentially caused by "boomtown" conditions should not be underestimated. The 'social disruption' thesis[161] argues that rapid economic and demographic changes associated with large-scale projects lead inevitably to social and psychological dislocation and a breakdown of established community social structures. The rapid pace of development stretches services and infrastructure, can undermine a sense of community and belonging, and can contribute to problems such as drug use, crime, alcohol abuse, domestic violence and suicide.[162] Socio-psychological impacts can be pervasive and diffuse, and can include an increased sense of insecurity, uncertainty, injustice, anger and family stress, either during the start-up phase or during a later down-turn. These, in turn, can affect the motivations, goals and decisions of community members.[163]

The cost of living will increase, as new demand for housing and commodities works through the local economy. However, this will be balanced by local employment (on the projects or secondary industries), which will increase people's cash resources. However, this will, in turn, cause the cost of living to increase even further. The important policy principle is to increase the diversity of opportunities for local people to earn these new wages, so that they can afford more expensive goods and services. It is also likely that the local economic growth will lead to investments that may *reduce* local prices, e.g. chain stores (with competitive prices) opening their doors in Port Nolloth. As more money circulates in the economy, new niches will open for informal and semi-formal occupations, such as child-minding, catering, vehicle maintenance and caring for the elderly. Local economic multipliers are likely to increase opportunities, although in a context of higher prices, and possibly an increase in social inequality.[164]

Inequality is often associated with (and confused with) severe poverty experienced by some strata of the community. Inequality can be either exacerbated or reduced by large projects, depending on how proactively local systems of empowerment (e.g. technical training) are undertaken. It is possible that the multiplier effects of the projects may entail greater levels of prosperity for almost all social strata, but that high levels of inequality may remain (everyone is somewhat richer, but some people are significantly richer than others). For example, the projects would pay municipal rates and taxes, which can ploughed into improved housing schemes and recreation facilities; however, inequality will remain because people with high-level jobs and skills will earn more than before. Poverty may be reduced, but levels of economic inequality may remain, or even increase.[165]

Boegoebaai employees who are long distance commuters may remain on the worksite ("man-camps"), where all accommodation, meals, entertainment and other amenities are provided. They may work for the main project companies, or for related services such as catering, transport, or construction. Typically, these migrants are male. For the commuters themselves, the system of single worker migration can be positive (e.g. extended leave, no interruption to family's residence, it does not affect their children's education, high incomes, camaraderie, career opportunities), but also bring negative consequences (loneliness, marital strain, anxiety and possible alcohol abuse). Facilities may be rather primitive during the construction phase.[166] Newcomers often bear social hardships, including substandard living conditions, stress from moving to a strange and isolated community, and social isolation from hostile old-timers.[167]

[160] Nzo, T (2021), Whose Power Is It Anyway.
[161] England, JL and Albrecht, SL, 1984. Boomtowns and social disruption; Lawrie, M., Tonts, M. and Plummer, P. 2013. Boomtowns, Resource Dependence and Socio-economic Well-being.
[162] Chapman, R et al, M. 2015. The resource boom and socio-economic well-being.
[163] Loxton, EA et al, 2013. Exploring the social dimensions and complexity of cumulative impacts; Shandro, JA. et al, 2011, Perspectives on community health issues and the mining boom-bust cycle.
[164] This point was added in response to public reviewers.
[165] This point was added in response to public reviewers.
[166] Misan, G.M. and Rudnik, E. 2015. The Pros and Cons of Long Distance Commuting.
[167] Pershee, J.P. 2011. North Dakota Expertise; Filteau, MR 2015. Go back to Texas, Gas Bastards!

Local communities would experience a rapid influx of newcomers, with different values, habits and needs. An increase in traffic and overcrowding may worsen their sense of physical insecurity, and face-to-face relationships become more distant.[168] Towns are suddenly flooded with strangers.

The rapid influx of people tends to loosen social ties, with a constant population churn. Community leaders complain that there is limited sense of community commitment, thus contributing to a sense of transition and 'shallowness'.[169] In rural communities, farmers may also perceive a threat to their social status as the most culturally and economically significant sector of the community, causing resentment and disorientation.[170] In boomtown conditions, tensions can arise between new in-migrants and old-timers.

There is a *prima facie* argument that benefits will not be distributed *equally,* due to factors such as geographic distance, average age of community populations, previous job experience, technical skills, and willingness to take on training. Another question is whether benefits will be distributed *equitably*, i.e. reasonably accessible to communities and demographic categories. Young people who are willing to enter training programmes will benefit significantly; older people without technical skills may be willing to take on manual labour jobs (also at different levels of skill). Some people will benefit more from on-the-job training and promotions than others. Individuals with an entrepreneurial mindset may work for other sectors (e.g. business services, catering or transport). It is likely that a small number of people in distant communities will respond to these opportunities, thereby increasing remittances to their communities. Some people will not benefit directly at all (e.g may not have skills, or have health to do manual work), but may enter the economy by home-based or local support services (e.g. childcare). To enable such an economic ecosystem to be *equitable*, as many points of entry should be made available as possible (e.g. by backward and forward linkages), and many types of support should be provided (e.g. childcare training). The more imaginative the private companies and the government agencies are, and the more they can spend CSR funding effectively, the more equitable the outcome will be.[171]

Social tensions are likely to increase, often in unexpected ways. However, many of these communities currently have high levels of underlying social tensions already, which are not very visible, because the status quo remains intact. With a new project, the same tensions, or new tensions, will emerge. That is always the case in any form of material progress or change. Again, the crucial challenge is to ensure that institutional capacity is improved to deal with it, e.g. additional police (and better police management); more social workers; more family and community health facilities (e.g. better staffed clinics for family planning, HIV/AIDS management); and new youth training and enrichment facilities to prevent delinquency and teenage pregnancy.[172]

Social identities may change rapidly. Local people who do get jobs on the new projects may soon develop a new identity for themselves, based on place and circumstances of work. Other cultural identities may take longer to change, or may even become reinforced (e.g. traditional-minded people who share a common dislike of the new developments). The strongest driver of new identities will be new workplace experiences, including blue collar workers (and trade unions), white-collar employees and sectoral service providers (eg. transport contractors).[173]

As boomtown conditions set in, communities are likely to experience different stages in their reactions.[174] Initially, officials and residents may be *enthusiastic***,** as they look forward to the economic impacts of job growth and retail spending, while the possible negative impacts are either unknown or are dismissed as unlikely in their specific area. When the new workers arrive in noticeable numbers, the town may experience some *uncertainty*, and people begin to become aware of negative impacts. Divisions may emerge within the community as to whether the growth is detrimental or beneficial. As the changes speed up, the community may experience *near panic,* with people becoming confused and angry with one another. Government services are overwhelmed and quality of services declines; any prospects of increasing revenues look

168 Jacquet, JB, 2009. Energy Boomtowns & Natural Gas, p. 24.
169 Chapman, R et al, Resource development, local adjustment, and regional policy.
170 Jacquet, JB, 2009. Energy Boomtowns & Natural Gas, p. 24.
171 This point was added in response to public reviewer comments.
172 This point was added in response to public reviewer comments.
173 This point was added in response to public reviewer comments.
174 Jacquet, J.B. 2009. Energy Boomtowns & Natural Gas, p. 12.

uncertain or remote. Finally, as the core problems are identified and planning or mitigation strategies are developed, the community *adapts* and accepts the reality of the situation.

Sometimes these phases can be experienced almost simultaneously, in different sectors of the community, creating a plethora of community responses which give rise to tensions and policy disagreements. Young people may face mixed impacts, with greater job opportunities, but also increased crime and overcrowding of schools. Marginalisation of local people can take place, on account of their lack of experience in the project activities.[175] Local government representatives may be caught up in this stressful environment, taking strong stands on different issues.

An influx of temporary workers (mainly young men with disposable income) can negatively affect community cohesion, increase the cost of living, and be associated with higher levels of alcohol and drug use, mental illness and violence. Such negative effects typically fall disproportionately on community members least able to bear them. An extensive literature[176] shows that boomtowns are often associated with higher mental health caseloads, crime, divorce, suicide and alcoholism, as compared to non-boomtowns.[177] Currently, local health clinics in South Africa are poorly resourced in dealing with mental health issues.

There are also potential security concerns. There are at least six kinds of crime-related risks potentially related to boomtowns:

- Crimes against property and people committed *by in-migrants* who cannot secure work – this could be against project staff as well as local people;
- Crimes against in-migrants (professional and unskilled workers) *committed by local people* who are unsuccessful in finding work, particularly if they are extremely unskilled or cannot hold down a job, and if they believe that in-migrants are "stealing their jobs";
- *Domestic violence* caused by the disruption of sudden new household revenue streams, and poor spending habits of family members (e.g. excessive alcohol consumption);
- *Increased social pathologies* such as prostitution, in the context of many young men in the locality with income at their disposal. This, in turn, can lead to an increase in unwanted and teenage pregnancies;
- Crimes committed against in-migrants *by locals* as a form of xenophobia; and
- The increase in traffic and in-migrants may lead to an increase in livestock theft.

Local traffic, including scholar transport, medical transport, agricultural goods freight, tourism and other current road traffic will be severely impacted. We argue strongly for a rail link (Postmasburg to Boegoebaai) to be considered as an intrinsic component of the port project. Small towns in the study area will have to expand their traffic management capability significantly due to much greater traffic pressure and more violations.[178]

Various mitigation strategies are possible, depending significantly on the capacity of policing and social support agencies. These are significant challenges.

Communities may be fairly adaptable to large-scale and rapid changes. Over time, communities are likely to experience significant shifts in their sense of contentment and social cohesion. This may initially take the form of declining social cohesion, but later they may evolve a greater sense of acceptance and a restoration of social networks.[179] The Transnet study proposed several CSI interventions, including the provision of community halls, libraries and sports facilities (see Appendix A).

Port Nolloth should be reserved primarily for project staff who are accompanied by their families. This will help to support the local schools, churches and other amenities. The Namakwa Spatial Framework made the following proposals for social development: Training centres in Okiep and Alexander Bay; "Soft outreach"

[175] Negi, R. 2014. 'Solwezi Mabanga': Ambivalent Developments on Zambia's New Mining Frontier.
[176] Jacquet, J.B. 2009. Energy Boomtowns & Natural Gas
[177] Raimi, D. 2012. The Potential Social Impacts of Shale Gas Development in North Carolina.
[178] This point was added in response to reviewer comments.
[179] Brown, RB et al, 2009, The Boom-Bust-Recovery Cycle.

(School awareness, stationary handouts, book donations); addressing the social ills of alcoholism; extending a local radio station signal; creating an SMME fund; and promoting sport, fishing, and livestock farming for subsistence and commercial purposes.

7.4.8 Economic support for local communities

The essence of a boomtown is that a large amount of capital suddenly enters local communities, and the prospects of jobs and money are multiplied, often to unimagined levels. However, this does not mean that all community members are employable in the new jobs, or can compete with in-migrants, or can manage the training processes required for such jobs.

Investment in economic projects, for individual entrepreneurs, SMMEs, NGOs or co-operatives, have the benefit of creating a more diverse buffet of livelihoods options for people with different talents and preferences. These should be tailored to local competitive advantages and suited to local skills and cultural knowledge, where possible.

The Transnet SEB Study has proposed several CSI initiatives, including community gardens, farmers' markets, support for mini-factories, promote technical skills training, and establishing an agricultural college (see Appendix A). For its part, the Namakwa District Rural Development Sector Plan (2023) has identified interventions such as using abandoned mining infrastructure for intensive agriculture development (aquaponics, hydroponics); a mariculture incubation centre at Port Nolloth or Kleinzee; constructing small-scale renewable energy development farms close to Farmer Support Units and other agro-processing plants; and wifi towers close to main fibre networks to improve communications with rural communities. [180]

For each of these proposals, thorough consultations and analysis will need to be done in the community about the appetite and potential uptake of these projects. Where similar projects have been introduced elsewhere in the region, these should be visited to learn about factors to promote and those to avoid. It should not be assumed that, simply because a project makes sense in a consultant's report, that it is feasible in local conditions. Practical experience matters.

Support from other agencies may be available. The Township and Rural Entrepreneurship Programme (TREP) of the Department of Small Business works to overcome the legacy of economic exclusion in rural and township areas.[181]

To benefit fully from initiatives such as Boegoebaai, the business sector needs to be organised, with a structured relationship with government at various levels. This can take the form of Business Chambers in the towns, and also in the region; and the establishment of a Namakwa District Partnership with the District and Local Municipalities.[182] They can work to promote the "ease of doing business" and removing non-essential procedures, forms, licenses and regulations that add to the cost of dealing with government, which tend to create costs and delays.[183]

At this stage, the SEA can pinpoint the main "lines of inquiry" and possible trends. The longer the time period, the more hazardous any proposed trends may be, due to inherent instability of economic conditions, markets, demographic shifts, and political priorities. The risk analysis emphasises the points of concern (for mitigation) and possible benefits (which could be maximised by deliberate policy choices). We can, however, confidently state that the Boegoebaai projects would have a significant impact on social conditions, because of more investment, money and jobs, which would benefit some people more than others, and some people may face increased vulnerabilities (e.g. due to boomtown conditions). One can also state confidently that more tax revenue would be available to municipalities and the Provincial government, which could be used not only to provide safety nets, but also to enhance local people's ability to engage with the projects (e.g. by providing technical training and transport). There is never any guarantee that such tax revenue would be used constructively. At best, one can assert that the chance for constructive use of funds would be greatly improved if there is adequate oversight by other spheres of government, as well as participation of specialist organisations (e.g. SALGA, engineering bodies, etc). In a democracy, there is ultimately uncertainty about the

[180] https://drdlrgovza.sharepoint.com. Richtersveld LM, *Spatial Development Framework*,2024, p. 70.
[181] https://www.sefa.org.za/products/township-and-rural-entrepreneurship-programme-trep-2
[182] DALRRD, *Namakwa Spatial Framework*, 2023, p. 66.
[183] DALRRD, Namakwa Spatial Framework, 2023, p. 58.

quality of public representatives that would be elected. One additional point of reassurance is that the proposed public participation process should **include political parties**, so that they develop experience and appreciation of technical, economic and management issues and options.[184]

7.4.9 Recommendations

There is a great deal of literature and past wisdom which can be gleaned from other sectors, particularly mining, where social impacts of booms (and busts) have been intense.

Various mechanisms are available to bolster local resilience and avoid excessive harm to the social fabric. Unlike the closure of mines, there are unlikely to be such drastic "bust" consequences, as construction processes are likely to be lengthy and sustained over time. It is also possible that assertive upskilling efforts can enable construction workers to join the projects as permanent employees.

These include a combination of South African mining approaches (Social and Labour Plans (SLPs), Social Impact Assessments (SIA), Social Impact Management Plans, United Nations Guidelines on Human Rights, and industry standards on community engagement. In addition, various forms of collaborative governance at local level, where local interest groups can develop shared policies and programmes, will improve social networks as well as government capacity. However, in practice, many mining SLPs have proven disappointing in the past, and therefore their use should be undertaken carefully, in the light of good practice.

In the final section, we offer a range of practical suggestions, drawn from recent political science literature as well as a new Green Hydrogen Community Participation "toolkit".

7.5 MACRO-ECONOMIC IMPLICATIONS OF THE PORT AND GREEN HYDROGEN COMPLEX

The Northern Cape economy has grown over the last thirty years, but the growth *rate* has been steadily declining. For the ten-year period between 2012 and 2022, the average annual economic growth rate was 1.2% per annum. In the latter five years (2017-2022), the average annual growth rate declined to 0.7% per annum. Fluctuations in the mining sector may have contributed to this decline.[185] The GDP of the Northern Cape is a tiny percentage of that of South Africa (about 2,2%).[186]

The economy of the Richtersveld LM is still heavily dependent on mining (with a lack of beneficiation), community services, transport and agriculture/fishing (in that order).[187] This concentration (and the lack of manufacturing) brings economic vulnerability due to factors such as external economic fluctuations, international commodity price changes, and climate change. The overarching priority of the Northern Cape government is to promote additional development drivers through diversification, skills development, infrastructure development, optimised resource utilisation, the empowerment of vulnerable groups and investment attraction.[188] Crucially, this means that sectors such as industry, manufacturing and transport need to be prioritised.

7.5.1 The impact of the Port and Green Hydrogen on Namakwa economic sectors

Historically, the region is known for its livestock farming, alongside its mineral resources, with diamonds, copper, zinc, and other minerals. Increasingly, it is seen as an area rich in ecological, geological and cultural heritage, contributing to its tourism appeal.

[184] This point was added in response to reviewer comments.
[185] OTP, Memorandum to NCOP, 26 August 2024.
[186] Provincial Gross Domestic Product: Experimental Estimates, 2013-2023, www.statssa.gov.za.
[187] Richtersveld LM, *Spatial Development Framework*, 2024, p. 131.
[188] Northern Cape Government, Provincial Growth and Development Plan, 2019, p. 24.

Since the 1980s, the regional economy shifted from mining to almost all other sectors, thereby promoting some diversification. In particular, agriculture, trade, transport, finance, and government now comprise the bulk of the economy (a total of 58%; see Appendix B for sectoral details). Interestingly, construction remained very constrained, suggesting that hard investments in infrastructure and top structures have not grown much.

Namakwa district has faced a long-term economic decline, mainly due to the decline in mining. In 2018, the Namakwa District Municipality had a negative annual growth rate (-0.54%), compared to the South African GDP growth rate of 0.79%.[189] In this rather prosaic economic context, the Boegoebaai Port and GH2 industry will bring a huge injection of entrepreneurial energy. Compared to previous development sectors (diamonds and copper), the Port and GH2 projects will be large, sustained, complex, with a large spatial footprint, and will require a very diverse range of skills and inputs. It will create numerous multiplier causal chains, which will interact with one another in rather unpredictable ways.

The proposed Boegoebaai harbour is explicitly targeted at growing the regional economy: "A new port at Boegoebaai will be a significant direct investment in a sub-region of the Northern Cape which is currently economically depressed. The provision of the port and supporting infrastructure could create temporary construction jobs, a demand for raw materials and, tourism accommodation and support services. A range of new temporary and permanent jobs will be created which will result in significant long term permanent economic growth in the Northern Cape".[190]

The harbour will have several important components, all of which have implications for construction expenditures and employment, as well as long-term operations. This includes building the breakwater, dredging, berths, roads, internal rail, dry bulk and liquid bulk components. For the longer term, there will be administration and technical operations, managing storage facilities, security, and disaster management.

As noted earlier, forward linkages refer to the "product" of the port and Green Hydrogen scheme supplied as a material to another industry. For example, the railway would be available as an asset to local industries and farms, to transport their goods to international markets. Backward linkages refer to the demand for materials and services caused by the Boegoebaai projects, and will include food, household goods, housing and transport services supplied to workers.

The Transnet study has calculated the backward linkages of both the development and operational phases of the Port, combined.[191] The most significant backward linkage is Manufacturing, followed by Finance and Business Services, Transport, and Trade and Accommodation. Government Services will be important, and should be understood as a greater demand for government activities, which will need to be paid for by the increase in taxes paid by the Port and Green Hydrogen Plant (see Appendix B for more data). The total value of backward linkages during the development phase is estimated at R2,3 billion, and R2,1 billion in the operational phase.

There will impact on Agriculture (around 2.5% of backward linkages), which seems fairly small, and is mainly related to food production for the new work force. This means that the impact on agricultural production is in the region of R60 million in the development phase, and R54 million in the operational phase. (Note that this calculation refers only to the impact of the Port, and not the Green Hydrogen dimension). Our agricultural section (below) expresses doubt about the likelihood of meaningful agricultural backward linkages.

Transport systems are likely to be impacted (and benefited) greatly, as backward linkages from the Port. This may well benefit local transport companies (goods and people, in terms of the new workforce). Similar, building and construction would also benefit local service and goods providers significantly. In contrast, the significant manufacturing backward linkages are likely to take place outside Namaqualand.

The Transnet report lists three types of industries connected to ports.[192] Firstly, **port-required industries** such as, port management, port security, stevedoring, supervising entity for the maritime sector, freight forwarder, customs, tugs, dredging, shipowners, mooring services, ship chandlers, coast guard, port authority, etc.

189 COGTA, *Namakwa District Profile*, n.d., p. 19.
190 Transnet 2024, Boegoebaai Port Development SEB Report, p. 5.
191 Transnet 2024, Boegoebaai Port Development SEB Report, p. 19.
192 Transnet 2024, Boegoebaai Port Development SEB Report, p. 12.

These are companies that offer services needed for ships to trade goods. These industries are the focus of the impact assessment, including the development (construction) of the port.

Secondly, **Port-induced industries r**efer to firms that import or export goods from the port, particularly mining and agriculture. They will benefit from lower transport costs and reduced processing time for cargo; they may also benefit from savings due to economies of scale and additional volumes. In our case study, this refers primarily to dry bulk goods in the mining and agricultural sectors. In the case of copper, the ore would come from the Namaqualand area itself; but many other mineral commodities will come from further afield (notably Aggeneys as well as the Kathu-Kuruman-Postmasburg mining complex). A further category would be liquid bulk products (diesel oil, green ammonia, e-kerosene, and methanol), also produced from further away. Finally, there would be containers for general cargo.[193]

Thirdly, **port-attracted industries** including restaurants, hotels, offices, road and rail freight services, commerce, recreational boating, etc. These firms are part of the port economic cluster.

This SEA chapter focuses primarily on **Port-induced and Port-attracted industries**, i.e. the likely spin-offs of the Port (and GH2 complex).

The total investment of R13,6 billion on the port will increase total production in the country with **R27 billion.** Of this amount, about 45% or R12,5 billion will be experienced at the Port site and direct environment (such as quarrying sites). A large impact of "induced" **new business** can be expected, estimated at almost R13 billion. This represents significant multipliers in the region (Richtersveld, Springbok, as well as metropoles further away). In addition, the **multiplier effect of new business** will be massive, at R2.2 billion. For every R1 spent, another R2.20 will be generated by stimulating input industries.

Multiplier effects will be the highest as regards **New Business Development**. Due to the expenditure on worker income, an additional R1,5 billion of value will be created. **Total worker income** will generate R1,7 billion of value, and this will be largely spent on household goods and services, including food, clothing, furniture, housing, and education. Even though the entire sum will not be spent locally, much will be spent by unskilled and semi-skilled workers in the local area.[194]

Taxes are also significant. Municipalities may well benefit from this rates income, but they will also be required to invest heavily in local infrastructure. **Regional broadband connectivity will be improved.**

After the robust construction phase has gone some way, the operations of the Port will commence. For a time, construction and operations will proceed simultaneously. During the Operations phase, the impacts will decline significantly, although it will remain sustainable in the long term.[195]

By 2036, **New Business Development** will reach just over R4 billion, and after multiplier effects are calculated, this will reach almost R9 billion. Total worker income will also have declined, to roughly R0,5 billion, and after multiplier effects will reach an additional R0,14 billion.

The benefits of the Port will be unequally distributed between national (53%), provincial (38%) and local levels (9%).[196] The Transnet report maintains that the most important local benefits will be to wages, construction materials, consumer goods, mining (quarrying), manufacturing, transport and storage, and services. However, there are concerns about the responsiveness of local agriculture and food production systems to this increase in demand; most of the food will be "imported" form main centres such as Cape Town, unless innovative methods are used to stimulate local food production. The main agricultural linkages are likely to be felt in the Western Cape.

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193 Based on Transnet 2024, Boegoebaai Port Development Socio-economic Studies: SEB p. 14.

194 Note that "Cost to Company" (**"Employment**" in the Table), refers to the perspective from the employer. This includes: Salaries and wages, Benefits (health insurance, retirement contributions, etc.), Payroll taxes, Training and development costs; Recruitment expenses' and Employee-related travel expenses. **Worker Income:** This is the money that workers earn from their employment. It includes: Gross salaries and wages; Bonuses; Overtime pay; Commissions; Benefits received (health insurance, retirement contributions, etc.); any other compensation for their labour. **"Worker income" is therefore also included in "Employment".**

195 Transnet 2024, Boegoebaai Port Development Socio-economic Studies: SEB Report, p. 19.

196 Transnet 2024, Boegoebaai Port Development Socio-economic Studies SEB report, p. 20.

Significantly, over time, the product mix of shipments at the Port will change. Initially, it will be more diverse, including general cargo, containers and agricultural produce. Over time, diesel imports, green hydrogen exports, and ore exports (mainly manganese, zinc, lead, ilmenite and magnetite) would upscale. This would be cheaper than transporting these commodities to Saldanha Harbour.

The current plan appears to be that *agricultural exports and general cargo would fall away by 2035, and copper by 2050*.[197] This seems a worrying assumption, since intensive crop expansion along the Orange River (an important economic diversification mechanism) may well expand *because* of a convenient and cost-effective export shipment opportunity at Boegoebaai. **Transnet's intention to phase out agriculture (and other general cargo) should surely be reconsidered**, as it would sacrifice important policy goals (such as promotion of innovative agricultural systems and products, agricultural employment, and food security). Agricultural role-players (Department of Agriculture, Agri-Northern Cape, producer associations) should engage Transnet in this regard. In particular, the large-scale irrigation agricultural production along the nearby Orange River would be a crucial export component, which would make our products much cheaper and fresher to export, compared to the current reliance on the Cape Town harbour.

The Northern Cape will also benefit from cheaper transport costs for diesel imports. This will benefit mining clusters at Aggeneys, Upington, Sishen, Postmasburg, Hotazel and Kuruman.

7.5.2 The importance of economic diversification and local preference policies

The key to Northern Cape future economic plans is sectoral diversification. Manufacturing, agro-processing, mining, beneficiation, energy (including renewable energy), tourism, the maritime economy and the knowledge economy will be the focus areas.[198] Digital innovation will also be key, and strategic partnerships will be prioritised.

Significantly, all these imperatives are impacted upon by the proposed Boegoebaai development. In several cases, the Boegoebaai project will stimulate these sectors directly (energy, mining, manufacturing and trade, infrastructure development, employment and skills development, innovation, and the marine economy).[199] In four other sectors, Boegoebaai could have positive impacts (agriculture and agro-processing, tourism, and rural development), although negative externalities will be felt most significantly in the tourism sector. Broadband telecommunications would be particularly important for the local business community.

The extent and nature of socio-economic benefits will depend at least partially on policy choices by government institutions (local and district municipality, influenced by provincial and national government). To some degree, it also depends on private sector consortium partners' approach to corporate social responsibility and community empowerment - although Government (at all levels) can provide guidance to private consortium partners on specific choices. The most directly relevant socio-economic benefit will be employment (ranging from manual to white-collar and technical jobs) and associated technical training or on-the-job upskilling.

A key question is the extent to which Government will require local recruitment and training effort, or whether jobs and skills will be mainly provided by in-migrants from elsewhere. This, in turn, will be affected by Government contract requirements, as well as the degree of co-investment by Government departments (e.g. Higher Education and SETAs), as a supply-side strategy. This will require political will at all levels, for example at National (higher education and training), Provincial (providing land for training institutions), District and Municipal (facilitating transport and housing for Namaqualand workers and trainees).[200] The existing skills training system is definitely not adequate, as indicated earlier. Providing relevant technical skills for local or regional inhabitants will require a major expansion of the TVET College, as well as additional specialised training institutions, such as Disaster Management, Traffic Management, Construction and Community Health.

[197] Transnet 2024, Boegoebaai Port Development Socio-economic Studies SEB report, 26.
[198] Northern Cape Province 2019, Provincial Growth and Development Plan (PGDP) Vision 2040, p. 24.
[199] Northern Cape, Office of the Premier, p. 29.
[200] This point was added in response to public reviewer comments.

7.5.3 Tourism

Since 2000, as the mining sector declined in Namakwa, it was gradually replaced by the tourism sector. The area is famous for the annual blossoming of the Namaqualand flowers in the Karoo Succulent Biome which transforms this semi-desert into an ecological fairyland. This spectacular show is confined to only a few weeks of the year. The promotion of tourism in the 'off-season' increasingly focuses on the unique features of Namaqualand's history, ecology, landscape and remote wilderness experience, including mine museums and mine tours, 4x4 routes, mountain bike and hiking trails, community camp and rest-house facilities and several nature reserves.[201]

Tourism can be described as the total experience that originates from the interaction between tourists, job providers, government systems and communities in the process of providing attractions, entertainment, transport and accommodation to travellers. It is a social, cultural, and economic phenomenon that entails the movement of people, referring to domestic or foreign tourists.[202] This includes business travellers.

Tourism product development leads to the creation of innovative products, experiences, and services that tourists can buy and enjoy. Furthermore, such expenditures lead to economic multiplier effects, and there is a built-in incentive towards novelty, creativity and innovation.

The development of the Boegoebaai port may stimulate tourism due to improved access, but may also disrupt the current tourism product offerings.

7.5.3.1 Tourism in the Northern Cape[203]

The Northern Cape province is the least visited province of all South Africa's provinces in terms of international tourist arrivals, and mainly caters for South African and Namibian visitors. There is an increase in domestic tourism interest in this province, but the numbers are small in comparison to other provinces. The region does have untapped potential, which motivates a better understanding of the current tourism offering and the types of tourists attracted to the region.

7.5.3.2 The current offering in the study area

7.5.3.2.1 The accommodation and catering sector of the Namakwa District

The Namakwa District in the Northern Cape includes at least five well-known tourist towns: Springbok, Port Nolloth, Garies, Kamieskroon and Hondeklipbaai. More niche tourist offerings are available at O'Okiep, Steinkopf, and Kleinzee. The towns offer a variety of accommodation options for tourists, including guest houses, hotels, lodges, and guest farms.

[201] Hoffman, M.T. and Rohde, R.F. 2007. 'From pastoralism to tourism'.
[202] UN Tourism, 2024. Glossary of terms, https://www.unwto.org/glossary-tourism-terms ; Saayman, M. 2013. En route with tourism.
[203] Namakwa routes. Available at: https://www.namakwa-dm.gov.za/wp-content/uploads/2017/07/Experience-Namibia-Map.pdf Accessed 20 October 2024.

Tourism enterprises and rooms in four municipalities[204]

	Tourism enterprises	Rooms
Nama Khoi LM	43	687
Kamiesberg LM	43	216
Richtersveld LM	22	157
Khai-Ma LM	10	136

The Richtersveld World Heritage Site as part of the product mix. The Namakwa National Park and the Richtersveld National Park have a significant number of accommodation facilities. A variety of catering options is available in Springbok, Port Nolloth and Garies. This reflects the amount of tourism traffic that comes through those towns. Self-catering accommodation is by far the most frequent type of tourist option, responding to the self-drive types of tourists (who are probably also budget-conscious) that explore this region.

The growing class of tourism providers is drawn from the cities, and has added a degree of sophistication and even cosmopolitanism to South African small towns. They have also created employment, often of a higher status and with higher wages than traditional small-town occupations. The slow but steady influx of "semi-grants" (people who move from cities to rural areas) has been stimulated by various factors, such as the architectural charm of many towns, as well as the opportunities offered by the hospitality, arts and crafts, and cuisine trades.

In particular, the standard of accommodation establishments has to be comparable with other towns and regions, and the online booking system tends to raise the benchmark, due to online reviews. To establish, furnish and operate such guest houses requires substantial capital, as well as a familiarity with tourist expectations. The "semi-grant" class of investors add value to tourist towns by restoring classic buildings, promoting neatness in the town, training staff, and undertaking innovative marketing.[205]

Domestic tourism represents roughly 76% of all tourism in the region. The region is remote enough to appear exotic to South Africans, but it is within a day or two of driving for almost all South Africans, making it fairly accessible. It is also not an expensive area to visit.

The predominant reason for travel in the Namakwa district is mostly leisure (48%), as tourists are drawn to nature reserves, the famous spring and wildflower reserves, hiking trails, amongst other areas of nature. These visits stimulate local economic multipliers when tourists spend on accommodation, transportation, attraction visits, and recreational activities.

Tourism in this region is on an upward trajectory. Tourism has the advantage of a low impact on the environment - in fact, tourists insist that the environment should remain intact and unspoilt. Tourism does not involve polluting industries, heavy traffic, stress or congestion. Tourists want to escape from urban crime, grime and traffic jams. It is therefore of cardinal importance that the Boegoebaai projects are planned in such a way that they do not obstruct the tourist pathways and corridors, or create an industrialised landscape. Sensitive spatial planning will be essential. An exquisite field of Namaqualand daisies will be fatally spoilt against the backdrop of wind turbines.

The fact that the region maintained a significant bed-night tally during the difficult COVID years (2020–2021) also suggests that a remote region, with a dry climate and sparse population, may appeal to people who are increasingly concerned about health and infections. These visitor figures are remarkable, given the limited extent of regional marketing. Features such as space, uniqueness, starry nights, local friendliness and safety can win much more market share.

The table below also suggests a slow but steady increase in bed-nights sold in the region:

[204] Information in this section drawn from an unpublished NWU online hospitality survey, 2024, based on extensive web searches and using well-known accommodation booking sites.

[205] Atkinson, D, 2016, Is South Africa's Great Karoo region becoming a tourism destination?

Trips and bed-nights in four municipalities, 2019-2023[206]

	Bednights 2019	Bednights 2021 (COVID)	Bednights 2023
Richtersveld LM	81 000	46 000	82 000
Nama Khoi LM	249 000	148 000	249 000
Kamiesberg LM	82 000	52 000	84 000
Khai-Ma LM	60 000	42 000	59 000
TOTAL	**472 000**	**288 000**	**474 000**

After COVID, tourism in Namakwa District reached a new high - R1.1 billion in 2023. Richterveld received about 22% of this spend (about R220 million). *Per capita*, this spend amounts to about R15 000 in Richtersveld and Kamiesberg, compared to R10 000 in Nama Khoi. This emphasises the centrality of tourism in Richtersveld, and the need for sensitive spatial planning and mitigation measures where required. Tourism development should remain a key developmental thrust, and not an afterthought.

7.5.3.2.2 The attractions in the Namakwa District[207]

Not many people live in the Namakwa region – which is part of its appeal. There is a palpable sense of remoteness, often untouched by human impacts and activities. This also means that tourism is not a mass activity in the region; typically, tourists travel in couples or small groups, eager to escape from densely populated cities.

Namaqualand is often described as the "Ocean and Flower Cluster". A major attraction is the Orange River, one of the longest rivers in South Africa, separating South Africa and Namibia. The Cape-Namibia highway along the N7 highway means that Springbok, Garies and Kamieskroon are good overnight stops. The Namakwa flower season is currently the best-known attraction. The Namaqua bike camino (Bikamino) is a 470km route (10-day) route which cuts across the arid Northern Cape from Okiep to Hondeklipbaai.[208]

a) Richtersveld Local Municipality

The Richtersveld region, historically inhabited by the Nama people—a subgroup of the Khoikhoi—has a deep cultural heritage tied to semi-nomadic pastoralism and a rich array of traditions, including music, storytelling, and indigenous knowledge. The Namas' semi-nomadic lifestyle was built around the movement of livestock to different grazing areas in response to seasonal shifts (transhumance). Today, the Richtersveld National Park is one of the few places where the original Nama traditions and language have survived.[209] The management plan of the Richtersveld Community Conservancy (RCC) includes infrastructure and tourism development.[210]

The two main towns in this local municipality are located on the Atlantic seaboard, namely Port Nolloth and Alexander Bay. Port Nolloth has a small vessel harbour with fishing trawlers and is a good line-fishing area. The Port Nolloth Museum has a history of diamond and copper mining and the people of the region. South of the town is McDougall's Bay, popular amongst tourists interested in boating and fishing. Alexander Bay is the most north-western town in South Africa, next to the Orange River mouth. The estuary at the river mouth hosts a wide range of aquatic and bird species. The Orange River Mouth is regarded as the sixth most important coastal wetland in Southern Africa, because of the huge variety of bird life that it supports.[211] The town has walking and cycling trails for visitors, while fishing and canoeing are important activities.

[206] Data: S&P Global Regional Explorer.
[207] The websearch included the following sites: hwww.namakwa-info.co.za/region, www.thegrowcery.co.za/, www.namakwa-dm.gov.za/b-municipalities/, www.sa-venues.com/north_cape_attractions_info.htm, khaima.gov.za/led-tourism/, www. experiencenortherncape.com/regions/namakwa-region/, www.namakhoi.gov.za/, www.kamiesberg.gov.za/, www.richtersveld.gov.za/.
[208] https://ridewithgps.com
[209] COGTA n.d. Namakwa District Profile, p. 6.
[210] WHC (World Heritage Convention). 2017. Richtersveld Cultural and Botanical Landscape.
[211] Kamiesberg LM, *Spatial Development Framework*, 2024, p. 114.

In 1991, a part of Namaqualand, and one of the last true wilderness areas of South Africa, was named the Richtersveld National Park. In 2003, the Ai-Ais hot Springs Game Park in Namibia was combined with the Richtersveld National Park in South Africa, and this is now known as the Ai-Ais/Richtersveld Transfrontier National Park. Rooiberg Conservancy is located south of the Richtersveld National Park, forming almost a continuous ecological unit. This includes the Nababiep Nature Reserve in the neighbouring Nama Khoi Local Municipality.

The Transfrontier Park holds World Heritage status (declared in 2007) and is one of the richest areas of fauna and flora – situated in the Succulent Karoo Biodiversity Hotspot. It hosts 4849 species of succulent plants, of which 40% are unique to this area. It is also the only arid biodiversity hotspot in the world.[212] In 2016, the international *Rough Guide* chose the stark beauty of the Richtersveld as one of the Top 10 places in the world to visit.[213] The estimated 350 000 Cape fur seals can be viewed at the coastal section of the Namaqua National Park.

The park is not financially sustainable, but it has the potential to improve its occupancy rates and offer additional products to visitors in future.. The primary development node remains the Sendelingsdrift rest camp, with limited expansion in the other areas. The main service route to the park is a provincial gravel road from Alexander Bay (about 80 km in length). The condition of this road affects the park and requires regular maintenance.[214]

Since the WHS was declared, the border post between Alexander Bay and Oranjemund was opened, as well as the river crossing at Sendelingsdrift. This has made the Richtersveld more accessible to tourists. Tourists can now drive a circulate route through the Richtersveld, which would make the WHS a central attraction.

There are two culturally and historically significant towns in the Richtersveld. **Kuboes** is regarded as the heartland of Nama tradition, with mission history, and still practicing transhumant agriculture. There is a new identity and pride in the Nama language, culture, cuisine, and rituals. The village of **Eksteensfontein** will be an important tourism gateway to the WHS. Eksteenfontein is part of the Richtersveld LM, but actually forms part of the "Springbok Cluster" (as delineated in the Namakwa District Rural Development Sector Plan (2023).[215] It would require a filling station and overnight accommodation, as well as an information centre, and a base for tourism operators (over-landing, cultural tourism, etc).

Promoting tourism in the communal lands area must be managed carefully. There are sensitive themes related to ethnic identity and historical land dispossession. These communities have been at the forefront of several legal battles related to land management, the declaration of the Richtersveld Park, and the restitution of Richtersveld land. The dictum must be that any cultural tourism planning should be deeply embedded in local engagement and consent, to prevent a shallow and over-simplified narrative being presented to tourists.[216]

b) Nama Khoi Local Municipality

The main towns within the Nama Khoi local municipality are Springbok, Steinkopf, Vioolsdrif and Kleinzee. The town of Springbok is strategically located at the junction of the N14 and N7 highways. It is the regional capital of Namakwa district, and offers a variety of shops that draw people from the region. Besides shopping, the town also hosts two historical sites, namely the Blue Copper Mine, which was the first operational copper mine in South Africa[217], and Monument Koppie, a hill within the town commemorates the Anglo-Boer war of 1899-1902.

The Okiep mining town is close to Springbok and has a history of fascinating copper mining activities, as well as the famous Siege of Okiep in April 1902, towards the end of the Anglo-Boer War.[218] Nababeep has a mining museum and a narrow-gauge steam locomotive used for coal transportation. Close to the town, one

[212] Richtersveld WHS (Richtersveld World Heritage Site). 2025a. https://www.richtersveldwhs.org
[213] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p 114.
[214] Richtersveld LM Spatial Development Plan, 2024, p. 81.
[215] Richtersveld LM, *Spatial Development Framework*, 2024, p. 39.
[216] Boonzaier, E, 1996. Negotiating the development of tourism in the Richtersveld.
[217] https://southafrica.co.za/1852-the-rise-of-the-namaqualand-copper-industry.html

[218] https://sahistory.org.za/dated-event/anglo-boer-war-2-siege-okiep-namaqualand-starts

also finds the Goegap Nature Reserve (managed by the Northern Cape Department of Environment and Nature Conservation) that offers 4x4, mountain bike trails, birding as well as spectacular wildflowers during spring. The Helen Malan Flower Garden has a large variety of Namakwa succulents.

North of Springbok, on the N7, lies Steinkopf, which developed from a Rhenish Mission Station (originally Kookfontein) that was established on in 1821. The Mission church is a monument and also hosts the Steinkopf Art Gallery. The town forms part of the flower route and has a succulent nursery with a tea garden and various arts and crafts. There are several historical sites, such as the Klipfontein Anglo-Boer War graves, the mass grave of Nama children who were massacred at Kinderlê, and the ruins of the hotel. Steinkopf is located on the old copper-mining railway line, which offers much interest to railway buffs.

Further north, on the border with Namibia, are the towns of Vioolsdrif (the official border post) and Noordoewer. It is the starting point of many Orange River rafting adventures. This is considered one of the top ten adventures in South Africa.

Kleinzee, to the west of Springbok, is an old diamond town. The Kleinzee Museum includes diamond mining and the environment and history of the area. The Kleinzee Nature Reserve has more than 100 indigenous plant species. The town offers visitors the opportunity to see the largest seal colony in South Africa, as well as various 4x4 routes, such as the Shipwreck Tour, and a relatively easy hiking route.

c) Khâi-Ma Local Municipality

Pofadder hosts the Niemoller Museum, which tells the history of Pofadder and the Old Roman Catholic Church. Pella is well-known for its palm trees and dates and its beautiful cathedral, built by French missionaries. As one of the less touristic areas in the Namakwa region, Khai-Ma offers adventure activities, such as 4x4 routes, canoeing and hiking trails.

d) Kamiesberg

The Kamiesberg municipality includes the Namaqua National Park and the Skilpad Wildflower Reserve, offering an annual spring flower extravaganza with a large variety of plant and bird species, the Silver Sands trail and 4x4 routes. The coastal area is also a Marine Protected Area and the Spoegriver caves contains the earliest archaeological evidence of sheep in southern Africa. The coastal town of Hondeklip Bay is especially important for 4x4 enthusiasts, fishermen and divers. The Aristea shipwreck lies just south of the town. The first copper was exported from this harbour, before the rise of Port Nolloth as an export harbour.

Kamieskroon and its surrounding villages, Leliefontein and Nourivier, also offer mountain bike trails. Leliefontein was established as Wesleyan a mission station; the church and parsonage are national monuments. There is an important Boer War memorial.

e) Kai !Garib Local Municipality (Orange River upstream)

Although the towns of Upington, Keimoes and Kakamas are not part of the Namaqualand study area, the impacts on tourism along the Orange River will be severe, due to heavy ore traffic along the narrow riverside road. This traffic will impact on houses and businesses along this scenic route (marketed extensively as the Red Dune Route). Undesirable building developments will result, including an excessive number of fuel stations and truck stops. Negative consequences of trucking include road deterioration, traffic hazards, littering petty crime and prostitution. Years of tourism investment will be destroyed.[219]

This is another reason why a rail link from the minefields to the coast must be considered *ab initio*, as part of the first phase of operations.

[219] This point was added in response to public reviewers.

7.5.3.2.3 Thematic attractions which may benefit from additional investment

Namaqualand offers a multiplicity of remarkable tourist themes, which can be enhanced by public displays, information centres, arts, crafts, merchandise, and theme-based accommodation or cuisine.

These tourism sectors include (see Appendix B for more detailed information):

1. Agri-tourism and on-farm attractions
2. Biodiversity, natural parks and protected areas
3. Indigenous San, Khoi and Nama history
4. Christian mission stations, including British, German and French
5. Copper mining
6. Diamond mining
7. Geology
8. Fishing, marine life, boating, and shipwrecks
9. Marine-based health and wellness, such as kelp baths[220]
10. Retail and craft industries
11. Transportation services.

Tourism regions take some time to reach a "tipping point", when there are sufficient and sustained tourism offerings, of different types, to ensure a steady stream of visitors. Namaqualand has reached that point. It is becoming a destination in its own right, stimulated by favourable word-of-mouth, as well as a growing "curiosity factor" and "bucket-list status", so that people in the rest of South Africa are taking special trips to the region. Unfortunately, the flower season is usually short (about two months per year), but the arid Atlantic coast and the desert remoteness are becoming attractions in their own right.

The next challenge is to lengthen the stay of tourists, so that they spend money for several nights (accommodation) and days (attractions, food and purchases), which is more financially impactful. The challenge, from the point of view of tourism developers, is to create sufficient products to offer variety, and to keep tourists in the area for as long as possible. Annual adventure events and cultural festivals will give exposure to the area and might encourage return visits.

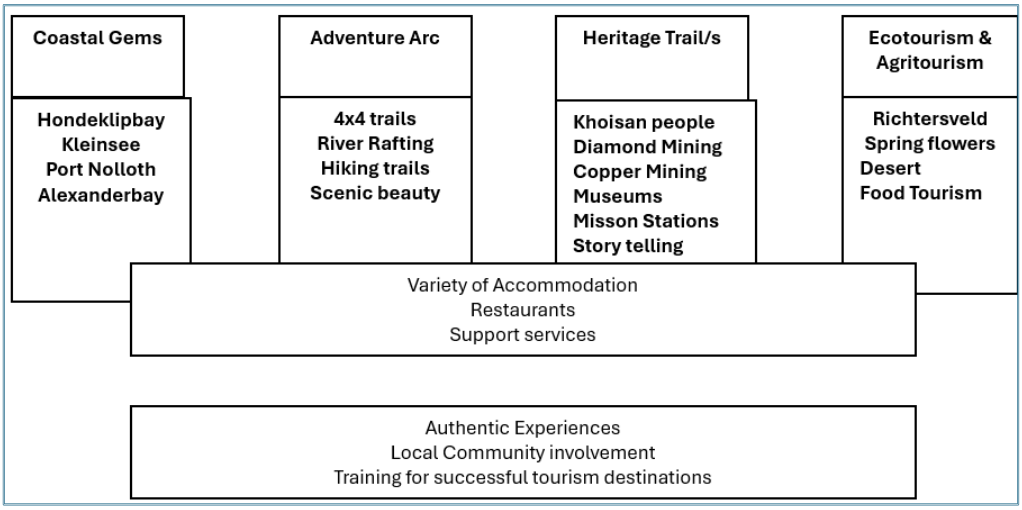
Given the strong history of mining, the Nama people and the unique nature of this area, an **interactive interpretation centre** focusing on the unique selling points of the area as a hub will be of great value in attracting visitors. Springbok, the busiest town in this area, will be ideal, and add will value to all the museums in the district with selected upgrading.

The Boegoebaai harbour could become a tourist destination in its own right, with trained guides explaining the development and functioning of these projects. The process of producing GH2 will also be an educational tourist offering as a new step in renewable energy production. Displays on international shipping can be featured at the Port.

Tourism routes can have a major impact, encouraging tourists to travel between sites. In all cases, these routes focus on a self-drive experience – they therefore provide a conceptual guide to what can be seen and done when travelling on these routes. At the moment, these routes are thus promoted on different websites but not are seldom managed by a dedicated team, as far as it can be ascertained. This highlights the current co-ordination problem that exist within the region of the proposed development. While "conceptual route guides" are useful, to orient the self-drive traveller, such routes become much more meaningful and effective once there is a management system comprising stakeholders who collaborate meaningfully with one another.

A possible composite marketing strategy for Namaqualand[221]

[220] Fourie and Oppel, Socio-Economic Baseline Assessment, 2024, p. 28.
[221] Developed by the tourism research team at North-West University.



Route development implies an economic injection for the whole area where different communities can tap into the supply chain – it also reduces seasonal slumps and brings hitherto unexplored sites into the tourism proposition. This expands the number and type of tourist service suppliers, ranging from well-established investors to small community-based organisations and even households. Furthermore, it promotes tourism products such as arts and crafts, which have low barriers to entry, but require a constant through-put of tourists to make such businesses worthwhile.

Namaqualand tourism can be promoted in several ways:[222]

- Branding Namaqualand as a single destination, perhaps in addition to Bushmanland
- Creating a Namaqualand Tourism Agency, to co-ordinate service providers, routes, and municipalities, under the auspices of the Namakwa District Municipality
- Focusing on specific "ports of entry", e.g. at Springbok, with scheduled flights and car rental (see below for a fuller discussion of a possible airport expansion)
- Providing tourism training to school leavers in the area. The TVET college in Springbok can be expanded to equip residents with the skills to work in the tourism sector.

7.5.3.3 Challenges faced by the tourism sector in Namakwa district

Tourism in Namaqualand shares many of the inherent difficulties found in promoting Northern Cape Tourism: Vast distances, limited public transit systems, some rural roads are poor, and the lack of a regional airport with scheduled flights.[223]

As far as the Boegoeberg projects are concerned, it is important to pinpoint specific threats to this promising tourism trajectory. An industrial investment may bring the risk of infringing on sensitive tourist sites and viewsheds, over-development, traffic congestion, demographic shifts and uncontrolled in-migration. Accommodation facilities may be booked out for months or even years at a time. The new arrivals – contractors and technicians - will be travelling in commercial bakkies and trucks, whereas the current travellers tend to be in sedan cars and 4x4s.

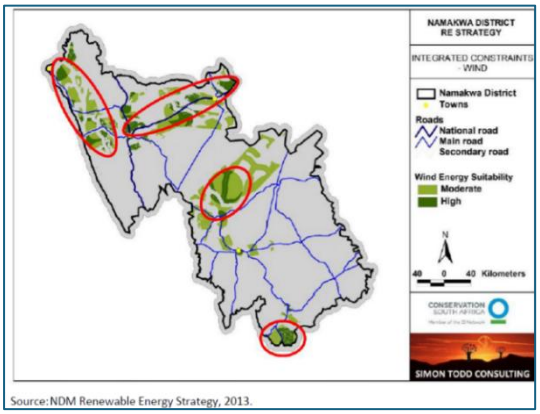
In the context of the Boegoebaai projects, the "leisured atmosphere" will be a thing of the past in Port Nolloth, and to some extent in Springbok. Restaurants will be full of hurried project staff members, rather than offer a quiet, relaxing meal for travellers seeking an old-world ambience. Crime and lawlessness, even of trivial kinds (such as littering and begging), are likely to be a major disincentive for future tourism investors, and

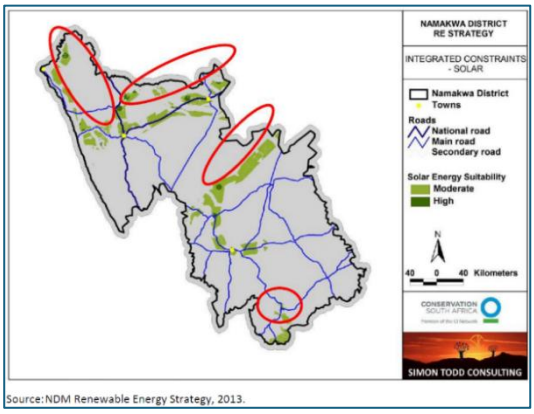
[222] DALRRD 2021, Karoo Regional Spatial Development Framework, p. 134. The entire Namaqualand can be marketed as multi-theme destination.
[223] Northern Cape Government, Spatial Development Framework.

may encourage them to leave this region. There may be an increase in animal and plant poaching and attacks on tourists in isolated rural areas.

The Richtersveld will become an important site for renewable energy (both wind and solar).

Areas earmarked for wind energy development (left) and solar energy development (right)[224]





The proximity of these renewable energy zones to sensitive natural heritage and tourist regions is a source of concern. There must be a thorough effort to protect "viewsheds", and to maintain Namaqualand's sense of place as a remote desert region.

In the spatial planning process, it will be important to identify certain towns, such as Alexander Bay, as the primary project service towns, thereby keeping Port Nolloth and McDougall's Bay primarily for tourism and local communities. Special-purpose accommodation should be built for employees and contractors, who travel without their families. These buildings could be converted to tourist (maybe back-packer) accommodation for sustainable future use. Where possible, existing guest houses should be reserved for professional staff and not technicians, artisans or labourers. (This will bring sufficient windfall gains to the guest houses, who may still be encouraged to enlarge their establishments, as a nett gain to tourism in the future).

The remoteness of the area is a significant attraction, and therefore, tourists do not want to see excessive industrialisation or heavy transport activities in this area. This requires a focus on viewsheds, i.e. directing industrial development away from scenic tourist vistas. The siting of industrial parks must take these considerations into account. This means that the planning of these parks must involve tourism stakeholders. Simply moving a project by a few kilometres can make a significant difference to the tourist impact.

7.5.3.3.1 Road and traffic management

The intensified road usage by the Boegoebaai projects has significant potential for clashing with tourism, and undermining this vital sector. The Namakwa Spatial Framework warned about transport s of the Boegoebaai projects. Heavy industrial factories and manufacturing business in the district will increase the volume of heavy freight vehicles in the area.[225] Key routes will be shared by tourists and Boegoebaai staff. On these routes, roads needed to be widened at several points to allow tourist and local users to overtake trucks easily and safely.

We should distinguish between trucks used in Port and GH2 construction, and trucks used for transporting ore from the Postmasburg manganese fields. The first category will pose significant challenges for tourism; the second type of transport will probably spell the death-knell of tourism in the Upper Namaqualand, Bushmanland and Green Kalahari region (Upington, Keimoes and Kakamas).

[224] Richtersveld LM, 2024, *Spatial Development Framework*, 2024, p. 189.
[225] DALRRD, Namakwa District Spatial Framework, 2023, p. 104.

We make a categorical recommendation that ore transport to Boegoebaai should be done by rail, *ab initio.* The revival of Transnet, combined with strong private interest in running rolling stock, should make a business case for a possible *privately owned* railway line from Postmasburg to Boegoebaai. This can transport copper and zinc as well. Given that the life span of the manganese mines in the Kalahari is estimated to be over 100 years, this would be a sensible investment.[226]

It is useful to first identify the roads currently used by tourists:

[226] See, for example, Tshipi Mine: https://www.jupitermines.com/tshipi-manganese/tshipi/operations#:~:text=Tshipi%20is%20a%20shallow%20open%2Dpit%20mine%20situated,production%20remaining%20manganese%20mines%20in%20the%20world.

Current main tourist thoroughfares

Traffic to Boegoebaai should skirt Port Nolloth on a specially-built bypass, to prevent ore trucks from travelling through the Central Business District. (Gqeberha has experienced heavy damage caused by ore trucks to urban infrastructure (streets, storm water drainage and nearby buildings).

The road between Port Nolloth, Boegoebaai and Alexander Bay will become very congested with industrial vehicles involved in construction of the Port. Ideally, there should be one substantial road for industrial use, and possibly an alternative, quieter road, which has more scenic appeal. Where possible, alternative tourist routes should be promoted, which avoid the main trucking thoroughfares. For example, the R382 will be particularly congested. Maintaining the R382 will be for the budget of the Northern Cape Province. There is already a concern that trucks are damaging the road.[227]

An alternative road would take tourists from Springbok to Kleinzee and then up the coastal road to Port Nolloth. This would benefit the more southerly coastal towns in Nama Khoi LM.

The Namakwa Rural Development Sector Plan has identified important road upgrading projects:

- The R382, linked with the N7. This will focus on linking Sendelingsdrift, Alexander Bay, the proposed Boegoebaai Harbour and Port Nolloth. This route will link to the N7 at Steinkopf. This route will be used for logistics (harbour), minerals and mining (ore transport), mariculture, and access to the World Heritage Site at Sendelingsdrif.

- Upgrading the coastal link road between Port Nolloth from the R382) to Garies (N7), via Kleinzee, Koingnaas and Hondeklipbaai (202 Km) [228]

7.5.3.3.2 Taking logistics to the next level: Expanding aviation

Currently, the airport at Springbok does not have scheduled flights. All planes using the airport are private or charter. This means that there is no air travel available for an ordinary passenger. Consequently, also, there is no car rental in Namaqualand. Typically, air passengers rent a vehicle to move into the airport hinterland. This will be a major boost to tourism.

Even if flight tickets are fairly expensive, there would at least be a commercial class of passenger, particularly linked to the Boegoebaai projects, for whom it would be more cost- and time-effective to fly than to drive from Cape Town or Johannesburg. At a minimum, Cape Town-Springbok flights should be considered, but a Johannesburg-Springbok route may also be feasible at a later stage. In addition, smaller shuttles can fly from Springbok to Alexander Bay or Aggeneys.[229]

Airports are increasingly recognised as key assets for cities and regions as economic generators and catalysts of investment. Direct impacts of airports include multiplier impacts on the regional economy, stimulated by money spent at the airport itself. Indirect impacts may be generated from expenditures by airport users or from regional expenditures at local businesses, as a result of airport use or travel. There are also 'Induced or tertiary impacts' of an airport which unlock further investments in the region. 'Perpetuity

[227] Richtersveld LM, *Spatial Development Framework,* 2024, p. 193.
[228] Plan found at https://drdlrgovza.sharepoint.com. Richtersveld LM, *Spatial Development Framework*, 2024, p. 70.
[229] Government officials will benefit from flights between Springbok and Kimberley, but it is not clear that sufficient commercial traffic will be available to make it sustainable. One possibility would be a Springbok-Kathu-Kimberley route.

effects' occur when an airport shifts the regional production function upwards by changing the structure of the economy.[230] Regional airports are considered to be of such strategic significance that many governments subsidise such airports,[231]

Given that the Namakwa SEZ precisely aims at "shifting the regional production function upwards by changing the structure of the economy", **it is almost inconceivable that the region would continue without scheduled flights.** The likely market would be "business tourists" (technicians and professionals working at Boegoebaai Port, GH2 project and renewable energy plants) who can also then fly to Alexander Bay on a shuttle service. It would also attract tourists who are "cash rich and time poor", wanting to take rapid breakaways from Cape Town. An airport may well open up Namaqualand to international tourists, particularly if there are a few flights per week from Windhoek. Other typical sectors are local businesspeople, local people visiting Cape Town for holidays or education, and medical trips. The example of the busy little airport in Alice Springs in the Australian Outback (at least four scheduled flights per day) highlights the important role that aviation can play in stimulating regional economic growth in arid areas.[232]

Several government plans have hinted at the need to upgrade the Springbok airport, as well as more remote airfields in Namaqualand West. The Namakwa DDM Plan mentioned the importance of a regional airport. In the Provincial Spatial Development Framework, an airport is indicated for Springbok.[233] The Namakwa Spatial Framework has indicated the possibility of an airport at Springbok, and various airfields situated at Alexander Bay, Kleinzee, Hondeklip Bay,and near Aggeneys.[234] The same kind of proposal is made in the Nama Khoi Spatial Development Framework, focusing on the airport in Springbok (which is described as an "national/international accessibility node") and the airfield at Hondeklip Bay.[235]

Air transport will also play a crucial role in the Boegoebaai development. The Namakwa Spatial Framework lists airfields that need to be upgraded: Springbok, Aggeneys, Alexander Bay, and Kleinzee, Furthermore, the Framework notes, "a new airport can be developed at an appropriate location in proximity of existing nodes and transport infrastructure", and that this matter be further investigated.[236] The Alexander Bay airport will add value to both the tourism and mining sectors.[237]

7.5.3.3.3 Protecting tourism in Namaqualand

The proposed Boegoebaai projects pose real dangers to tourism, due to the industrialisation and commercialisation of the area.

In particular, traffic congestion should be minimised. We argue strongly for a rail link during Phase 1, to manage the ore shipments. This will also help to mitigate against dust and noise. The only way to mitigate against the loss of the sense of remoteness ("sense of place") would be through careful road and rail spatial planning, to direct transport routes some distance from the Port Nolloth village, and to minimise impacts on farmland.

The only way that such a rail link will be financially feasible will be by private capital. Currently, Transnet is in the process of bringing private railroad operators into South Africa. This is a massive shift in policy, and it may mean that a privately-owned railway link becomes possible. It is not clear whether Transnet or the private party will build the actual railway line. That will depend on the demand and price of manganese, copper, zinc and lead, and the profitability of the SEZ. All of these seem to be robust into the medium term.

The project is certainly likely to create more local jobs and incomes than tourism. However, the tourism sector is a valuable custodian of heritage and "sense of place", and should therefore not be undermined. Concerted efforts should be undertaken to protect it from industrial encroachment.

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230 Button, K, Doh, S & Yuan, J, 2010. The Role of Small Airports in Economic Development.
231 Donehue, P & Baker, D, 2012. Remote, rural, and regional airports in Australia.
232 Atkinson, D. 2016. Thinking regionally: Aviation and development implications in the Karoo region.
233 Northern Cape Government, Provincial Spatial Development Framework, p. 41.
234 DALRRD, Namkwa Spatial Framework, p. 118.
235 Nama Khoi LM, *Spatial Development Framework*, 2025, p. 31. 60.
236 DALRRD, Namakwa Spatial Transformation, p. 105.
237 Richtersveld LM, *Spatial Development Framework*, 2024, p. 18.

7.5.4 Agriculture

Agriculture is commonly defined as the practice of cultivating the soil, growing crops, or raising livestock for human use – mainly in the form of food or fibre. These products have economic value and jobs and livelihoods are created. However, agricultural activities not only have economic value, but may also have strong social and cultural significance.

Farmers are part of the larger economy and economy with many backward and forward linkages. The impact of agriculture in the district is enhanced due to its **backward linkages** (purchases of goods such as feeds, equipment, vehicles and fuel by livestock producers and fertilisers, chemicals, mechanisation, etc., by irrigation producers support many industries) and **forward linkages** (most agricultural products are delivered as raw products to various processing and manufacturing industries, creating forward linkages). In the case of Namakwa areas, these forward linkages are primarily felt outside the region; however, the distribution channels are important shops in the local towns.

As for the Northern Cape and Namakwa District as a whole, the contribution from agriculture to the entire economy is larger than for South Africa (roughly 10% of Gross District Product, compared to just less than 3% of South Africa's national GDP). In Richtersveld LM, the figure is about 6%, or roughly R96,8 billion in 2023 prices.[238]

"The history of Namaqualand agriculture is one of drought and isolation".[239] Given the challenges of farming in Namaqualand, its productivity is remarkable. In addition to the normal aridity of the climate, the area has experienced catastrophic droughts, such as 1933, and in 1975-1983. During such hard times, production and incomes tend to decline dramatically. In 1986, Dunne found that the drought had reduced the carrying capacity of land in Namaqualand by half, which led to reductions in livestock as well as increasing farm size. Farms are generally capital-poor, and average employment per farm is low.

Nevertheless, livestock farming remains close to the heart of many rural households, not only for its practical significance for economic survival, but also because it is the strongest cultural link with ancestral generations of herders. As such, livestock agriculture – for coloured communal and white commercial farmers – have deep emotional and heritage significance.

During the last twenty years, sophisticated irrigation crop farming has developed along the Orange River. This is an entirely different economic proposition compared to extensive livestock production; revenues, incomes, are employment are much higher, and production takes place for the export market. These projects do not have the same heritage significance as livestock farming, but form a significant growth engine in the district.

In this agricultural assessment, these two streams of agricultural production need to be analysed separately. Almost no meaningful generalisations can be made between them, and they will be impacted very differently by the Boegoebaai projects.

7.5.4.1 The ecological potential and constraints of agriculture in the Namakwa region

Economically, the region remains reliant on agriculture, particularly livestock farming, but faces challenges such as droughts, land degradation, and water scarcity.[240]

Rainfall, temperature, elevation, and soil type are the main drivers of the unique plant distribution, abundance, composition, structure and biomass of the Namakwa district. Various soil types and the landscape's elevation and slopes, affect microclimates and water runoff, creating diverse habitats. This is

[238] S&P Global – South Africa Regional eXplorer (2540), 2024 – 2023 data.
[239] Dunne, JM, 1986, Towards a Regional Development Strategy for Namaqualand, p. 160.
[240] Namakwa DM, 2023a. Municipality Vulnerability Assessment and Climate Change Response Plan; Namakwa DM, 2023b. Climate Change Adaptation Plan.

the basis of the extensive livestock industry. The region's climate is very diverse, with predominantly winter rainfall west of Springbok and predominantly summer rainfall east of Springbok towards the Bushmanland.

Rainfall is generally very low, between 60 and 120 mm per annum, while in the Richtersveld, with its predominantly winter rainfall, between 50 mm in the desert to more than 120 mm in the mountains (the Kamiesberg is an exception, with about 300 mm per annum). Along the coastal areas, mean annual rainfall can vary between 80 and 140 mm.[241] Sea fog and heavy dewfalls supplement the low rainfall substantially. Many plants in Namakwa have adapted to respond quickly to rainfall, often flowering and producing seeds shortly after rain events. In the north of the region and especially along the Orange River Basin, summer temperatures often exceed 40°C, causing extreme moisture loss in plants and the soil.

The two main water sources for agriculture include sub-terranean water pumped via windmills and solar pumps and the perennial Orange River to the north, bordering Namibia. Mountain run-offs are seasonal in nature, and alien vegetation encroachment along riverbanks is a real threat to this resource. The conservation of water resources is paramount to the sustainability of agriculture in the study area. The lack of water is probably the most serious limiting factor in agricultural expansion in communal areas. The use of stock watering points has made grazing control methods based on a system of fenced camps virtually impossible. Invasive tree species also encroach grasslands.

Virtually the entire region's soil capability is graded as Low or Very Low.[242] It is very difficult to mitigate the pressure on the environment by means of fodder production, because of the very limited availability of water (except along the Orange River). Generally, the soils in the central and western parts of the region are not suitable for cultivation.

Sustainable agriculture relies on environmental health and diversity of grazing. If sustainable stocking rates are not maintained, appropriate to rainfall in specific seasons, then veld deterioration due to overgrazing causes a decline in the ability of the land to support dense concentrations of stock. To survive in arid areas, farmers require large enough land, knowledge and excellent financial planning ability. Farmers that don't have this, tend to go out of production and sell their land to more viable farmers. Skilled extension services are almost non-existent, there is greater environmental pressure on the land. In the communal areas, access to markets and insufficient technical skills are limiting factors. This suggests that some members of the farming community may be receptive to changing to other forms of income, particularly young people growing on farms may choose to divert to urban careers.

Commercial livestock agriculture, especially cereal cultivation (and to a lesser extent livestock), has rapidly declined due to national and global economic conditions, improved transport networks and the cessation of agricultural subsidies. "De-agrarianization" is taking place, supplement partially by agri-tourism and eco-tourism. Conservation initiatives, many of them associated with the promotion of tourism, have gained momentum and large areas of agricultural land have been acquired as parks and conservancies.[243]

7.5.4.2 The scale of agriculture in the Namakwa region

Despite the constraints on agricultural production, the sector is one of the most important sub-sectors in the area and the second largest employer of labour. The study area has around 615 farming units (approximately 13% of the farming units in the Northern Cape (see Appendix B). Farming units are generally larger in Namakwa than in other Districts, because of the low grazing capacity of the land. Particularly for commercial farmers, producing at scale and as intensively as possible, this also increases the production cost per animal as compared to more intensive systems.

In the arid areas in South Africa, agriculture has generally been under increasing stress. While small stock historically has provided a source of economic growth, provided jobs, and supported rural livelihoods, the commercial agricultural sector has been in decline and maintaining economic viability is an ongoing challenge. This phenomenon is compounded by a 'cost price' problem (rising input costs, falling prices), and

241 www.weather-and-climate.com
242 DALRRD, 2018. Find source details.
243 Hoffman, M.T. and Rohde, R.F. 2007. From pastoralism to tourism.

may lead to more extensive practices, further compounding the challenges in remaining economically competitive.

7.5.4.3 Land ownership types in livestock areas

There is a significant diversity of land ownership types: Private, communal and municipal.

Agriculture has developed into two distinct sectors: Large-scale, well-capitalised commercial farmers, and small-scale, partially subsistence farmers. Both sectors are important for the region, where large-scale commercial farmers contribute to national food security (and therefore revenue in-flows into the district), while small-scale farmers are significant contributors to household food security in the local communities. The approaches to the management of these land tenure units vary significantly. In the study area, most of the desert biome is communally owned and part of land reform and restitution initiatives.

In practice, land management systems are complex and varied. Many commercial farmers also have farms in both winter and summer rainfall areas and apply a transhumance system where livestock is moved between these areas to utilise the best grazing opportunities.

Communal areas are based on allocations of cropping units, at the cost of an annual fee; they receive only user rights and not ownership rights. Farms on State Land and those bought from commercial farmers (through the Land Reform Programme) are farmed on a mixture of commercial, communal and subsistence principles. Some land reform beneficiaries farm at commercial scale.

7.5.4.3.1 Communal and commonage farming

Communal land and land reform farms have a deep bearing on not only the economic, but also the social profile of communities. The initial history of communal land tenure is derived from the time when contact was first made between the settlers and indigenous communities. Namakwa used to be inhabited by the San and Nama people. From the 1730s, settlers penetrated Namaqualand and the region was annexed to the Cape Colony, first in 1798 and then in 1847. The early settlers in the Cape encountered the San, Nama and Khoi, who were hunter-gatherers and pastoralists who moved from place to place. To various degrees, the local indigenous people resorted to violence to protect their water resources and hunting areas. That, too, was seen as an act of aggression against the colonial government. and land disputes were settled by means of force. Those Nama people who did not move to the Orange River to escape the wave of white settlement became impoverished, dependent on their new colonial masters, and were no longer able to live according to their tribal customs.

The Coloured Rural Areas (CRAs) date back to the establishment of mission stations, in the late 1800s, where indigenous people could live and farm unmolested by the growing number of white farmers in the neighbourhood. These areas form the basis of the current Communal Areas in Namaqualand – and in particular, the important case of Richtersveld CPA, where the Boegoebaai projects will be located. (Additional history is provided in Annexure B).

The post-Apartheid Government passed the Transformation of Certain Rural Areas Act (TRANCRAA), Act 94 of 1988, to provide for the transfer of communal land to municipalities or to legal entities such as Communal Property Associations (CPAs). The TRANCRAA process is meant to devise suitable land tenure systems for each of these areas. The CPA Act, no 18 of 1996, is designed to protect individual land rights within a group, through a constitution which sets out rules of membership and management.[244] Henceforth, these land parcels could be owned and managed by the residents and users themselves, not a government minister.

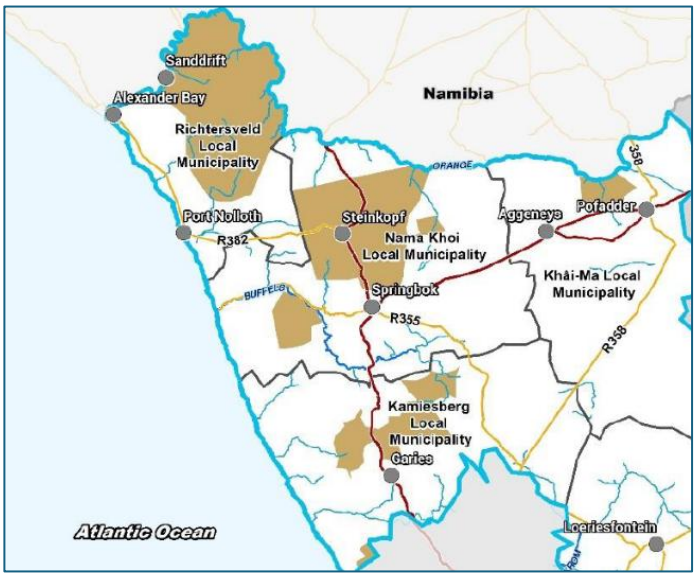
Trends regarding Act 9 Trust Land (TRANCRAA land)[245]

Region		Population	Hectares per capita

[244] DALRRD, *Namakwa Spatial Framework*, 2023, p. 64.

[245] Dunne, J, 1986, Regional Development Strategy for Namaqualand, p. 20; DALRRLR, Namakwa Spatial Framework (2023), p. 62.

	% of TRANCRAA land, 2023	1986	2023	1986	2023
Richtersveld	36 %	2 328	3 643	221	48
Steinkopf	31 %	5 725	7 822	56	56
Leliefontein	13 %	4 385	4 825	44	40
Concordia	8 %	3 439	4 564	18	26
Komaggas	6 %	3 129	4 927	20	18
Pella	6 %	1 509	4 092	32	20



The enlarged TRANCRAA areas[246]

The TRANCRAA tenure reform has been augmented by the Extension of Commonage programme, where land was procured by government, but title deeds were transferred to municipalities and not individuals. This is aimed at supporting livelihoods in the communal areas as well as peri-urban areas. On the "TRANCRAA land", population has grown steadily over the last forty years. However, the hectares per capita have declined, due to the additional land purchases.

For the Boegoebaai project, it is significant that Richtersveld is the largest piece of "TRANCRAA land", and the roughly 3 600 hectares in the Richtersveld LM today need to be incorporated into planning for Corporate Social Investment Projects. This will require an in-depth study and consultation with community members about their current livelihoods, needs, prospects and desired directions of development. (The dynamics of the "TRANCRAA land" are described in more detail in Appendix B).

Economic and agricultural development on the communal land has been retarded, for several reasons, including insecure land rights; limited access to inputs, finance and information; limited government support; inadequate working capital; inadequate or damaged infrastructure; poor farm management; and high competition in the industry. Efforts to address these challenges include land reform initiatives to restore land rights, improve land management practices, and support sustainable agricultural development. Some business plans have been over-optimistic, and others have been inadequate to enable emerging farmers to obtain loans.

The scale of farming on the communal land and the commonages varies from subsistence to semi-commercial; a few of these farmers own more than 800 sheep and can make a decent living from animal production; and some have even larger livestock holdings, indicating substantial wealth. The average farmer on the communal and state land owns fewer than 150 sheep and goats.[247] This is partly due to shortage of land, but mainly a shortage of capital inputs, water and technical support systems. These farmers cannot afford construction and even maintenance of infrastructure, or genetic material, medicines and fodder. Many farmers previously worked on mines and have received small pensions, but most rely on state social grants. Many of their land allocations are too small, and they have lost the option of being able to return to communal land, and their agricultural experience is tailored to traditional knowledge with less dependence on technology and large capital inputs. Recurrent droughts cause livestock losses.

Today, farming in the communal is still part of a multi-income stream livelihood strategy. Livestock farming is often a post-retirement activity to supplement pensions. In many cases, pastoralists concentrate on keeping as many animals as possible (by selling and slaughtering animals only when it was necessary to buy

[246] DALRRD, *Namakwa Spatial Framework*, 2023, p. 63.
[247] B. Saal local extension officer DAELR, personal communication, November 28, 2024.

food and supply household meat) to reduce the risk of destitution. Pastoralists employ a range of risk-mitigating farming strategies (manipulating herd composition, spatial distribution and timing of grazing) to maximise the efficient harvesting of available forage and water resources. Livestock management also promotes social cohesion between farmers, in mutual help systems.[248] The environmental challenge can also be improved by involving herders, employed by stock-owners, in decision-making about grazing distribution.[249] There is a strong need for assistance to access markets.

As with communal farming, groups of small-scale farmers organise themselves around a water point from where animals are allowed to graze during the day and kraaled by night. These areas are often overgrazed on land close to towns. Animals are kept mostly for own family use and consumption, with periodically selling animals through an informal system in the community to generate some cash.[250]

For semi-commercial farmers, a low input-output system is followed with marketing mostly through cash sales within the community. This means that all tax systems are bypassed in the informal economy. Commercial marketing ventures are only used when required by some financial system, i.e. where loans are used and payments towards that is required. Farmers are price takers and not price makers. Most of the land reform farmers will make use of "speculators" who buy animal and "round them off "on pastures or feedlots. The main attraction to sellers is that speculators come to their farms, reducing the need for transport and saving on transport costs. In contrast to abattoirs, speculators pay cash which allows for by-passing of all financial and tax-related systems. This seems to be a cycle of poverty, where prices are kept low.

Given the prominence of TRANCRAA ("Act 9" or communal) land, a key question will be the future productivity of these areas, in terms of food production (mainly involving mutton and goat meat). The TRANCRAA areas received over 1,1 million hectares in land reform expansion, reaching a total of over 5 million hectares. If productivity can be enhanced in these areas, it could make some impact on local agricultural productivity.

A related question is whether the farmers in the TRANCRAA areas are "transitioning" from being communal to commercial farmers, and whether their land needs are changing. In other provinces, a policy of "stepping off" communal and commonage land and accessing private farming land, through land reform purchases, has meant that proto-commercial farmers can get a boost and start to operate on their own.

7.5.4.3.2 Commercial farming units and trends

The area under commercial farming has been reduced substantially since 1994, due to extensive land purchases under various land reform programmes. Each of these land reform or restitution cases has its own unique history, making it very unwise to generalise about future development options and strategies. Almost 35% or 1.8 million ha of the available farmland in the study area (the four Local Municipalities) has been or is in the process to be redistributed through land reform processes. (These land reform projects are detailed in Annexure B).

According to the 2017 Agricultural Census, there were 838 commercial farming units in the Namakwa District (from Survey-General data). According to Agri-NK, there are approximately 280 commercial farmers in the entire district (according to Agri-Northern Cape), which suggests that there are commercial farmers managing several farming units, possibly due to economic pressures. The Boegoebaai study area (the four relevant LM areas) only contributes approximately 20% of the agricultural gross value of the Namakwa District as a whole (the rest is in Karoo-Hoogland and Hantam municipal areas).

Livestock products are primarily mutton and lamb, with goat and cattle playing a lesser role. Most commercial farms are fairly well developed with camps and water reticulation that allows for better management of veld (rotational grazing and/or resting) and herds. In general, a higher input-output practise is followed with marketing through commercial outlets. Margins are tight, with economic models indicate expected income of around R520 000 per 100 LSU with farming cost around R430 000 per 100 LSU.[251]

[248] Hendricks, HH et al, 2004, Why communal pastoralists do what they do in the Richtersveld Park.
[249] Michler, LM et al, Marginalised herders: Social dynamics and natural resource use in the fragile environment of the Richtersveld National Park.
[250] Interview, local extension officer DAELR, November 21, 2024/
[251] DAERL Enterprise Budgets, 2024.

Marketing is done through commercial ventures, such as selling directly to abattoirs or selling livestock via agents. Such agents will also make use of local abattoirs, or transport animals to abattoirs in Gauteng. Slaughter numbers in the Northern Cape province decreased around 30% for cattle and 20% for sheep for the 5-year period up to 2022,[252] due to prolonged drought conditions, resulting in lower livestock productivity and higher mortality rates.[253] Additionally, changes in livestock farming practices, such as adopting more sustainable and resilient farming methods, may have contributed to decreased slaughter numbers. In the formal commercial farming sector, farmers have reduced their herd sizes to cope with the challenging environmental conditions and to allow the land to recover.[254]

In general, there is also an increasing number of farms that get purchased by "non-farmers" from outside the province for lifestyle and recreational purposes, again reducing livestock numbers and slaughtering numbers. Many productive commercial farms that have been procured for land reform purposes, which negatively impacts production and slaughtering numbers. Furthermore, nature reserves have been expanded, with more land lost to agriculture.

The market is dominated by the supermarket retailers as local buyers of meat. They require a ZA-registration from abattoirs (abattoirs must comply with a basic export accreditation which adds to the cost factor). This gives the consumer better assurance that the product complies with best practices, but it all comes with a price tag which results in reduced producer prices and increased consumer prices. For the last three years, the bulk purchasing organisation KLK Landbou paid a zero premium on all its qualifying lambs (for registered and accredited producers and for lambs that meet a certain criteria), meaning that the farmers get zero additional return paid for meeting all the standards and requirements expected from them.[255]

This is also one of the largest factors driving the "informal market" in rural townships, where backyard or farm slaughtering takes place. This bypasses the cost of abattoirs. This means that the farmers get higher producer prices, while being able to pass on slightly lower prices to the consumer.

Although exports do take place (furs, carcasses, fresh meat and frozen meat) and good prices are achieved, the added production costs tend to erode much of the price benefit.

Live sheep imports are taking place from mainly Namibia and cattle from Botswana. This is also cyclical, due to veld conditions and droughts in those countries. Most of the live sheep imports from Namibia get slaughtered within the Northern Cape and this adds to the cyclical nature of slaughter numbers and the challenge to keep abattoirs viable. Over the last five years, there was a decline of almost 25% in registered abattoirs in the Northern Cape (from 50 registered abattoirs to 38 in 2024/5). The total registered abattoirs for Namakwa in 2024/5 are three high-throughput abattoirs (one in in Springbok), five low-throughput and rural abattoirs (one in Pofadder) and one rural poultry abattoir in Kamieskroon. In the study area, one high-throughput abattoir closed in Springbok in 2023. Low-throughput and rural poultry abattoirs and rural game registered abattoirs decreased in total from nine to seven.[256]

There are fewer than 80 people employed on a full-time basis by the three abattoirs in the study area (the four Local Municipalities). Recent closures of abattoirs in Springbok and Calvinia suggest the challenges of abattoirs in an arid environment with big fluctuations in numbers of market-ready animals, due to dry and wet climatic cycles. The closure of abattoirs has several implications for commercial livestock production: It increases the distance farmers must transport their livestock for slaughter, leading to higher transportation costs and increased animal stress. The decrease in local abattoirs impacts small-scale farmers most, as they

[252] Red Meat Abattoir Association slaughter statistics.

[253] Bahta, YT, & Myeki, VA, 2022. The Impact of Agricultural Drought on Smallholder Livestock Farmers.

[254] Coleman, A. 2021. Northern Cape sheep farmer's lessons from the drought (https://www.farmersweekly.co.za/animals/sheep-and-goats/northern-cape-sheep-farmers-lessons-from-the-drought/) .

[255] Yet accreditation remains important. Accreditation is linked to health and traceability systems, which are required for exporting mutton and lamb. If the farmers are producing according to higher export regulations, are they likely to get better prices for their meat, which would make them more sustainable in the long run. The export market keeps demand going and reduces the risk of major decreases in producer prices during periods of lower local demand. However, it takes time to develop these value chains.

[256] DAERL unpublished Industries Report.

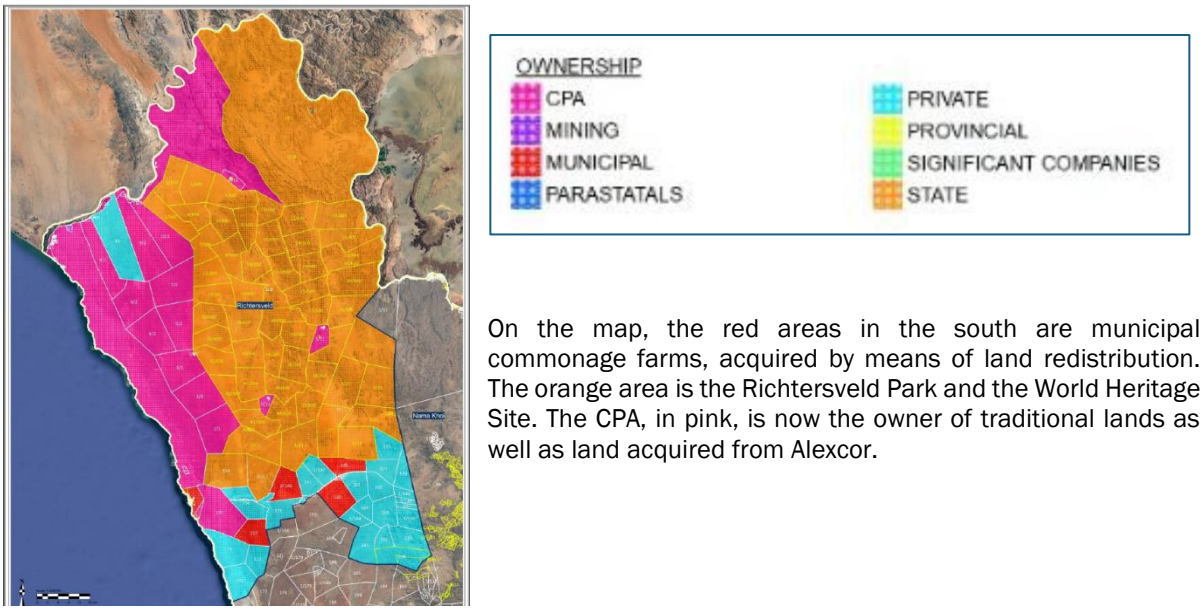
may find it increasingly difficult to access slaughtering facilities. There is therefore a negative cycle: Decreasing productivity on farms cause abattoirs to decline; if abattoirs close, then farming transport costs increase and farmers are under even greater pressure.

7.5.4.3.3 Land ownership in the Richtersveld jurisdiction

In the case of Richtersveld LM, TRANCRAA areas were extended by more than 400 000 ha by land reform purchases. Municipal commonages (mainly around Port Nolloth) was extended by more than 22 000 ha, in the south of the jurisdiction. In this area, no land reform was aimed at individual ownership, in contrast to other Namakwa municipalities where there was some land redistribution to commercial-level beneficiaries.

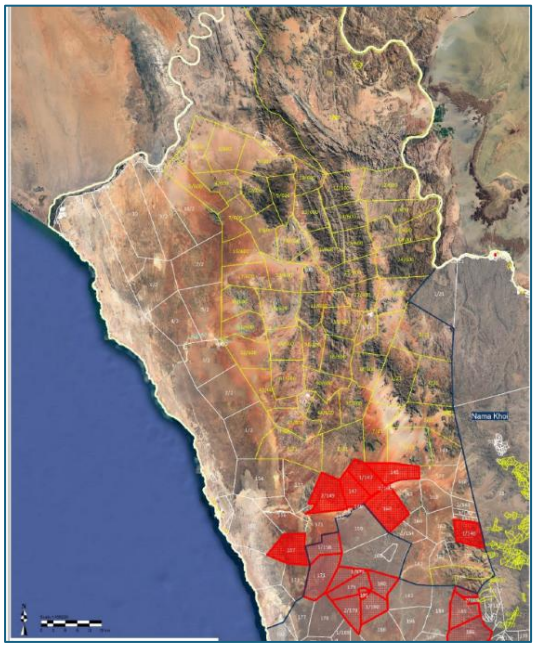
Land ownership in Richtersveld is complex:

Land ownership in the Richtersveld area: Richtersveld CPA, municipal, government, and private land[257]



On the map, the red areas in the south are municipal commonage farms, acquired by means of land redistribution. The orange area is the Richtersveld Park and the World Heritage Site. The CPA, in pink, is now the owner of traditional lands as well as land acquired from Alexcor.

[257] Richtersveld LM, *Spatial Development Framework,* 2023, p. 157.



Land reform farms , marked in red, purchased for the Richtersveld CPA (communal area) [258]

In the Richtersveld, the Department of Agriculture, Land Reform and Rural Development has transferred several pieces of agricultural land to the Richtersveld Community:

- Municipal land (about 12 430 hectares) located along the R382
- Portions of the farms Nieuwefontein, Nanassen and Riet Kloof
- Commonage land in the town of Port Nolloth (2 800 ha) is used by subsistence and emergent farmers for small-scale livestock farming, including goats, pigs and poultry.[259]

In terms of land restitution, the Richtersveld Community launched a land restitution claim in 1998, against the diamond mining company, Alexcor. This included compensation for diamonds extracted from it since the 1920s.The largest land restitution settlement agreement in South Africa was confirmed by the Land Claims Court in 2007. The Settlement Agreement was entered into between the Sida !Hub Communal Property Association ("CPA"), Alexkor and the Government of South Africa. Alexkor's land mining rights, as well as agricultural and maritime assets were transferred to the Richtersveld Community, and R190 million as extraordinary reparation was to be paid to the Richtersveld Community's Investment Holding Company.

The settlement entailed 194 600ha handed over to the Richtersveld community, including an 84 000ha coastal strip of diamond-bearing land currently being mined by the ailing state-owned Alexkor. The state made an "extraordinary reparation payment" of R190-million to a community-owned investment company, a R50-million development grant and also transfer Alexkor's farming operations to the community. Alexkor and the community entered into a joint mining venture, in which Alexkor holds 51% interest, to which the state will contribute R200-million in capitalisation. The mine-owned town of Alexander Bay was transferred to the community.[260]

Statistics about the number of farmers in Richtersveld vary. According to one source, there are about 42 farmers, farming with about 2 200 goats, 143 cattle and 1 300 sheep.[261] The relatively small number of farmers in the Richtersveld will probably facilitate ongoing interactions between them and the Boegoebaai

[258] Richtersveld LM, *Spatial Development Framework*, 2024, p. 162
[259] Richtersveld LM, *Spatial Development Plan*, 2024, p. 102.
[260] Lawyers for Human Rights, https://www.lhr.org.za/archive/news/2007/tears-joy-richtersveld-land-claim-settled.html.
[261] DAELR Data Base, unpublished, 2020

authorities or other planning agencies. According to another source, there are currently about 153 communal farmers in the Richtersveld: Kuboes (31), Eksteenfontein (48), Lekkersing (29), Sanddrift (16), Port Nolloth (29). [262]

Communal farming is practised in large areas of these districts. Sheep production (usually a mixture of indigenous and commercial breeds) is still prominent, but goats and cattle tend to play a more significant role in communal areas than at commercial farms in the same area.

Subsistence farming is practiced around towns and villages, but further away, farmers operate on a semi-commercial basis, with shepherds looking after livestock during daytime and being kraaled at night. These farmers' transhumant lifestyle (migrating with livestock according to seasonal rainfall) has been severely curtailed by fences enclosing the diamond mines, making the entire area long the coast and along much of the Orange River inaccessible to the stock farmers. Transhumance still takes place, but to a more limited degree. It is important that a Grazing Plan is drafted so that people do not degrade the natural environment and heritage through overgrazing.[263] In the light of climate change and possible increases in temperatures and droughts will make livestock farming even more difficult in future.

However, in recent times, many fences were removed by farmers and shepherds to facilitate direct routes to water points. The remaining water reticulation is in a very poor condition. Currently, farmers "organise" themselves around remaining water points, maintaining it for their own use. The result is that areas around water points are heavily over-utilized, while areas too far from water are hardly grazed at all, due to insufficient water and neglect of existing water infrastructure. Around villages such as Steinkopf and Leliefontein, the land is particularly degraded.

The relationship between grazing and environmental management remains a somewhat contested one in Richtersveld Nature Reserve, as well as other communal areas. There is evidence that the natural environment is being damaged near stock posts. Livestock movement patterns indicated that forage is the motivation for winter movements and water is the motivation for summer. On average, a pastoralist moved his animals six times a year between stock posts in a network of grazing routes.[264] In 2005, a survey showed that all the 36 identified conservation-worthy sites in the National Park were threatened by livestock grazing. Management strategies need to find a balance between biodiversity conservation and livestock grazing. Effective management strategies could include zoning, closing some stock posts and careful consideration for opening new roads.

Farmers on state land along the Orange River rely mainly on the river as a primary source of stock water with only a few inland boreholes still functional. Profit margins are extremely low, and input costs are rising all the time. Farmers therefore rely on municipalities or national government to maintain infrastructure on State and commonage land through conditional grants such as the Comprehensive Agricultural Support Programme (CASP) and the Ilima Letsema programme, but this is generally insufficient.

7.5.4.3.4 The likely impact of the Boegoebaai project on livestock agriculture

The key question for the livestock industry is: Will meat consumption due to the operations of the Port and the GH2 project stimulate local meat production and marketing in the area? If so, will it gradually boost the commercialisation of agriculture, as farmers adjust their production and marketing strategies?

Currently most food is transported into the area by big retail chains via their centralized distribution networks to shops and supermarkets. This traffic might increase in the short term to cope with additional demand at Port Nolloth and Alexander Bay. Such highly concentrated value chains, which leaves few opportunities for small business to enter the value chain.[265]

[262] Richtersveld LM, *Spatial Development Framework,* 2024, p. 90. The reason for the statistical disparity may be definitional issues. This suggests the need for a thorough agricultural census to be undertaken in Richtersveld.
[263] Richtersveld LM, Spatial Development Framework, 2024, p. 90.
[264] Hendricks, HH et al, 2005, Movement response patterns of livestock to rainfall variability in the Richtersveld National Park.
[265] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 30.

Careful analysis of the likely impacts of the Boegoebaai projects suggest that these projects are not likely to stimulate *local* agricultural production (i.e. mainly meat production) to any meaningful level.

During the construction phase, 7 190 direct jobs will be created at the Port; after the construction phase, 420 full time jobs will be created. Between 6 000 and 8 400 people are likely to move into the Port Nolloth area, but this peak will only last for 2-3 years. The number of jobs resulting from the green hydrogen plant is uncertain, and it is likely that the demand for red meat will increase significantly due to higher incomes. Will this higher demand be met from mainstream supermarkets, accessing much of their product from the metropoles? Or will local farmers find new supply chains, either directly with consumers, or via independent butcheries, or even supply meat to some of the supermarket chains?

The answer to this question hinges on the extent of market domination by large retail chains, and the likelihood that local farmers will experiment with new marketing channels, given new levels of demand. It seems that the impact on local meat production will be very limited, for several reasons. Firstly, the sale of livestock by communal farmers is determined by numerous factors, including rainfall patterns, which are highly unpredictable: "The establishment of marketing systems that will maintain constant levels of stock sales in order to prevent herd growth is difficult to achieve".[266]

Secondly, local sheep meat consumption is likely to decrease to less than 3% of local meat demand, while chicken will grow to almost 40%. This is due to the affordability of chicken as a protein source versus the significantly more expensive red meat products. The expected increase in food demand resulting from the industrial development may therefore be oriented to chicken rather than red meat. Thirdly, although the salaries paid by the Boegoebaai projects may push workers into higher income brackets (particularly locally recruited workers), it is doubtful whether their expenditure on meat (calculated at an average of 2 kg/person/ annum)[267] will be sufficient to change the dominance of large retail supply chains.

7.5.4.4 Large-scale and commercial production

The Namakwa District Municipality is bordered by the Orange River to the North. Large areas of arable soil can be found on the banks of this river and the proximity to high quality irrigation water creates attractive opportunities for development of intensive agricultural development. Significant distances between production units together with good air quality, low humidity and high temperatures provides natural buffers for biosecurity.

Intensive commercial agriculture is very important in the national economy. In 2012, The National Development Plan 2030 (NDP) recognized the key challenges facing South Africa in order to eliminate poverty and reduce inequality by 2030. It identified agriculture and its value chain as a catalyst for radical socio-economic transformation and focus on job creation and decent work towards the year 2030. Its vision is to create close to 1 million jobs in agriculture and to reduce unemployment through expanded irrigated agriculture (by at least 500 000ha); revitalization of underutilized land in communal areas; supporting commercial sectors with highest potential for growth; and supporting job creation in the upstream and downstream industries. Being a flagship project, the Boegoebaai initiative may have a beneficial impact on large-scale irrigation farming, due to the provincial government placing pressure on municipalities, mines and producers further up-river to curb polluting activities.

Production of high-value irrigation crops along the Lower Orange River is a vital agricultural component of the Northern Cape Province. Farmers grow a variety of crops, including table grapes, citrus fruits, raisin grapes, dates and pecan nuts. These crops are chosen for their profitability and demand, mainly for international markets.

This is a high-profit, highly productive industry, and it creates a momentum towards re-investment. Expansion is currently limited by arable land with irrigation rights. Much of this land is held by communities along the

[266] Hendricks, HH et al, 2007, Biodiversity conservation and pastoralism—reducing herd size in a communal livestock production system in Richtersveld.
[267] https://www.bfap.co.za/

river, which could in future become available for intensive production. All of these commodities can benefit from reduced distances and transport cost that can arise from the Boegoebaai port development.

Depending on cultivar and seasonality, up to 4.5 tons of table grapes can be produced per hectare. In the 2024 season, 24.4 million crates of table grapes were harvested in the Lower Orange River region.[268] Packing and branding is done in on-farm in cold store facilities, and are transported in refrigerated shipping containers to overseas markets. Most of these grapes are earmarked for export markets in Europe, North America and to a lesser extent, China. The Lower Orange River produced 80 000 tonnes of raisins in 2024. Most of this is produced for markets in Europe and North America.[269] More than 24 000 ha of pecan nuts with a potential yield of 72 000 tonnes have been planted in the Northern Cape. These are mainly meant for export to China.

In the study area, table grapes are mainly being produced in the Khâi-Ma Municipal area on the South African side and at Hakiesdoring and Aussenkehr on the Namibian side of the river. Development costs exceed R 1.2 million per ha at current costs and will typically include soil preparation, drainage, plant material, trellising, mechanization, packing facilities and housing.

Dates are produced at Klein Pella, Hakiesdoring and Aussenkehr. Plant material is extremely scarce and expensive. Dates only come in full production eight to ten years after establishment and therefore significant capital is required for such ventures. Similar packing facilities and cold chain requirements are needed as table grapes and pre-packed fruit are also exported through ports in refrigerated shipping containers.

Raisin grapes and vegetables (mainly tomatoes and cucurbits, a type of pumpkin) are being produced at Vioolsdrift and Noord Oewer (Namibia). Most of these products are destined for local markets along the N7 from Windhoek to Cape Town.

In wet years, winter cereals are planted on 26 836 ha under dryland cultivation. Yields are generally low, and plantings are mainly meant for fodder production and as supplementary feed.

While insignificant in terms of land area, this intensive irrigation cropping offers a sustainable and reliable source of income to many families and contribute significantly to the agricultural economy of the study area. It also diversifies supply chains, particularly hardware and agricultural input suppliers in the towns, and functions as an important backward economic multiplier in the local towns.

The bulk of intensive irrigation cash-cropping is located in Khai-Ma LM (3 563 ha) and Nama Khoi (1 277 ha). In Richtersveld, only 408 ha are utilised for this purpose.

The area currently under cultivation in Richtersveld, to the east of Alexander Bay

[268] South African Table Grape Industry, 2024. https://www.satgi.co.za/
[269] Raisins SA, 2024. https://raisinsa.co.za/

Agricultural employment in the formal agricultural sector is particularly significant in Khai-Ma LM (944 jobs) due to irrigation farms. Nama Khoi LM has 638 agricultural jobs, while Richtersveld stands at 436.[270] The irrigation activities in the Onseepkans/Pella area of Khai-Ma contribute significantly to agricultural employment, while a large proportion of the Richtersveld employment will be concentrated around the Vioolsdrift irrigation area. This figure is about 10% of the Richtersveld total employment, and has remained largely static between 1996 and 2023.[271]

Partly due to the low population density next to the Orange River, in-migrant workers from mainly the Kuruman area are often used on the export table grape and date farms. This does impact on local economies in that salaries and wages are often spent elsewhere and does not fully benefit the local economies.

7.5.4.5 Community-owned irrigation projects

In several localities along the Orange River, community-based irrigation agriculture is being attempted (more details are available in Appendix B), based on the potential of fertile alluvial soils.

The two most proximate projects to the Boegoebaai area are Sanddrift and Richtersveld Sida !Hub. **Sanddrift** lies 80km east of Alexander Bay. Its unique climate with its coastal influences makes this area highly suitable for the production of cash crops and even high-quality wine grapes. The Richtersveld Municipality is the caretaker of Sanddrift. The beneficiaries of this land are the Richtersveld community which consists of approximately 2 700 individuals, living in 4 small rural towns: Eksteenfontein, Lekkersing, Sanddrift and Kuboes.

The **Richtersveld Sida!Hub** project is located on five farms near Alexander Bay: Dunvlei, Pagvlei, Beauvallon, Brandkaros and Arriesdrift. A number of irrigation farms were developed by the Alexcor mine along the banks of the Orange River in order to increase job creation and also produce food (milk, cheese, meat, vegetables, citrus and grains). Grains were mainly produced as feed for the ostrich and dairy production units. These farms were however highly subsidised via the lucrative mining enterprises.

The area has largely been denuded of its diamonds, and the mining operations have decreased markedly over the last five to ten years. The irrigation farms were alienated from the mines through land reform processes, but without the support and the subsidies from the mines, profitability has declined and it has reached a point where all production came to a complete standstill.[272] When Alexkor's agricultural and mariculture assets were transferred to the Richtersveld Community, the implementation of the Settlement was fraught with difficulty and conflict, resulting in all agricultural activities coming to a halt in 2008/9 and to the eventual liquidation of the Richtersveld Agricultural Holding Company.

BENESON Agri was formally appointed by the CPA in 2013 to revitalize the irrigation lands. However, barely 2 years later, BENESON Agri was liquidated and all the irrigation development came to a standstill yet again. During 2016, Agri Sol (Pty) Ltd was approached by the Richtersveld Community in their search for a new strategic partner to unlock the agricultural potential in the region. The owner is a commercial farmer that grew up in the area and is a respected vini- and viticulturist. Agri Sol (Pty) Ltd has been operating on the farm since 2017, planting grains, fruit and vegetables.[273] Richtersveld Growers (Pty) Ltd ("JV") was established with equal shareholding between Agri Sol (Pty) Ltd (50%) and the Richtersveld community through the Richtersveld Property Holding Company (50%). The JV agreement was signed in December 2018. The JV leases the farming property from the community, with the main purpose of developing agriculture in the area and ensuring its commercial viability and long-term sustainability. There is an opportunity to develop 540 ha of the agricultural land to irrigate a number of crops. Thus far approximately 212 ha of the irrigation lands is under production. Products produced include raisins, potatoes, wheat, dry beans and maize. [274]

[270] S&P Global Market Intelligence, 2023.
[271] S&P Global Market Intelligence, 2023.
[272] Alexcor Farms, unpublished report, DAELR, 2012).
[273] Personal communication, Mr Mike De Neuilly Rice, 5 November 2024.
[274] https://web.facebook.com/richtersveldgrowers/?_rdc=1&_rdr

Competition for water from the Orange River might impact this farming operation negatively, especially times of low flow. With increased demand for potable water from growing settlements as well as industry, this threat can be devastating to this agricultural operation.

This irrigation development lies closest to the proposed port and industrial development site and is likely to benefit most by planned infrastructure and possible service centres that might arise. Currently the closest irrigation-orientated mechanization services and input providers is located at Vredendal. Improved road and digital connectivity infrastructure will also be very beneficial for marketing and access to markets and input providers.

7.5.4.6 The potential benefits of the Port and GH2 for agriculture

7.5.4.6.1 Port infrastructure

The Boegoebaai Port will be an important export facility for these intensive crop-farmers, particularly to reach European markets and to shorten travel distances and time frames.

One of the main challenges of exporters of agricultural products from the Northern Cape Province is the distances to ports which results in relatively higher logistical costs when compared with its major trading competitors. Apart from this, there are also capacity constraints at existing ports leading to extended periods in transit as well as complications with cold chain requirements of fresh produce. This impacts directly on quality and shelf life of products.

However, according to the Boegoebaai Port Development Study by Transnet there is little potential growth in export or import of agricultural produce envisaged over the long term. Agriculture is expected to make up less than 2% of shipping volumes in 2028 and will disappear by 2035, due to the expected volumes of iron ore exports. Direct benefits for the agricultural sector will then become virtually extinguished. This will be extremely unfortunate for agricultural enterprises – having a port nearby and not available for agricultural exports. There should be a ring-fenced capacity at the Port which will continue to ship agricultural commodities in the long-term. This will serve the often-repeated purpose of promoting diversification from mining enterprises.

7.5.4.6.2 Local economic diversification

The induced economic benefits of the Port and GH2 projects will enable the local and regional economy to become more diversified, in terms of business services and technical support. Such services will also be to the benefit of farmers.

By stimulating economic growth generally, these projects will bring additional money into circulation, which will find its way into local agricultural purchases. These may be episodic and small-scale, but nevertheless will assist low-income families to get new funding streams.

Farmers may find opportunities to diversify or supplement their income by providing goods and services to the Port or engaging in complementary businesses, such as services, agri-tourism or eco-friendly initiatives. This would strengthen the trend towards multi-stream rural incomes, which promotes diversification and economic resilience.

7.5.4.6.3 Improved infrastructure

Improved road networks, particularly the N7 and N14 will assist the farmers to export their livestock and crops to markets in Cape Town and Gauteng. However, the intensity of truck traffic would be a dampener, due to truck accidents and unsafe travel conditions. If the roads are not maintained well by SANRAL, to cope with the massive increase of ore trucking, then poor road conditions would deter agricultural transport as well as tourist travel.

As argued in the Tourism section, a possible upgrade of the Springbok airport will also benefit farmers in terms of the rapid movement of small but high-value inputs and products.

The improvement in telecommunications (such as fibre) along the highways and to the Port and GH2 plants will be a benefit to communities *en route*. This network can then be expanded to surrounding towns and communities. It would be major factor in overcoming the centuries-old remoteness experienced by Namaqualand. The beneficial impacts to young people, educational institutions and health services providers would be immense. It would also stimulate new rounds of "semi-grant" investors from the metropoles.

7.5.4.6.4 Promoting agriculture through CSI

Various strategic and practical proposals have been made to strengthen agriculture in the Northern Cape in general, and in Namakwa in particular. Furthermore, various socio-economic initiatives have been mooted for support by the Port, and by implication, possibly by the GH2 projects. There is already support in official strategies for promoting such agricultural development, diversification and intensification. It would be crucial to create synergies between such proposals.

It will be important to optimise agricultural opportunities in the region, and support the establishment of small-scale farming activities, agri-enterprises and agriculture-led industrialisation. This will foster productive regional-rural development, and enhance food security.[275] Agricultural skills development is crucial, as well as developing crops and livestock genetics that are less vulnerable to climate change.[276] One intervention that may yield significant fruit is to focus on women farmers, ranging from survivalists to those starting to grow their own herds and flocks, and with a particular focus of strengthening multiple livelihoods and supporting diverse household economic strategies simultaneously.[277]

The Provincial Growth and Development Plan has highlighted programmes which will support agriculture, including Farmer Support and Development, Sustainable Resource Management, Veterinary Services, and Agricultural Economics. The agro-processing sector will be a strong focus, with its high potential for employment.[278] Other initiatives will include upgrading infrastructure (marketing information, markets, electricity, transport, storage, abattoirs, and dams); upskilling agricultural workers (there is currently no agricultural college in the Northern Cape), value chain development, smart climate investments (e.g. solar panels), and research stations. Similarly, COGTA's *Namakwa District Profile* is optimistic about the prospects of agriculture, in terms of high-value irrigation crops along the Orange River; sheep farming (wool and mutton); and agro-processing in the form of high-value aquaculture, such as abalone.[279]

Land reform projects need assistance, such as training, market information, management practices, and trade relationships.[280] These initiatives need to consider research that has already shown the importance of "pluri-activity" (farming as one of a suite of income streams). Pluriactive systems may require different types of support, in particular different types of extension services".[281] In addition, agricultural and land reform programmes should assist large commonage and communal farmers to "step off" from this land and access their own farms, where they can farm commercially. This model has already been tested in other provinces, such as the Free State.

The AgriParks progamme aims to assist farmers through mechanisation centres and Farmer Production Support Units, with the necessary machinery, equipment and inputs. The 2023 Namakwa Spatial Development Framework highlighted the importance of the Springbok abattoir, as an anchor for an Agri-Hub or Agri-Park (more details are provided in Appendix B).

The challenges associated with agricultural support programmes should not be underestimated. The arid environment and poor soil qualify affects animal and crop farming activities, limiting the sector's economic

[275] Richtersveld LM, *Spatial Development Framework*, 2024, p. 34.
[276] Richtersveld LM, *Spatial Development Framework*, 2024, p. 66.
[277] Kleinbooi, K and Lahiff, E, 2007, ''Die man is die hoof en vat voor'": Women's attitudes to land and farming in the communal areas of Namaqualand.
[278] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 28.
[279] COGTA, *Namakwa District Profile*, n.d., p. 20.
[280] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 29.
[281] Anseeuw, W and Laurent, C, 2007. Occupational paths towards commercial agriculture.

viability. Another difficulty is the loss of technical skills in agriculture-related departments, and consequent under-spending in such departments.[282]

The Namakwa District Rural Development Sector Plan (2023) has identified possible agricultural projects, such as Goat or sheep handling facilities and feedlot at Eksteenfontein, to improve livestock feeding, and animal drinking troughs in more remote areas to lessen the grazing pressure around existing watering areas.[283] The Namakwa SDF has proposed an irrigation project in Sanddrift, to stimulate employment, as well as other irrigation projects in the Richtersveld CPA, and the Richtersveld LM Spatial Development Framework proposes a Wildlife Economy Zone, as well as an abattoir at Port Nolloth.[284] In all these cases, in-depth feasibility studies will need to be undertaken, and conditions can differ greatly in different towns and districts.

7.5.4.6.5 Biodiversity through CSI

The Namaqualand landscape is renowned for its globally important and abundant biodiversity (primarily plants, reptiles and insects). Rangeland degradation is a growing threat to large areas and is expressed through lowered groundwater tables and reduced water quality, soil erosion and decreased soil fertility. Furthermore, climatic changes (e.g., changes in precipitation, CO2 levels) and anthropogenic activities (e.g., mining, infrastructure development, and social pressures) contribute to rangeland degradation.

In areas away from livestock watering points, pockets of vegetation have remained protected from animal husbandry and remains an important resource for seed. Where possible, highly degraded veld should be rehabilitated and the variety of species that naturally occurred in the ecosystem should be re-established for the ecological functioning of the area to be restored. Active rehabilitation is often the only way to improve the quality of veld in these areas. This requires technical expertise and is costly, but there is already a valuable literature on this topic in the Karoo. However, these efforts are often inadequate due to funding constraints.

With the increase in local income and investment through industrial development, there may be opportunities to invest in environmental restoration and conservation projects. Furthermore, as part of the CSI efforts of the Port and GH2, particularly in the Richtersveld and Nama Khoi areas, there may be funding mechanisms to offset environmental impacts and to invest in environmental technology and innovation. New techniques to revive local vegetation have been tested, and could be used to restore degraded rangelands and mining areas;[285] this may also offer job creation opportunities to local people, and an opportunity for ecological education and training. Community-based nurseries can propagate seedlings for rehabilitation projects.

7.5.4.6.6 On-farm Green Hydrogen use

The development of an industrial port near agricultural production areas can offer several potential advantages for intensive farming operations, such as those along the Orange River. Modern agriculture is carbon-intensive, and the global food system, from fertilizer manufacture to food storage and packaging, is responsible for up to one-third of all human-caused greenhouse-gas emissions.[286]

Hydrogen is also a key component in the Haber-Bosch process, which synthesizes ammonia from nitrogen. Ammonia is then used to produce nitrogen-based fertilizers. The adoption of green hydrogen technologies can spur economic growth in rural areas by creating new job opportunities in hydrogen production and distribution.[287]

[282] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 29.
[283] Plan found at https://drdlrgovza.sharepoint.com. Richtersveld LM, *Spatial Development Framework*, 2024, p. 70.
[284] Richtersveld LM, *Spatial Development Framework,* 2024, p. 233.
[285] Simons, L and Allsop, N, 2007, Rehabilitation of Rangelands in Paulshoek, Namaqualand; Carrick, PJ and Kruger, R, 2007, Restoring degraded landscapes in lowland Namaqualand.
[286] Thornton P., 2012, Recalibrating Food Production in the Developing World:
[287] Kleperis, J. et al, 2021,. Hydrogen supported bioconversion of biogas CO2 to upgrade biomethane in fuel for vehicles.

Farmers can also potentially benefit from carbon credits or incentives for adopting greener practices associated with the hydrogen economy.[288]

The presence of a cutting-edge industrial facility may encourage research and development initiatives that could benefit agriculture, such as innovations in sustainable practices and resource management. Public and private agricultural organisations can partner with the Boegoebaai GH2 project to test new on-farm innovations.

7.5.4.7 Potential risks posted by GH2 to agriculture

A new port and industrial development at Boegoebaai will be a significant direct investment in the region which is characterized by poverty and lack of employment. This initiative has the potential to not only create jobs on a direct level, but can stimulate other economic drivers such as construction (industry and human settlements, tourism and support services.

Establishing a port and industrial plant near agricultural areas can pose opportunities and risks to farming operations. Agriculture (crop farming) could benefit at household level by enhanced desalination facilities linked to Green Hydrogen; some of this water would be available for household use, which can then be used as grey water for local household agriculture. The crop agriculture along the Orange River is unlikely to be affected. Land degradation is not a significant risk for livestock farming; however, ecosystem degradation may be caused by noise and dust along the highways. Once again, a rail link would reduce traffic-related impacts. Local communities could raise the importance of this matter in negotiations.

7.5.4.7.1 Water: Household and Port water supply

Water infrastructure is not addressed as one of the main port development elements,[289] and it is assumed that the water demand of the port and associated new settlements, will be addressed using existing natural resources. Currently most of the towns and settlements of the study area rely on potable water from the Orange River. Water shortages occur during dry spells when upstream demand increases, and the flow of the Orange River is low. This situation will escalate when expansion of farming as described earlier in this report commences.

A key mitigation factor may be the proposed Noordoewer/Vioolsdrift Dam (NVD) on the Orange River between Namibia and South Africa. A feasibility study was undertaken in 2015 by Namibia and South Africa under the auspices of the Permanent Water Commission. The purpose of the dam will be to serve as a re-regulating and/or storage dam to improve water resources availability in the Lower Orange River system, while supplying ecological water requirements (EWRs), domestic, industrial, mining and irrigation water requirements. The construction of this dam will offer opportunities to supplying the growing water demand from the agricultural, domestic, mining and energy sectors.

For GH2 production, it is almost categorical that there is no local water available in this arid environment for industrial uses, and desalination will have to be utilised for GH2 production. The prospects of desalination projects were discussed earlier.

7.5.4.7.2 Dust pollution

One of the biggest threats to biodiversity today is sand and dust storms.

Dust pollution due to ore shipments at the harbour is a major hazard. The port and industrial zone of Saldanha Bay transports iron and manganese ore. Dust emission, transport, and deposition play several

[288] Paviour SJ., 2014, Carbon sequestration and trading potential in semi-arid South Africa; Rybchak O. et al, 2024. A Fine Line Between Carbon Source and Sink.

[289] Transnet, 2024, Boegoebaai Port Development SEB report.

critical roles, affecting land degradation, climate, the environment and public health.[290] The visible emission of dust from the ore raises concerns for public health.[291]

In the Transnet strategic plan, iron ore will continue to be shipped to Saldanha, while other ore types (such as manganese) will be steered to Boegoebaai Port, presumably by road. Manganese also creates dust, which affects public health, as experience in Gqeberha has shown: "The manganese ore is often transported without sufficient coverage (tarpaulins), and fine dust is released directly into the air while the trucks carry it to and from the warehouses. Strong winds easily disperse this dust throughout surrounding areas, choking the air with thick clouds and making visibility difficult for motorists and pedestrians."[292] Fruit exporters tend to refer to the Saldanha port as a "dirty port", and not conducive for the export of agricultural products.[293]

Dust fractions in shipping containers are monitored by The Perishable Products Export Control Board (PPECB), an independent service provider of certification and cold chain management services for producers and exporters of perishable food products. The main export fruits from the study area (table grapes and dates) are packed on-farm in dust proof closed vented, refrigerated shipping containers. However, a portion of the already packaged produce is transported in cold trucks, and pallets are transferred to refrigerated shipping containers at the port.[294] Since the shipping containers need to be dust free, this can create a window of pollution impact. Other products such as citrus, which is grown in the lower Orange region around Kakamas, are transported in partially vented shipping containers, and dust will be a big problem.[295]

The dust is not only a problem for fruit exporters. In Gqeberha, dispersed manganese dust and ore falling from trucks onto the roads and pavements increase the mineral concentration in the soil and nearby waterways. Long-term exposure creates adverse ecological conditions for the growth of plants and other living creatures that take up the mineral, and the quality of resources in these areas decreases. Animals in these areas may suffer from respiratory and visual issues, and the hides of farmed animals are contaminated with thick layers of dust. High manganese concentration in drinking water and food also impacts its taste.[296]

Shipping ore by road, in particular, brings major risks. It would involve hundreds of big trucks, laden with dust-producing manganese; air pollution caused by diesel trucks churning up the roads, blocking traffic; dangerous traffic conditions and traffic accidents; potholes causing deaths and damage; trucks thundering through small towns (e.g. Keimoes and Kakamas); a lot of roadside services that become hubs of crime, prostitution and littering; and destroy agricultural and tourism assets. This road would have to go from Postmasburg to Upington, then along the "Green Kalahari Route" (Keimoes, Kakamas) to Pofadder, then through Springbok, then just past Steinkopf, then over the scenic Anenous pass to Port Nolloth, then through the town, and north to Boegoebaai.

The dust and ore pollution would imperil agricultural transport (quality of produce). It would destroy many tourism enterprises along the way.

7.5.4.7.3 Waste management near the Boegoebaai plant

The production of ammonia and methanol generates waste and often involves the use of catalysts and other chemicals that can be toxic or harmful to the environment, potentially contaminating water sources and soils during production and transportation, if not handled properly. In case of continuous discharge or leaks into water bodies, this may represent an immediate danger to not only aquatic life, but livestock depending on sub-terranean water, with subsequent impacts on the livelihood of communities depending on it.

[290] Vos HC, et al, 2024, Spatial variability of dust concentration and deposition around an industrial port in South Africa
[291] https://mg.co.za/news/2024-10-07-residents-of-saldanha-bay-say-red-dust-from-transnets-ore-terminal-is-staining-their-homes/
[292] https://www.dailymaverick.co.za/article/2022-05-30-gqeberhas-role-as-key-port-for-export-of-manganese-comes-with-high-environmental-and-health-costs/
[293] Interview, P. Karsten & D Duvenhage, Karsten Boerdery, November 6, 2024.
[294] Interview, L Hanekom, Southern Farms, personal communication November 7, 2024.
[295] Personal discussions with export farmers from the study area, November 6, 2024),
[296] https://www.dailymaverick.co.za/article/2022-05-30-gqeberhas-role-as-key-port-for-export-of-manganese-comes-with-high-environmental-and-health-costs/

To mitigate these air pollution risks, it is of utmost importance that all the specifications and conditions stipulated in the various Environmental Authorizations that will be required, be adhered to during and after the construction phase.

7.5.4.7.4 Air pollution and noise due to trucking (i.e. vehicle emissions)

Air pollution may be the most significant impact caused by large-scale trucking, in the form of greenhouse gasses generated from burning diesel. This is already experienced in Gqeberha, in the light of manganese and ore trucking.[297] This will affect rural and peri-urban farmers, in terms of the health of their animals.

7.5.5 Mining

The closure of the diamond mines at Alexander Bay and Kleinzee will have ripple effects for years to come. In both cases, there was a lack of planning for diversification of the local economies – despite decades of warnings in the international and South African mining policy literature. "Like death and taxes, mining closure is certain".[298] The implications of the lack of economic diversification are made even more severe due to South African policies of "open mining towns", whereby employees were encouraged to become home owners; when mines close, these assets become almost valueless. The closure of mines are extremely disruptive to local communities. (In contrast, fly-in-fly-out arrangements in other countries do not promote families' attachment to the mining locality, and therefore are much less disruptive when mines need to close). Mines' Social and Labour Plans (SLPs) have often remained ineffective in planning for these radical changes.

The dire consequences of economic and social disruption often have to be managed by municipal and provincial governments, who are not prepared for such challenges. This is the difficult process of "normalisation", when mine-owned towns have to become re-oriented to democratic government and management, with an entirely new set of fiscal arrangements based on local rates and service charges.[299]

Economic diversification is often hampered by a range of factors, such as resource price volatility, higher wages in mining areas, production linkages that benefit only the larger urban areas, and mining-related institutions that erode regional and local decision-making. Mines create specific types of economic geography over time, with including specific types of infrastructure, human and institutional assets, local styles of leadership, and the role of the state. This creates "path dependencies" that are very hard to re-orient to new types of economic investment. Turning a local or regional economy around calls for sophisticated planning, information sharing amongst stakeholders, and using an incremental planning process to evaluate progress, rather than a dogmatic steering approach.[300] In the case of Namaqualand, the Namakwa Distrct Municipality will, inevitably, be responsible for creating such a new institutional ecosystem.

Yet mining still forms an important sector in Namaqualand.

In 1977, a validation study of a zinc deposit at Gamsberg (80km from O'kiep) was undertaken. The project was owned by Anglo American Corporation (45%) and Newmont Mining and O'kiep Copper (27.5% each). It was deferred in 1976 due to the depressed state of the zinc market. The Gamsberg site was expected to yield 350 000 tons of zinc concentrates per annum.[301] In 1978, the project was put on hold until the zinc market strengthened.

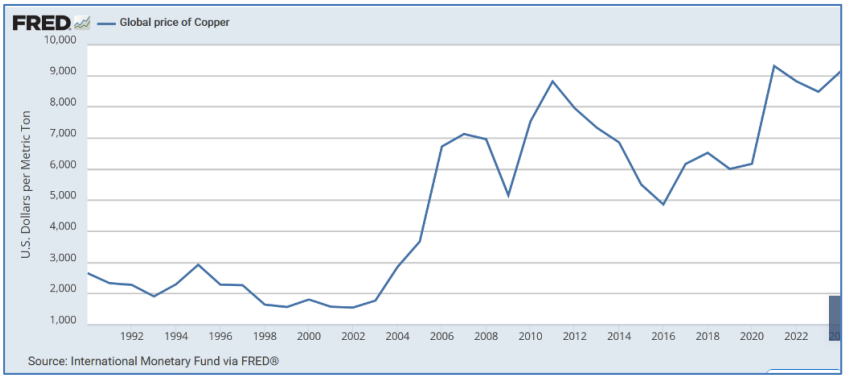
Today, Vedanta Zinc International has invested at the Gamsberg Zinc Mine, and will build a smelter within the Khai-Ma Local Municipality. It will be the anchor investor of the proposed SEZ at Aggeneys.[302] Zinc prices

[297] https://www.dailymaverick.co.za/article/2022-05-30-gqeberhas-role-as-key-port-for-export-of-manganese-comes-with-high-environmental-and-health-costs/
[298] L. Marais, 2023, The Social Impacts of Mine Closure in South Africa, p. 4.
[299] L. Marais, 2023, The Social Impacts of Mine Closure in South Africa, p. 40-55.
[300] L. Marais, 2025, Planning for post-mining economies: Misconceptions and opportunities.
[301] Dunne, J, 1986, Regional Development Strategy for Namaqualand, p. 138.
[302] COGTA, Namakwa District Framework, n.d., p. 31.

are estimated to return to higher levels.[303] Employment in the Vedanta lead and zinc operations, will be about 2 000 in the short and long term.[304]

The long-term trend for copper prices is generally upward, driven by factors such as increasing demand for copper in green energy projects, potential supply imbalances, and economic conditions in major regions like the US, China and Europe. Nevertheless, the Transnet study indicated that copper is likely to employ between 50 and 70 people in the short term (before 2030), but by 2050, those jobs would have fallen away. [305] Copper resources were said to be virtually infinite, with those at Carolusberg (the deep ore mine) relatively untouched. The future of copper mining therefore depends entirely on the exchange rate, copper deamand, and the copper price.[306]

The price of copper in US$, 1992-2022



Power demand is set to double through 2050. This will happen amid a shift away from fossil fuels and thermal generation capacity and a move towards more renewable power. Much of renewable power generation is copper-intensive – indeed, electrification cannot happen without it.[307]

This is an important insight to take forward in the region, and planning for the railway and port, particularly in the light of the EU's CBAM principles (Carbon Border Adjustment Mechanism), which incentivises low-carbon transport systems for exports. Copper 360 is currently mining good quality surface ore in Namaqualand, [308] A more detailed investigation of copper prospects in Namaqualand is required.

The Richtersveld community won an important stake in the diamond industry in the successful land restitution claim. It will be important to consider the longer-term potential of diamond mining in the area. The current view is that the outlook for diamond production in the Northern Cape remains muted, due to several factors: Diamond miners are unloading excess and lower quality diamonds; polished prices are in continual decline; there is a slowdown in diamond demand; and there is a growing interest in laboratory-grown diamonds, which would require natural diamond miners to undertake better niche marketing for their product.[309]

In the latest COGTA Namakwa District Framework, alluvial mining is proposed as focus projects at Port Nolloth and Hondeklipbaai.[310]

A separate issue, which requires much more investigation, is the current wave of illegal small scale mining in Richtersveld. Mining can cause severe, long-term environmental damage, which can be injurious to health and livelihoods. The negative externalities of mining need to be understood, minimised, and carefully managed so that local communities are not left to fend for themselves, especially once the mining is over

[303] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 34.
[304] Transnet 2024, Boegoebaai Port Development Socio-economic Studies SEB report, p. 36.
[305] Transnet 2024, Boegoebaai Port Development Socio-economic Studies SEB report, p. 36.
[306] Dunne, J, 1986, Regional Development Strategy for Namaqualand, p. 145.
[307] https://www.woodmac.com/news/opinion/copper-rush-a-strategic-analysis/
[308] Simon Brown, **Copper 360 revels in finds of high-grade surface deposits, 1 March 2024,** https://www.moneyweb.co.za/moneyweb-podcasts/moneyweb-now/copper-360-revels-in-finds-of-high-grade-surface-deposits/
[309] Northern Cape Government, *Provincial Growth and Development Plan,* 2019, p. 34.
[310] COGTA, Namakwa District Framework, , p. 31.

and mines have closed.[311] As the country's attention turns to Boegoebaai and the Richtersveld, this issue will need to be addressed at municipal, district, and national level (the Department of Mineral Resources).

7.6 INSTITUTIONAL CAPACITY IN THE REGION

The Namakwa district, located in the arid Northern Cape region of South Africa, has been shaped by both colonial legacies, apartheid, and post-apartheid developments. The region is primarily inhabited by the Nama people, the largest Khoikhoi group, with a history of dispossession and violence dating back to the early 20th century.[312]

7.6.1 Institutions in flux: The political and social context

Following the end of apartheid in 1994, the establishment of the Namakwa District Municipality was part of broader administrative restructuring to ensure equitable service delivery and local governance. Local municipalities within the district, including the Namakwa DM itself, often struggle with inadequate resources and have been the subject of national and provincial efforts to improve infrastructure, access to services, and local economic development.[313] The shift towards green hydrogen and renewable energy is seen as a potential way to revitalise the region's economy, but it must contend with the socio-political legacy of the past.

The community's involvement in decision-making processes remains a critical issue. Many local communities, particularly those with a history of marginalisation, are concerned about the impact of industrial developments on their land, livelihoods, and rights.[314] Without effective engagement, these projects risk replicating the same inequities that characterised previous development patterns in the region. Mitigating the risks of social tension would require a multifaceted approach that balances economic growth with the preservation of agricultural livelihoods and community well-being. This will require municipalities with adequate skills and resources, as well as inclusive planning processes, ongoing stakeholder engagement, and collaboration between industry and the local agricultural community.

Involving local residents in decision-making processes can help ensure that their needs and concerns are addressed. Promoting agricultural innovation, access to markets, and support services can enhance the resilience of farming communities, helping them adapt to changes brought by industrialization. Investing in infrastructure that benefits both farming and industrial sectors, such as roads, infrastructure, and broadband internet, can enhance overall community resilience. Politically, local governments struggle to meet the needs of marginalised communities, with political divides and a growing demand for more inclusive governance, particularly regarding land use and resource management.

In the Northern Cape, rural municipalities have faced multiple and sustained challenges of governance, administration, staffing, and financial management. Richtersveld, Khai-Ma and Kamiesberg municipalities are classified as represent "moderate to high distress" in the Richtersveld, Kamiesberg and Khai Ma Local Municipalities. Richtersveld LM, in particular, is in the category that "none of the four critical competencies are achieved", referring to planners, engineers, accountants and environmental officers. [315]

From an institutional point of view, this is not a promising area to implement two very sophisticated infrastructural and industrial projects. This is an urgent signal that the municipalities will have to undertake a quantum leap in terms of their management capabilities. This will require concerted action by a range of support agencies.

311 DALRRD, *Namakwa Spatial Framework*, 2023, p. 57.
312 Robins, S. 1997. 'Transgressing the borderlands of tradition and modernity; Rawson, K, 2018, Rawson, K. 2018. *Land rights & identity: the establishment of the Leliefontein Mission.*
313 Nama-Khoi Municipality. 2024. Local Economic Development Strategy: 2024- 2029.
314 Human, L. 2024. Diamond mines everywhere but Richtersveld town battles poverty.
315 DALRRD 2021, Karoo Regional Spatial Development Framework, 2021, p. 66.

7.6.2 Municipal capacity

Institutional capacity is crucial not only for the efficient implementation of large-scale projects but also for ensuring that development benefits are equitably distributed among local communities.

In South Africa, the Municipal Structures Act (Act No. 117 of 1998) categorises municipalities into different groups based on their capacity to govern and provide services. A "**Category B" municipality** refers to a local government that is responsible for providing services, such as water supply, waste management and local planning, to a specific urban or rural area. Category B municipalities form part of a district municipality ("**Category C" municipality**), which co-ordinates services across a broader region.

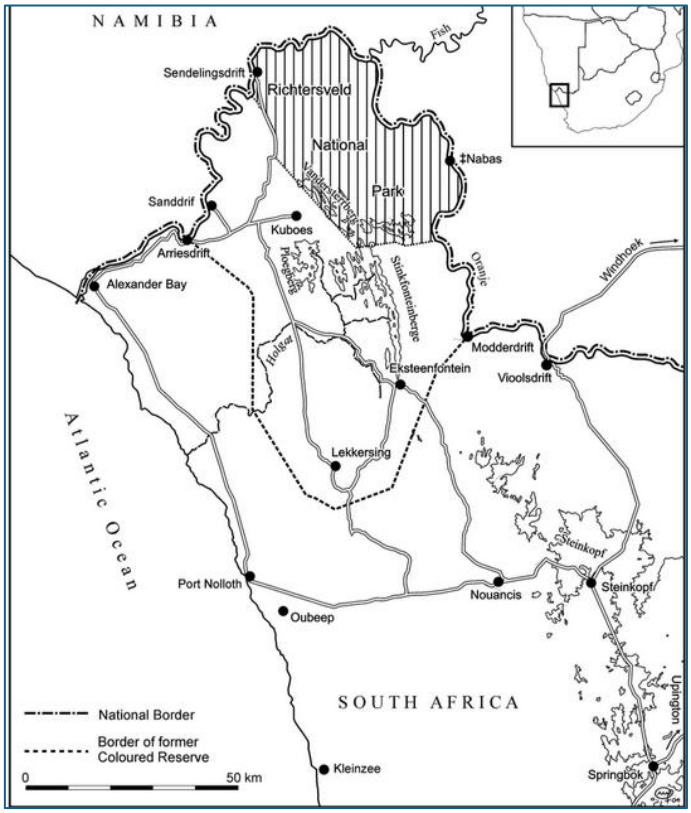
Namakwa District Municipality and its six Local Municipalities[316]

316 www.municipalities.co.za

The Namakwa District Municipality (NDM) is a Category C municipality in the Northern Cape Province, covering over one-third of the province's land area, making it the largest district geographically in South Africa. District municipalities are responsible for coordinating the efforts of various local municipalities within their jurisdictions, often acting as the intermediary between the provincial and local levels of government. They should provide key advisory and technical services such as infrastructure development, environmental health and district-wide planning. Most importantly, district municipalities should ensure that local governments receive support in areas such as financial management, governance, spatial planning and policy execution, especially in remote areas where local municipalities may have limited resources.

In Richtersveld LM, There are six wards, demarcated as follows:

Richtersveld[317]



Ward	Town/ suburb
1	Kuboes, Eksteenfontein, Sendelingsddrift
2	Lekkersing, Sanddrift
3	Sizamile and part of town (Port Nolloth)
4	Mcdougalsbay & Lydia Links Park
5	Alexanderbay, Beavallon & Baken
6	Nollothville & Barracks

[317] Berzborn, S and Schnegg, M, 2007, Vulnerability, social networks, and resilience: Rural livelihoods in the Richtersveld.

The municipal council consists of eleven members, of whom six are elected as ward councillors, and the remaining five are proportional representation (PR) councillors.

The new DDM (District Development Model) has placed District Municipalities as a strategic point of focus in the intergovernmental system. District Municipalities are required to compile "One Plans" for their jurisdictions. With the assistance of the Northern Cape Department of Co-operative Governance, Housing and Traditional Affairs (COGTA), Namakwa DM has indeed compiled such a plan.[318]

7.6.3 Political movements in the local and district municipalities

Governance of municipalities is decisively influenced by party-political dynamics – in terms of policy preferences, as well as the stability of decision-making dynamics on Councils, Councillors' skills and capacity; relationships to socio-economic classes and special interests; and disciplinary measures as far as potential corruption is concerned. Parties that have strong internal discipline and policy coherence tend to fare better than those which are lax and have factional conflicts. Parties that are pragmatic and outcome-oriented are more likely to be successful coalition parties than those that are strongly ideologically-driven.

While political parties are characterised by their national or regional norms, they can also manifest differently in different municipalities, based on local norms and personalities. There is therefore no clear way of "reading off" a political party's response to issues, problems and opportunities. However, the political party profiles are useful to identify potential shifts in internal political culture and electoral fortunes.

Three of the four local municipalities in the Namakwa District—Richtersveld, Kamiesberg, and Khai-Ma—are governed by the African National Congress (ANC). In Nama Khoi (Springbok), the ANC is the largest party, but is not able to form a Council. Consequently, two opposition parties, the DA and the Namakwa Civic Movement (NCM) govern in a coalition. This section provides a brief overview of party-political dynamics (a fuller description is

7.6.3.1 The African National Congress (ANC)

In this region, the ANC is still the largest party in each municipality. In two municipalities, Khai Ma LM and Kamiesberg LM, the ANC still enjoys an absolute majority in the municipal elections in 2021. In Richtersveld LM, the ANC has dipped to 47,3%; and in Nama Khoi LM, it declined even further, to 42%.

The ANC's support is hovering around the 50% mark (absolute majority) in the Northern Cape. The four municipalities in our study therefore broadly reflect the provincial ANC electoral position.

7.6.3.2 The Democratic Alliance (DA)

The DA generally commands about a third of the votes cast in the municipal elections of 2021. The one outlier is Khai Ma LM, where the DA only commands around 12% of the vote. The DA is placed second in size in each municipality, except in Khai Ma LM, where it is placed third, and the Namakwa Civic Movement captured the second place slot.

During the 2021 Local Government Elections (LGE), the ANC won the largest share of the vote (42%), but did not achieve an absolute majority. Consequently, the Democratic Alliance (DA) and the Namakwa Civic Movement (NCM) formed a coalition government. A remarkable shift in political culture has taken place on the Nama Khoi Council, away from "winner take all" politics, towards the politics of coalitions. The DA and NCM signed a formal agreement outlining the rotation of key leadership roles.[319] The July 2024 leadership transition, where the incumbents of the positions of Mayor and Speaker were rotated, aligns with this agreement.

[318] http://www.coghsta.ncpg.gov.za/index.php/resource/more-info/ddm-one-plan/category/65-namakwa
[319] McGluwa, H. 2024. DA takes up mayoral position in Nama-Khoi coalition municipality.

7.6.3.3 The Namakwa Civic Movement (NCM)

The NCM is a political movement born and bred in the Namakwa District itself. It therefore has a special significance, in that it is competing with two national political parties. Its fortunes indicate the extent to which local residents feel a place-bound political loyalty.

It has contested elections in all four local municipalities in the Namakwa District. It has positioned itself as a challenger to established political parties like the ANC. The NCM currently has representation on three councils: Nama Khoi, Khai Ma and Kamiesberg LM. In Richtersveld, the NCM has barely featured, at 3.8%. In Kamiesberg LM, the percentage was almost double, at 7,5%, and here the NCM managed to capture one seat.

In Nama Khoi LM, the NCM has been particularly successful. [320] Because the ANC in Nama Khoi LM dipped below 50% of the vote, this meant that the NCM became a kingmaker in Nama Khoi, and in an alliance with the DA, it is now ruling this crucial municipality. As the third-largest party, it has successfully formed a ruling coalition with the Democratic Alliance (DA), which is the second-largest party.

The NCM appears highly pragmatic in its approach to social issues. It is grounded in community activism in many fields, including labour relations, and care for schools and the elderly.[321] Its vision is: "To transform the communities in Namakwa by being pioneers in the management and organization of her wealth", where "everyone with proven origins in the geographic area of the Namakwa District Municipality has access to equitable opportunities and equally benefits from the wealth of this area". This formulation suggests that there will be a significant proactive redistributive agenda, whereby revenue generated by any new project (such as Boegoebaai) will require specific measures to uplift the Namakwa communities. It may have a reluctance to encourage or assimilate with in-migrants into the area, but this will have to be verified.

The NCM Constitution posits the following mission statement: Socio-economic transformation by strategically mobilising communities; lobby and advocate for identified relevant focus areas; establish vibrant governance structures to ensure effective organisational output and accountability, promote the beneficiation of the natural resources of the area, and funding and execution of projects via the investment arm. It sees itself as a "civic movement", which participates in politics, but remains anchored in the civil society of Namakwa. The movement appears to be broadly transformative with a strong focus on effective organisational development, promoting social inclusivity, promoting socially responsible economic investment, and building local pride. In particular, it espouses the principle of "For Us, By Us" within the communities where it governs", which will be significant in any discussions on the Boegoebaai projects.[322]

The NCM constitution provides detailed requirements for organisational structures and procedures, in order to prevent the party elite from drifting away from the membership. At the most senior level, the organisation's District Executive Management Committee is the ultimate decision-making body. Consisting of 15 members, it will be selected from the municipal management committee leaders every four years, or about one year before a local government election. Nama Khoi LM has four delegates on the committee: Hantam LM has three, and all the other municipalities have two each. There is therefore a strong degree of political coherence amongst the municipalities that comprise Namakwa District. The NCM also has linkages the Northern Cape Communities Movement (NCCM), which has representation at the Provincial Legislature and the national NCOP.

Significantly, the NCM constitution requires all aspirant councillors to be interviewed and assessed for competency. There are detailed requirements for appropriate conduct, and discipline and procedures in cases of misconduct. The NCM requires all members and councillors "to participate in the effective functioning of their respective wards and municipal structures, attend meetings punctually, come prepared for agenda items, collaborate as a cohesive team, take action on identified tasks, foster constructive discussions and decision-making, and abide by group decisions. They should encourage membership growth".

[320] Mkhwanazi, S. 2021. The rise of civic movements as they challenge political parties.
[321] https://namakwacivic.org.za/.
[322] NCM Constitution, available on www.namakwacivic.org.za.

The Constitution provides an overview of key policy priorities, which are generally very progressive. These could be an important guide for the organisation's future stance in policy questions and CSI decisions related to the Boegoebaai project:

1. Health: Establish an exemplary health care system for all Namakwa citizens, prioritizing the well-being of health care workers; promote superior service delivery; and transform digital health tools and information management systems in the district.

2. Education: Foster critical thinking through digital education platforms, providing resources to learners and teachers; encourage subject choices aligned with future careers and support non-academic achievers; enhance and expand TVET colleges to accommodate local and national careers; promote and support science education, including bursaries for science teachers.

3. Social development: Promote self-reliance and self-worth within Namakwa communities; address unemployment and food security challenges; and engage communities in self-improvement efforts.

4. Arts and culture: Identify and preserve Namakwa's cultural heritage; promote artistic and cultural preservation at grassroots levels; develop infrastructure and educational centres to nurture artistic expression;

5. Economic development: Prioritise new sector development projects to retain capital within Namakwa; focus on economic liberation within the next 20 years; hold private companies accountable for their socio-economic responsibilities; and execute turnaround strategies within municipalities and collaborate with the private sector.

6. Sport: Revive and improve existing traditional sport infrastructure; establish accessible sport infrastructure for people with disabilities; and integrate district sport gatherings into municipal budgets to stimulate sport participation and boost the economy.

7. Agriculture: Revive and commercialise viable agricultural initiatives; develop drought relief policies and support subsistence and commercial farmers; implement high-value agriculture projects; and make agriculture central to Namakwa's development.

8. Public benefit infrastructure: Maintain roads and public property to prevent decay; hold accountable those responsible for irregular expenditures; research and construct new public benefit infrastructure; address informal settlements and expedite housing delivery; ensure consistent provision of water and electricity.

9. Safety: Participate actively in safeguarding Namakwa communities; hold law enforcement agencies accountable; improve crime prevention; and collaborate with community groups.

10. Mining and energy: Safeguard the mineral wealth of Namakwa for the benefit of current and future generations; advocate for responsible mineral exploitation; monitor and encourage corporate social responsibility; execute turnaround strategies within municipalities; and collaborate with private sector organisations to provide viable business opportunities.

These NCM goals may offer useful guidelines for CSI activities in the Boegoebaai region.

The NCM has a strong local base and local values, which are not primarily ethnically based. The NCM may well grow and become more influential, due to its overt pragmatism and strong normative basis. Its highly successful partnership with the DA in governing Nama Khoi LM will also contribute to its reputation and confidence. Its local base may make it more amenable to local problem-solving, in a context of dealing with a large new regional project such as Boegoebaai.

The rise of civic movements like NCM reflects the increasing disillusionment with the traditional parties and a push for more localized and direct forms of governance. The ability of smaller parties to win seats points to a complex and evolving political landscape in the Northern Cape Province, which can also be seen as a maturing of democracy.

7.6.3.4 The National Economic Fighters (NEF)

In October 2021, a new political party, the National Economic Fighters (NEF) was established by Dawid Markus. For years, he had been known as a fiery activist for the rights of poverty-stricken local miners.[323] Its first foray into political competition took place in 2021, in the four municipalities that are the focus of Boegoebaai study. The NEF managed to secure a seat in the Richtersveld Council, and one in Kamiesberg. Their numbers are still small, but it may be the case that there is a dedicated following, based significantly on a single issue (the rights of artisan miners).

7.6.3.5 The KhoiSan Revolution

This party was also established in late 2021, to contest the municipal elections.[324] The party is led by Stanley Petersen. In our region of study, the KRP only stood for election in Nama Khoi municipality. In fact, several Khoisan parties registered for the municipal elections in 2021.[325] The KRP was by far the most significant Khoisan party, focusing on ethnic mobilisation. In the Northern Cape, the KRP won 1745 ward votes and 2129 PR votes, giving it a total of 3874 total votes. Although these numbers are small, the issue of ethnic mobilisation is a very important one, as it can easily be activated during times of contestation on ideas or projects.

Ethnic parties often tend in the direction of zero-sum politics, whereby issues are interpreted as either a loss or a win. This may make multiparty negotiations and problem-solving more difficult. On the other hand, this may be a positive way of addressing the historical concerns of the past, instead of such issues being sidelined and left to smoulder.

Such KhoiSan parties may be tapping into a well of resentment and grievances, based on historic loss of land, livelihoods, and status. These matters will need very careful handling, with slow and systematic development of common points of view. Given the historical uniqueness of Namaqualand, and its still-current ethnic and linguistic character, there will need to be special effort and sensitivity paid to the issues and concerns of such local ethnic parties.

7.6.3.6 Economic Freedom Fighters

The EFF draws its appeal from the national profile of this political party. In the 2021 municipal elections, it managed to win one seat in Richtersveld LM and one in Khai Ma LM. Its voter support was generally low, below 8%. It was particularly weak in Nama Khoi LM, possibly due to the strong performance of the Namakwa Civic Movement. This should be compared to the outcome of the 2024 provincial election, when the EFF secured 13.23% of the provincial vote.[326]

7.6.3.7 The Freedom Front Plus

The FF+ presumably relied predominantly on white voters. It managed to secure a seat in the Nama Khoi Local Municipality. Its percentages were generally low – less than 4%. However, given the important socio-economic class of EFF+ supporters, notably as commercial farmers or other middle-class occupations, it may be the case that this party punches above its weight.

The FF+ municipal performance should be compared to the outcome of the 2024 provincial election, where it secured only 1.94% of the provincial vote.[327] The low population of this study area, combined with its

[323] https://www.ofm.co.za/article/centralsa/310433/nuwe-politieke-party-sien-die-lig-in-noord-kaap
[324] https://www.dailymaverick.co.za/article/2021-10-01-actionsa-gauteng-registration-blip-highlights-the-polls-pressure-cooker/
[325] The other Khoisan parties in the Northern Cape performed much less impressively than the Khoisan Revolution Party. They are The Khoisan Heavenly Party (269 PR votes); the Khoisan Kingdom and All People Party (38 ward votes); the Khoisan Kingdom of RSA Party (50 ward votes); and the Khoisan United Movement (70 ward votes and 79 PR votes = 274 total votes). Independent Electoral Commission, 2021.
[326] https://results.elections.org.za/dashboards/npe/
[327] https://results.elections.org.za/dashboards/npe/

predominantly Afrikaans language profile, may account for a relatively higher support for this party in the study region, compared to the provincial profile.

7.6.3.8 Congress of the People (COPE)

COPE is a national party, largely based in Gauteng. One can expect its appeal to be limited in the Namakwa area, but it managed to secure one seat in Khai Ma LM.

This should be compared to the outcome of the 2024 provincial election:[328] Its performance in Khai Ma, at just under 6%, is much better than the provincial profile in 2024, at 0.2% of the Northern Cape vote.

7.6.3.9 Patriotic Alliance and Good Party

The PA is also a national movement. It secured very little interest in the study region, at fewer than 300 votes. The Good Party also purports to be a national party, although its main base is in Cape Town. It secured very modest support in our study region. Neither secured any councillors in the Namakwa region. Both stood only in Nama Khoi LM, where both secured just less than 1% of the vote. They are listed here, not because their current strength warrants it, but because both these parties tend to compete for the "coloured vote", and may become more significant in future. This information therefore serves as a baseline for future comparisons.

7.6.3.10 Independent candidates

Independent candidates did not win a single seat in the district (i.e ward, since Independents cannot stand as PR candidates) in the entire region. They did win some votes in 2021, particularly in the Richtersveld LM (522 votes), possibly because the number of parties competing for the election was significantly smaller than in the other municipalities. In Nama Khoi LM, no Independents stood for election. Independents are typically local notables who have a personal following.

7.6.4 Municipal and civil society organisational capacity

The proposed new multi-faceted project at Boegoebaai will rely heavily on a range of organisational capabilities on the part of municipalities.

Without a detailed empirical study involving extensive fieldwork, it is not possible to assess municipal capacity – either at present, or in the future if they were to be confronted by the largest investment projects in the history of Namakwa. This section provides an outline of issues which require further investigation, as well as preliminary impressions and cautions.

Each Municipality requires an effective Council as a decision-making body, and an effective relationship between the Council and senior officials. This dimension of organisational functioning difficult to detect, but it can change rapidly, particularly if new people are appointed or promoted. Conversely, though, new appointments may be trapped within a pre-existing institutional culture, which prevent desired changes to be effected. "Organisational culture" can make or break an institution. A positive, collaborative culture can enable an under-resourced municipality to govern effectively, while a negative, conflictual culture can destroy a well-resourced municipality.

7.6.4.1 Human Resources and staff performance

The vacancy rates and staffing challenges across the four municipalities in the Northern Cape have significant implications for governance, especially as they prepare for complex development projects like green hydrogen.

[328] https://results.elections.org.za/dashboards/npe/

To develop the skills of councillors and staff, the Richtersveld LM has compiled a Workplace Skills Plan (WSP). Performance Management Contracts have been formalised between the Municipal Manager, the Mayor, and Senior Managers. A Service Delivery and Budget Implementation Plan (SDBIP) serves as the Municipality's key performance measurement tool. A Task Job Evaluation Committee has been established, and the Job Evaluation process has been completed. [329]

In Richtersveld, significant strides had been made in formalising job evaluation processes by 2023, marking a shift from the *ad hoc* practices of the previous year. Performance Management Contracts now include Senior Managers. While the establishment of a Health and Safety Committee remains a work in progress, centralized record-keeping for injury-on-duty cases demonstrates improved administrative efficiency. Vacant posts had been filled, though critical gaps persisted, notably in Local Economic Development (LED) and Wastewater-Sanitation. Vacancy rates in 2023 were particularly concerning in community services (12 out of 57 posts), administration (12 out of 57 posts), and administration (3 out of 10 posts). [330] The problem of high levels of sick leave required sustained attention.[331]

Nama-Khoi Municipality reported a high vacancy rate of 54%, with significant gaps in technical and administrative roles. The lack of skilled personnel in departments like Technical Services, Corporate Services, and Community Services could severely hamper the municipality's ability to undertake infrastructure projects. Furthermore, the high turnover rate of 33% annually creates instability, leading to loss of expertise and disruption in long-term projects.

Khai-Ma Local Municipality had a vacancy rate of only 9% in 2023. The municipality faced several human resource challenges, which include: Persistent morale problems, coupled with widespread disciplinary concerns; absenteeism and Unauthorised Leave; Staff health issues, such as HIV/AIDS, and substance abuse; Difficulty to utilise funding sources (such as MIG, ACIP, INEP, and EPWP); inadequate office space; and critical skills gaps (technical and management areas), which hampers the municipality's ability to efficiently implement projects. [332]

According to the Khai-Ma IDP (2024), The municipality monitors staff performance through the implementation of a Service Delivery and Budget Implementation Plan (SDBIP). Senior managers in finance, corporate services, and technical services are required to sign performance agreements as part of this process.[333]

The Kamiesberg municipality faces significant institutional and financial capacity constraints. The loss of skilled and trained staff remains a pressing issue, requiring wider and more affordable advertising for vacancies, along with targeted skills development programs and the recruitment of technicians within the area.[334] Employee punctuality is another concern. There was a vacancy rate of 13% in 2022, including the CFO position.

At the **Namakwa District Municipality**, there was a vacancy rate of 36% in the Budget and Treasury Department in 2023.[335] Staff turnover rate was 20% per annum, and the amount of sick leave caused concern.

7.6.4.2 Public participation mechanisms

Ward committees are the most important and potentially most effective mechanism of exchanging views with the public.

In Richtersveld, functional ward committees have been established in all six wards of the Richtersveld Municipal Area. The roles of ward committees include clarifying programmes for the community, enhancing transparency, harnessing local resources for development, and improving planning based on local needs

[329] Richtersveld LM, 2022, *Annual Report,* p. 26.
[330] Richtersveld LM, 2023, *Annual Report,* 26
[331] Richtersveld LM, 2023, *Annual Report,* p. 26.
[332] Khai-Ma Local Municipality. 2023. *Integrated Development Plan*
[333] Khai-Ma Local Municipality, 2024. *Integrated Development Plan.*
[334] Kamiesberg Local Municipality, 2023, *Annual Report*, p. 23, 77.
[335] Namakwa DM, 2024. *Annual Report 2023/2024*, p. 101

and strengths. These committees meet monthly with administrative support from the municipality, where agendas are set, and minutes are systematically recorded. During these meetings, issues are directed to relevant departments, and officials are invited to present reports. The ward councillor, who serves as chairperson, plays a central role in overseeing development activities, participating in planning processes, and facilitating community engagement. However, operational challenges, such as difficulties with sector report-back meetings, remain a concern in Richtersveld LM.[336] Various factors affect the success of meetings, such as weather, timing, venue proximity, notice periods, and the nature of the topics discussed. While stakeholder meetings are typically productive, it is noted that some participants come unprepared. A significant issue, however, arises from the scheduling of public participation meetings for the Integrated Development Plan (IDP), which are held during working hours, which access for the working people.[337]

In Nama Khoi, ward committees meet once every two months, with the agenda based on matters raised by the various members. In terms of funding for out-of-pocket expenses, the Council has approved a monthly stipend of R500 for each committee member to cover transport and telephone costs, on the condition that they attend the quarterly standing ward committee meetings (NKLM, 2022:32). All ward committees are listed as functional. [338] In addition, the municipality provides training for both municipal officials and ward councillors. In the 2022/23 period, a total of 30 individuals received training.[339]

The Communication Unit in the Office of the Municipal Manager employs several communication strategies:[340]

- Newsletters: A quarterly publication for internal and external communication.
- Website: An active platform where all official documents are published.
- Customer Service: A section handling queries, complaints, and information requests.
- Social Media: The municipality uses its Facebook[341] page to engage with the public.
- Council Meetings: Open to the public, media, and stakeholders for transparency.
- Ward Committees: Facilitate communication between the council and local communities.
- Councillors: Host quarterly meetings for two-way communication with residents.
- Radio: Council discussions are aired on local station Radio 98.1.
- Media Statements: Issued regularly with approval from the Municipal Manager.
- Advertising: Local newspapers[342] and Media24 for statutory and promotional purposes.

The Nama Khoi Municipality is therefore working towards building a more transparent, accessible, and accountable communication environment. The municipality uses a variety of platforms to engage with both internal and external stakeholders.

In Khai-Ma Local Municipality, one of the significant challenges facing the municipality is the low attendance of community members at scheduled meetings. There is a perception that slow development does not adequately address the needs of residents, leading to a lack of motivation to participate. Additionally, many inhabitants feel that their basic service needs have already been met, reducing their eagerness to attend. There is a noticeable lack of interest, particularly among the youth. Communication issues also play a role: Not all residents are informed in a timely manner about scheduled meetings, compounded by the absence of a local newspaper and community radio, which could provide vital information. To improve community participation, the municipality contemplated regular door-to-door visits by ward committee members will help

336 Richtersveld LM, 2024, *Integrated Development Plan,* p. 70.
337 Richtersveld Local Municipality, 2023, *Annual Report,* 2023, p. 57
338 Nama Khoi Local Municipality, 2022, *Annual Report,* p. 32.
339 Nama Khoi Local Municipality,2024, *Integrated Development Plan,* p. 40.
340 Nama Khoi Local Municipality, 2024, *Annual Report,* p. 45.
341 Municipal Facebook page: https://www.facebook.com/NamaKhoiofficial/
342 Local newspapers: Die Plattelander (https://www.dieplattelander.com/), Die Namakwalander (https://www.facebook.com/p/Die-Namakwalander-koerant-100063591549426/)

gather information for their monthly meetings, which can then be shared with ward councillors and brought to the council.[343]

In Kamiesberg Local Municipality, there is a reliance on councillors interacting with senior officers to facilitate communication. The lack of a clear community liaison mechanism may hinder effective communication and engagement with the public. In 2023, ward committees were active in four of the six wards in the Kamiesberg Municipal Area, and played a role in the IDP review process. (At the time, the Koiingnaas and Spoegrivier wards did not have ward councillors). These committees are chaired by part-time ward councillors and meet quarterly to update the community on municipal matters. They did not always function well, and the municipality planned to address these issues through targeted training.[344] The municipality was only able to hold nine out of the 16 planned IDP review public participation sessions, and attendance at these meetings was very low, with some sessions having no public participation at all.

7.6.5 Municipal infrastructure management

The Boegoebaai initiatives will rely on robust municipal infrastructure, including roads, water supply, urban planning, waste management, and electricity grids.

7.6.5.1 Richtersveld LM

Towns and villages in the Richtersveld jurisdiction are geographically dispersed, requiring duplication of critical infrastructure like sewage treatment, water purification, and electricity networks for each settlement. This fragmentation complicates service delivery, forcing the municipality to operate separate service desks in each town to handle account queries, payments, and service disruptions, resulting in redundant staffing. Although the Richtersveld Municipality has centralised many administrative functions in Port Nolloth to minimise redundancy, this creates new challenges in ensuring consistent reporting and oversight across its scattered towns.[345] The transfer of Alexander Bay from Alexkor has further expanded the municipality's responsibilities.

The current municipal Blue Drop score is at 36%, and needs to improve water quality management. The upgrading of the 8 Mile pipeline must be undertaken to ensure improved water service to communities of Sizamile, Port Nolloth town, Nollothville, as well as McDougall's Bay.[346]

The following table provides an overview of the basic services in the Richtersveld Local Municipality:

Overview of Basic Services in Richtersveld Municipality[347]

Service	Details
Indigent Households	Over 1,164 poor households are registered as Indigents, representing 20.6% of the 5,643 households in the municipality (2022).
Access to Basic Services	97% of households in the entire municipal area have access to basic services.
Water	All towns have access to potable water, except for the informal settlement in Sanddrift, which has access via communal taps.
Sanitation	All towns have access to basic sanitation services, including reticulation systems (waterborne), chemical toilets (UDF and VIP), and eradication of bucket systems.
Energy	All areas have access to electricity. The 4 satellite towns and Sizamile are covered by ESKOM. No National Infrastructure (INEG) funding received for 2020/21.
Refuse Removal	All households have access to refuse removal services.

[343] Khai-Ma Local Municipality, 2023, *Integrated Development Plan,* p. 28, 55.
[344] Kamiesberg Local Municipality, 2023, *Annual Report,* p. 30-31, 41.
[345] Richtersveld LM, 2024, *Integrated Development Plan,* p. 63.
[346] Richtersveld LM, *Spatial Development Framework*, 2024, p. 192.
[347] Richtersveld LM, 2024, Integrated Development Plan.

Housing	In 2019, 91% of households had access to formal housing.
Storm Water Drainage	Storm water drainage remains a challenge, particularly in Port Nolloth and low-lying residential areas.

In several sectors, Richtersveld faces great challenges:

Summary of Service Delivery Challenges and local impact[348]

Service Area	Challenges
Housing & Sanitation	Insufficient housing and limited sanitation infrastructure result in inadequate waste management and hygiene risks.
Bulk Water Supply	Difficulty in ensuring reliable water supply, especially in distant communities.
Operations & Maintenance	Limited budget and capacity for infrastructure upkeep, resulting in service disruptions
Road Infrastructure	Poor road conditions and connectivity issues hinder accessibility. Road maintenance and construction face challenges due to high costs, inherited backlogs, and funding constraints, which limit economic activities and access to health care and education. No Infrastructure Master Plan for bulk services.
Healthcare Services	Communities are located far from health facilities, especially for emergency and after-hours care.
Education	Students in rural areas must travel long distances to reach secondary schools, creating barriers to consistent school attendance.
Municipal Demarcation	Fragmented settlements increase complexity in service coordination.
Financial Sustainability	High costs of service delivery due to dispersed settlements.

The Richtersveld Municipality is an accredited Water Services Authority under South Africa's National Water Act. The municipality collaborates with other entities, such as Lower Orange River Diamonds and Alexkor RMC JV, to ensure fresh water supply, especially in case of breakdowns. Most towns, except for Alexander Bay and Sanddrift, face insufficient water sources. The municipality is working to improve its Blue and Green Drop status for water quality management, with a focus on addressing high water losses and exploring methods like borehole development, wastewater recycling, and desalination. Domestic usage in Port Nolloth places significant demands on resources, with peak consumption during December holidays. The municipality is reviewing its Water Services Development Plan (WSDP) to secure future water sources and improve infrastructure.

Port Nolloth's water supply relies on boreholes and an ageing asbestos pipeline constructed in 1989. Water is pumped from the Orange River to a main reservoir in Alexander Bay. From there, it travels through two booster pumps and a 46.5 km asbestos pipeline to the Muisvlakte reservoir near Port Nolloth, and then distributed via pipelines to Port Nolloth, Sizamile, and McDougall's Bay. Historically subsidized by Alexkor, the cost of water has risen significantly, currently standing at R2.75 per kilolitre. The pump system was designed to deliver 44,000 litres per month. However, investigations reveal that it supplies only 50–75% of that volume, due to deteriorating infrastructure (leaking pipes, non-functional air valves, and failing pipe sections).

The lack of a monitoring and control system for the pumps and reservoir water levels increases operational costs for the Richtersveld Local Municipality's technical staff. This water supply is inadequate to meet current needs, let alone accommodate future growth, particularly if the Boegoebaai port project adds further pressure. Only seven municipal boreholes are currently operational, none of which provide water suitable for long-term human consumption. Water storage capacity at Port Nolloth is also inadequate: The existing

[348] Richtersveld LM, 2024, *Integrated Development Plan;* Richtersveld 2023, *Annual Report.*

reservoir holds only 2,500 litres, far below what would be required to meet the projected population growth associated with the Special Economic Zone. The town's storage needs to double by 2040 .[349]

Dilapidated road infrastructure has several negative impacts on community development in Richtersveld, such as hindering local business and agricultural activity, limiting market access, delays in social services, social isolation, retarding tourism development, increasing and infrastructure maintenance costs.

These infrastructure challenges could exacerbate existing social and economic disparities, and inhibit new investments, preventing the town from fully capitalizing on opportunities for growth and development.

The Auditor-General's office has indicated that Richtersveld LM underperforms in meeting its planned waste management and water quality targets. The municipality aimed for a 95% water quality level in compliance with SANS 241 standards. However, during the 2021/22 financial year, none of the reported performance indicators were achieved, with AGSA noting a significant shortfall, quantified as a 100% underachievement.[350]

7.6.5.2 Nama Khoi LM

The Nama Khoi Local Municipality outlines the following service delivery challenges in their annual report : Submitting grants and business plans for funding opportunities; implementing stricter procurement processes; increasing the budget to fill vacant positions and strengthen staff capacity; clearing illegal dumping sites and rehabilitating landfill sites.[351]

In January 2024, The Nama Khoi Local Municipality (NKLM) and De Beers Consolidated Mines (DBCM) successfully concluded the transfer of municipal responsibilities for Kleinzee, marking a significant milestone in regional development and public-private collaboration. Valued at R270 million, this transition ensures sustainable service delivery, economic development, and improved infrastructure. To ease residents into municipal service structures, the municipality has introduced financial support measures, including temporary property tax rebates and free basic services for qualifying households until mid-2025. Planned upgrades in Kleinzee include infrastructure improvements and enhanced water and electricity services.[352]

7.6.5.3 Khai-Ma LM

Khâi-Ma Municpality renders basic services to the inhabitants of Onseepkans, Blyvooruitsig, Pofadder and Wittbank. Black Mountain mine provides services to the inhabitants of Aggeneys, which has been proclaimed as a town. The municipality does not extend services to non-urban areas like Dwagga Salt Works, Raap-en-Skraap, Vrugbaar, and Rooipad Boerdery, which are privately owned. Consequently, the needs of Aggeneys and these non-urban areas are not included in the IDP, as they fall beyond the municipality's current service responsibilities.

The municipality faces extensive service delivery difficulties (see more detail in Appendix A).

7.6.5.4 Kamiesberg LM

According to the Kamiesberg Local Municipality (IDP, 2024:68), the municipality faces knumerous service delivery and infrastructure challenges (see Appendix A).

There are systemic governance weaknesses, such as the lack of an Integrated Asset Management Plan (IAMP), the lack of proper implementation of Municipal Regulations on Standard Chart of Accounts (MSCOA)[353], insufficient personnel and rising vandalism of municipal assets.

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[349] BVi Consulting Engineers. 2024. Feasibility Study on Port Nolloth's Bulk Water Supply.
[350] AGSA, 2022. Consolidated General Report on Local Government Audit Outcomes.
[351] Nama Khoi LM, 2022, *Annual Report,* p. 20.
[352] https://www.namakhoi.gov.za/2025/02/07/nama-khoi-local-municipality-and-de-beers-consolidated-mines-finalize-historic-agreement/
[353] Kamiesberg LM, 2024. 2023/24 Final Annual Budget and MTREF;

The Kamiesberg Local Municipality acknowledges the mining industry's significance for local socio-economic development. Under the *Mineral and Petroleum Resources Development Act*, mining companies are required to implement Social and Labour Plans (SLPs) that benefit the communities in which they operate. These SLPs should address key municipal challenges in alignment with the Integrated Development Plan (IDP), rather than focusing on isolated projects, to maximise their impact. According to SLP guidelines, companies must consult with local communities and coordinate their activities with provincial and national economic development frameworks. It remains unclear whether mining company representatives actively participate in these forums in Kamiesberg.

7.6.6 Municipal finance and audit performance

This analysis examines the primary sources of income, such as property rates and service charges, and compares these across municipalities to evaluate financial health. The assessment also explores the impact of outstanding debts, particularly those owed to entities like Eskom and water boards, on municipal stability. Financial constraints may limit municipalities' ability to engage in or benefit from capital-intensive projects like green hydrogen development.

Municipalities' ability to submit adequate financial statements to the Auditor-General's office can also be taken as a proxy for administrative effectiveness.

7.6.6.1 Richtersveld Local Municipality

The municipality's total expenditure consistently exceeds its revenue, leading to a recurring deficit each year. The municipality faces difficulties in managing its operational costs and servicing its debt. The municipality relies on transfers from higher levels of government grants to fund its operations. Without a strong base of locally generated revenue, the municipality remains vulnerable to fluctuations in intergovernmental transfers, which may not always be sufficient to meet its financial obligations. [354]

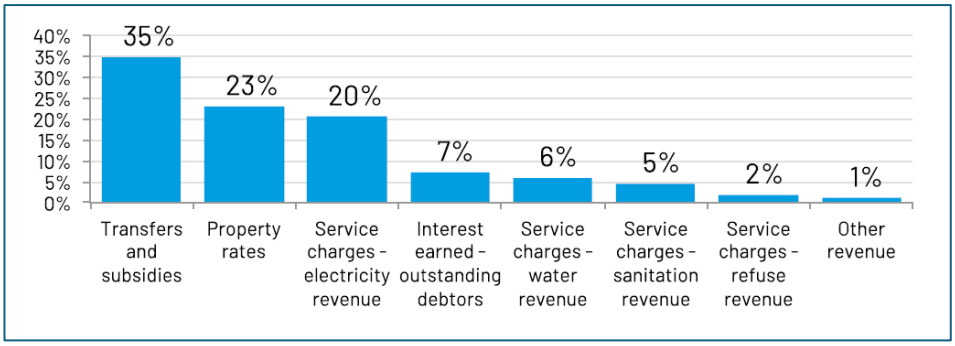
The municipality's current liabilities have also increased over time, including a significant shortfall of R64,226 million in 2022/23. The municipality is struggling to generate enough cash from its operations to cover day-to-day expenses, including debt repayment and service delivery. Between 2018/19 and 2022/23, the municipality's debt grew from R2,5 million to R10, 7 million, which limit its ability to fund essential services or invest in future infrastructure development. There was a negative cash balance of just under R14 million at the end of 2022/23.

Additionally, the municipality has faced significant unauthorised, irregular, and fruitless expenditure, which reached R161 million in 2021/22. Irregular expenditure, totalling R39 million in 2021/22, suggests issues with procurement and contract management.

In conclusion, the municipality's financial position is precarious. To improve its financial sustainability and creditworthiness, the municipality must focus on improving revenue generation, implementing stronger financial controls, and addressing its debt management challenges. The municipality envisages prepaid water meters; this will require a thorough process of public awareness and buy-in.[355] During the 2022/2023 financial year, the Richtersveld Local Municipality increased property rates in line with a new valuation roll. In response, some local residents refused to pay the higher rates.[356] Intergovernmental transfers form the bulk of the municipality's operating revenue:

[354] https://municipalities.co.za/financial/1172/richtersveld-local-municipality
[355] Richtersveld LM, *Spatial Development Framework*, 2024, p. 192.
[356] Richtersveld LM, 2023, *Annual Report.*

Operating Budget Revenue Sources (2020/21) : Richtersveld LM[357]



The local government equitable share (LES) forms the single largest component of revenue, and amounts to about 35% of total revenue.

The bulk of Richtersveld LM's capital budget over the past seven financial years is funded from national government transfers. Richtersveld currently receives funds from the MIG for water, sanitation, refuse, roads and sport infrastructure, the integrated national electrification programme (INEP) for electricity infrastructure and the water services infrastructure grant to support further water infrastructure. "With the exception of the MIG, most of these grants are not consistent, that is, they enter and exit the fiscal framework in a generally uncoordinated manner and the allocations can differ substantially between years. This likely explains the relatively large variations in the capital budget spend across the years in the Richtersveld LM. These grants are further constrained by a tight national fiscal framework, resulting in cuts to grant allocations at times of revenue pressures at the national level".[358] Richtersveld LM's own contribution via internally generated capital funds and borrowing is negligible.

As proportions of the budget, Employee Costs are not exorbitant, at around 33% of expenditure. An additional high cost is "inventory consumed and bulk purchases", referring mainly to high costs of electricity and raw water at about 20% of expenditure. This is not surprising, since much of Richtersveld community water supply is pumped from long distances, with concomitant electricity and maintenance costs. Since 2020, "inventory consumed" has increased (nominal growth rate), and employee costs have declined.[359]

Richtersveld LM's growing debt level, from R80 million in 2018 to R120 million in 2022, is largely driven by three main factors. Firstly ,it can indicate an *inability to pay* for services, because consumers are facing financial pressures due to changing economic circumstances. Secondly, it can indicate an *unwillingness to pay* for services, which is an indication of unhappiness with government services. Lastly, it can also indicate *capacity issues in debt management* within the municipality, whereas the municipality's databases, billing, meter reading and credit control systems have fundamental issues that contribute to poor revenue collection,[360]

The South African government has approved a substantial debt relief package for municipalities owing Eskom, with specific conditions that municipalities must meet to qualify. These conditions include adopting financial best practices, implementing prepaid metering systems, and improving revenue collection rates. Municipalities are required to adhere to these conditions for a period of three years to gradually reduce their debt, with the possibility of full debt cancellation if the requirements are met for 36 months. One of the municipalities approved for the debt relief package is the Richtersveld Local Municipality, which owes R53 million to Eskom. [361] In 2020, the Richtersveld Local Municipality *defaulted on several payments to Eskom*,

[357] National Treasury Section 71 Reports – Schedule C)18, in Nzo, T., Mahabir, J., 2023. *Inclusive and decentralized renewable energy development*, p. 29.
[358] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 32.
[359] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 35.
[360] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p 35.
[361] Creamer, T. 20203. Municipalities approved so far for Eskom debt relief owe a combined R26.69bn.

accumulating an outstanding debt of R13 million. For the 2022/2023 financial year, as of April 2023, the Richtersveld Municipality had not made any payments to Eskom. [362]

The municipality's audit findings have highlighted concerns regarding unauthorized, irregular, and fruitless expenditure, which reflects poor governance and compliance with financial regulations.[363] From 2018 to 2023, the Richtersveld Local Municipality received qualified audits.

Key issues included material misstatements in financial records, particularly regarding taxes, receivables, and inventory, and a lack of sufficient audit evidence for certain transactions, such as maintenance expenses and contracted services. The municipality also faced challenges in complying with supply chain management regulations, resulting in understated irregular expenditure in the financial statements. There are weaknesses in internal controls and risk management practices, which reduce the municipality's ability to comply with financial regulations.[364]

Richtersveld Local Municipality financial overview[365]

Indicator	Details
Audits	2018-2013: Qualified audits
Going Concern Uncertainty	Doubts about municipality's ability to continue operations (1 year)
Creditor Payment Period	Average of 574 days (should be <30 days)
Unrecoverable Municipal Debt	92% of municipal debt cannot be recovered
Debt Collection Period	Average of 85 days to collect debts owed
Total Liability Position	No total liability position at year-end
Bank Balance at Year-End	Positive cash balance (no overdraft)
Deficit for the Year	Spent R8.6 million more than income
Budget Spending	Over 50% of following year's budget already spent, i.e. overspending

Concerns over financial sustainability were highlighted, indicating the municipality's struggles in effectively managing its resources and meeting financial obligations. In the context of large-scale projects like green hydrogen development, these reporting gaps could potentially delay project execution and undermine trust in the municipality's ability to manage large-scale initiatives effectively.

7.6.6.2 Nama-Khoi Local Municipality

Despite a relatively stable revenue base from property rates, service charges, and government transfers, the municipality has consistently recorded deficits; the deficit amounted to R18,6 million in 2022/23, which worsened from previous years.[366] (More details are provided in Appendix A).

The Nama Khoi ruling coalition has achieved significant successes. In March 2025, it secured a debt write-off of nearly R70 million owed to Eskom. This achievement represents a third of its total debt to the power utility. Nama Khoi entered Eskom's debt write-off programme in 2023 as part of a broader strategy to address its outstanding liabilities, which exceeded R209 million. (The municipality also inherited significant water infrastructure challenges due to years of neglected maintenance under the previous ANC-led local government, as well as additional debt owed to the Vaal Central Water Board). Sound fiscal discipline

[362] Rhoda, F. 2023. Municipal debt puts residents at risk of Eskom wrath, DA Northern Cape. 9 October; Motse, O. 2020. Richtersveld Municipality owes Eskom millions.
[363] AGSA, 2022. *Consolidated report on local government audit outcomes*, 2022-2023.
[364] Municipal Monies: Richtersveld Local Municipality https://municipalmoney.gov.za/profiles/municipality-NC061-richtersveld/
[365] AGSA, 2022. Consolidated report on local government audit outcomes, 2022-2023

[366] https://municipalities.co.za/financial/1171/nama-khoi-local-municipality

achieved an 86% compliance rate within the Eskom debt-relief programme, noteworthy compared to many other Northern Cape municipalities who have struggled to comply. “This debt relief marks a turning point for Nama Khoi, providing much-needed fiscal space to strengthen local governance and improve the quality of life for residents”.[367]

The Nama-Khoi Local Municipality's audited outcomes from 2018 to 2020 were marked by recurring challenges in financial management, resulting in qualified audits.[368] In the 2020-2021 financial year, the Nama-Khoi Local Municipality received an "audit outstanding" opinion, signalling the municipality's failure to provide sufficient documentation or resolve outstanding issues, which may impact its credibility and long-term financial sustainability. [369] Note that the new coalition government in the municipality has only been in power since November 2021, and there may be a trend towards improvements in audit reporting.

7.6.6.3 Khai-Ma Local Municipality

The municipality’s financial health and credit control are under considerable strain. Despite a relatively stable revenue base from property rates, service charges, and government transfers, the municipality has consistently recorded deficits. In 2022/3, the deficit amounted to R18,6 million, which worsened from previous years. [370] (More details are provided in Appendix A).

7.6.6.4 Kamiesberg Local Municipality

Despite an increase in revenue from property rates, service charges, and other own revenue sources, the municipality continues to face substantial deficits and capital funding challenges. (More information is available in Appendix A).

7.6.6.5 Namakwa District Municipality

The operating revenues sources for Namakwa DM are very limited and is almost fully funded by intergovernmental fiscal transfers. Other revenue sources are negligible. [371] This is due to the fact that Namakwa DM does not provide any of the basic services to its residents, as it is not assigned those functions. District Municipalities such as Namakwa play a key role in district-wide planning, economic development and other regional services, such as environmental health.

The most crucial functions of the DM are to provide technical support to Local Municipalities, to undertake district-wide planning, and to facilitate relationships between national, provincial and local stakeholders, including the public and private sectors. In terms of the District Development Model, this is a crucial and strategic function, which does not require much capital funding, but does require adequately skilled staff to engage with projects at a very sophisticated level.

7.6.6.6 General financial position of Namakwa Local Municipalities

The four Local Municipalities have several common features regarding their auditing and financial reporting, as shown in five years of local municipal audit reports:

- Qualified audit reports, which highlight specific issues or discrepancies
- Unauthorised, irregular, fruitless expenditure

[367] Van der Lith, D, 2025. Nama Khoi Municipality achieves R70 million Eskom debt write-off.
[368] Municipal Monies: Nama-Khoi Local Municipality, https://municipalmoney.gov.za/profiles/municipality-NC062-nama-khoi/
[369] AGSA, 2022. *Consolidated report on local government audit outcomes*, 2021-2023. Typical factors are material misstatements in areas such as taxes, receivables, and inventory, alongside insufficient audit evidence for several financial transactions, including maintenance expenses and contracted services. Non-compliance with supply chain management regulations also contributed to understated irregular expenditure in the financial statements.
[370] https://municipalities.co.za/financial/1168/kamiesberg-local-municipality
[371] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 30.

- Material financial misstatements (e.g. taxes, income received, inventory, maintenance, and contracted services)
- Non-compliance with procurement regulations, leading to doubts about the municipality's capability to manage public funds
- Poor performance monitoring and reporting, particularly in infrastructure management
- Risks of financial instability, e.g. due to poor resource management, loss of investor confidence and delayed project execution
- Budget imbalances
- Unrecoverable debt.

Interventions need to be strong and sustained, presumably by the Northern Cape COGTA, possibly assisted by national agencies. This will require strengthening internal control systems, training of municipal staff, appointment of more experienced and skilled staff, prioritising debt collection efforts, and project management skills.

Several systemic problems that characterise municipal functioning and finance in rural areas in the Northern Cape generally, and South African in general:[372]

- Unrealistic budgeted revenue collection levels are not realised while operating costs remain high, with no effort made to contain expenditure
- The local government equitable share is mainly used to fund operational costs rather than utilised for service delivery
- The large number of outstanding debtors indicate that minimal fiscal effort has been applied by municipalities to generate revenue
- Municipalities depend on central government grants
- Government departments owe significant debt to municipalities; in 2019, this amounted to R3.8 billion in the Northern Cape
- Many municipalities have negative cash coverages ratios; they cannot meet their financial obligations, in the event that the municipality becomes unable to collect revenue
- Understaffed and poorly skilled municipal financial management departments
- Politicians pressure officials to relax credit control policies, especially with regards to service disconnections
- Council audit committees exercise inadequate oversight, officials and low literacy levels of councillors place power in the hands of unsupervised officials
- Lack of proper IT governance is responsible for loss of data, and data collection is poor
- Instability in senior management (such as acting Municipal Managers and CFOs) create poor oversight and policy direction
- Illegal connections and tampering with meters lead to distribution losses
- "Malicious compliance" to regulatory requirements.[373]

To address these problems, the Northern Cape PGDP proposed interventions such as:[374]

- Develop and implement credible credit control and debt collection policies

[372] Northern Cape Government, 2019, *Provincial Growth and Development Plan,* p. 183.
[373] "Malicious compliance" is defined as strictly following the orders of a superior despite knowing that compliance with the orders will have an unintended or negative result.
[374] Northern Cape Government, 2019, *Provincial Growth and Development Plan,* p. 187.

- Create an effective query handling system
- Implement data cleansing projects
- Create revenue enhancement initiatives
- Key vacant positions must be filled
- Strengthen oversight structures at Council level
- Implement consequence management
- Draft affordable payment agreements with creditors.

These guidelines would be a useful yardstick for future financial management interventions.

7.6.6.7 Namakwa DM

According to the Audit-General report, the municipality is stable, with no significant issues in its council or key leadership positions. The position of Municipal Manager was filled in February 2023; however, the Chief Financial Officer (CFO) position remains vacant in 2024. Essential governance structures, such as the Audit Committee, Internal Audit, and the Municipal Public Accounts Committee (MPAC), are fully operational. This solid institutional framework provides a strong foundation for the municipality's involvement in regional development initiatives.

NDM generally complies with financial governance standards, but there are concerns regarding the management of large-scale projects. The reports suggest that the municipality needs to strengthen internal controls and strategic planning to oversee the effective implementation of renewable energy projects and the Boegoebaai projects.

The Namakwa District Municipality has demonstrated consistent fiscal discipline, achieving unqualified audits (with findings) until 2020; thereafter, the audits were rated as “unqualified audits with no findings”. There has been a steady improvement over the last five years. [375]

In 2018-2019, the audit report for this period highlighted significant challenges in financial management, with the municipality failing to meet some of the basic governance standards. Key issues included inadequate internal controls, poor performance in revenue collection, and lack of compliance with procurement policies. However, the municipality received an unqualified opinion, meaning that the financial statements were generally presented fairly, but there were concerns that needed attention.

In 2019-2020, the audit outcome for this period showed improvements in financial governance and reporting practices, although issues with supply chain management and irregular expenditures persisted. There was a concern about the lack of transparency in some procurement processes. While the municipality improved its cash management, the audit raised concerns about long-term financial sustainability and the overreliance on national transfers.

In 2020-2021, the DM received a clean audit opinion, which indicated that the financial statements were free from material misstatements. Improvements in financial reporting were observed, alongside a reduction in unauthorized and wasteful expenditure. However, concerns about the municipality's internal controls and oversight mechanisms remained. A key finding was the failure to implement effective project management systems for infrastructure development, which had delayed important projects.

In 2021-2022, the municipality continued to show financial discipline, but a lack of strategic planning and budgeting for long-term projects was a persistent issue. Budget allocations for key projects, including renewable energy and infrastructure development, were often exceeded.There were concerns regarding the municipality’s limited capacity to manage and monitor large-scale projects, particularly in the renewable energy sector, which was becoming a priority area.

[375] Audit-General of South Africa. Audit Report: Namakwa District Municipality, 2019, 2020, 2021, 2022.

In 2022-2023, the DM received an unqualified audit opinion with fewer instances of non-compliance and financial mismanagement. However, the audit flagged challenges with project implementation, particularly as it may impact the green hydrogen and infrastructure sectors. The report pointed out that although budget allocations for renewable energy projects had increased, the actual spending was often delayed due to inefficiencies in procurement and project execution.

7.6.7 Building institutional capacity

This section includes several recommendations which could develop the institutional robustness to manage large new projects, with an emphasis on municipal empowerment and ongoing stakeholder participation. This section incorporates key insights from the SEA public participation process.

7.6.7.1 Building municipal capacity

Municipal support requires political will, institutional effort and technical skill on the part of a variety of support agencies, such as COGTA at national and provincial level, SALGA and DBSA. The most crucial intervention would be a system of inter-governmental collaboration, whereby national and provincial sectoral knowledge and options are shared with District and Local Municipal councillors and staff. One can envisage a series of sectoral task teams, dealing with land use planning, housing, skills training, transport, health, and disaster management, in a shared learning process, involving institutions at several levels of government. Private consortium members need to be part of these multi-level planning mechanisms, so that the realities of the projects are matched with policy choices in each sector. In addition, key stakeholder agencies, such as the Richtersveld CPA, chambers of commerce, and environmental organisations should be included, to determine broad strategic directions and practical options. In the international literature, this is termed “Collaborative Governance”[376]

The argument was made, in the public review process, that institutional capacity should be built *before* large projects are launched. In principle, that would be an optimal approach. Ideally, bolstering systems should precede investments. However, that is unlikely, for two reasons. Firstly, without an impending investment, the area remains an economic backwater, and there is no real incentive for provincial governments or development agencies to focus on the Richtersveld. Government resources (both financial and skills) are spread very thin. A potential development project "focuses the institutional mind". It is likely that institutional support will be provided only once the projects have been accepted in principle.

Secondly, the bolstering of institutions could, and should, take place *alongside* the development project, so that institutional lessons are learnt *in response to* new features of the development project. This creates a learning environment, where new development options and challenges spur the focus on institutional improvements. Institutional strength is not a static phenomenon; rather, it is the ability to respond timeously and appropriately to developmental options and challenges. For example, the spur of the Boegoebaai project may require provincial government to make accountants available to Richtersveld LM to streamline its budgeting and financial management; with this capacity, the Richtersveld LM councillors will be exposed to financial management standards which will enable them to budget effectively for social services (which are not directly associated with the Boegoebaai project).

The important intervention is the learning environment, where officials, councillors and community representatives will learn the techniques of responding to a challenging environment.[377]

7.6.7.2 Managing cumulative impacts

These are intrinsically difficult to address before *any* project is implemented. These are likely to be a combination of unintended or unanticipated positive and negative impacts, and these in turn, can have further unintended or unanticipated positive and negative impacts. The most effective response is to build

[376] Voets, J.J *et al,* ."Collaborative Governance",,2021. This issue reflects inputs by public reviewers.
[377] This point was included in response to public reviewer comments.

institutional capacity to deal with unforeseen impacts and choices. That, in turn, requires the political will and institutional effort referred to above.

7.6.7.3 Maximising community benefits

The harbour and energy projects are not "extraction" enterprises in the same sense as mining, where resources are removed from the ground, leaving nothing behind, so if the mine closes, there is a vacuum in the economy. The port and green hydrogen projects have significant backward and forward multipliers, to create new rounds of investment, which will benefit local communities. This will require institutional effort to *maximise* beneficial impacts, such as technical training, employment, and corporate social responsibility.

This will be the shared responsibility of private sector companies working on these projects, as well as national, provincial and municipal policy-makers, who are ultimately responsible to the electorate. A great deal will depend on the local communities to vote for parties and candidates that make useful developmental proposals about community benefits, and appear to have the capacity to make a meaningful contribution. Ongoing stakeholder participation in decision-making structures will be another important mechanism to identify and promote community benefits.[378]

7.6.8 Planning for a potential Green Hydrogen and Harbour project

Municipal planning documents (IDPs) play a crucial role in determining how local governments can support green hydrogen development. While Richtersveld's IDP demonstrates a strong alignment with the Boegoebaai projects, backed by comprehensive research and evidence-based planning, other municipalities such as Kamiesberg and Nama-Khoi face challenges due to less detailed or outdated plans. This disparity in planning capacity impacts their readiness for large-scale renewable energy projects.

There are no inherent difficulties with IDPs and SDFs, and the real challenge consists of the intellectual leadership of such planning efforts, knowing what questions to ask, what information to obtain, and what options to present to policy-makers. The Namakwa DM will play a crucial role in this regard, overseeing planning for the entire region. The DM should proactively employ suitable municipal planners; however, it should also obtain support from universities, provincial government, SALGA, and knowledge institutions such the HSRC and the CSIR. This does not mean that these institutions should actually write the IDPs; but they can be involved in steering the work of private consultants, e.g. by scoping the questions to be addressed, evaluating and supporting research methodologies, accessing useful data from various project participants, and devising coherent policy options for policy makers. This support and guidance should be provided to all four Local Municipalities in Namakwa. **In addition, the impacts of road traffic in the Dawid Kruiper LM (Upington area) and the Kei !Garip LM (Keimoes area)** should be drawn into regional discussions, spearheaded by the Namakwa DM and the ZF Mgcawu DM, as part of the SEZ region.[379]

In reality, the main planning agency may well be Namakwa District Municipality, whose planning capabilities may far outstrip those of the Local Municipalities. Furthermore, planning activities are expensive, requiring trained and experienced staff, software, and access to data and travel to outlying areas. Namakwa DM may well require additional financial support from one or more of the stakeholder agencies, or from COGTA.

Additionally, gaps in environmental and energy planning, as seen in Khai-Ma, highlight the need for more robust energy master plans. A consistent issue across all municipalities is water infrastructure challenges, with Kamiesberg and Richtersveld experiencing water shortages and aging infrastructure, which could impact a future green hydrogen projects Comprehensive water management and long-term infrastructure investments are essential to ensure these municipalities can effectively support the growing energy sector.

The National Spatial Development Framework (2022) requires much more effective spatial targeting, integration and alignment in infrastructure investment in future. Existing and possible systemic links between places and communities need to be optimised.[380] This must be a transition to a compact, service-

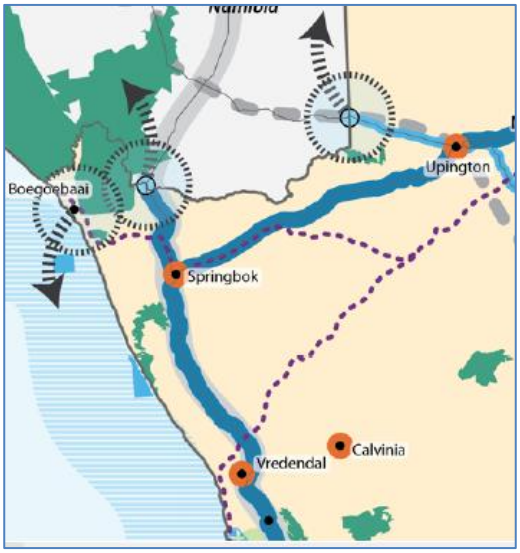
[378] This point was added in response to public reviewers.
[379] This point was included in response to public reviewers.
[380] NSDP p. 88.

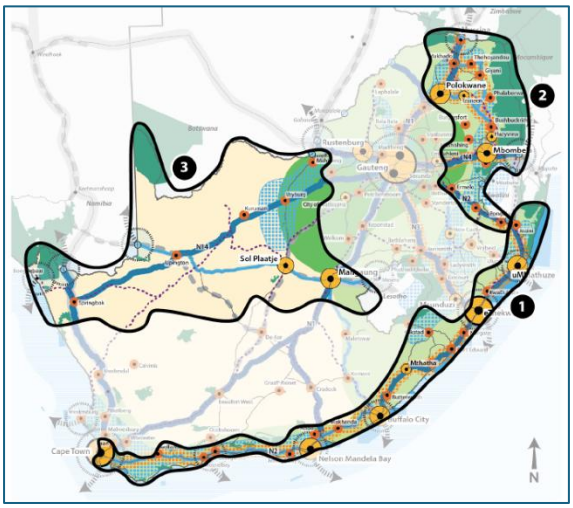
based, resource-efficient space economy, including rural and urban spaces, with a more compact settlement pattern, with suitable housing types, building materials and construction methods.

In the context of Namakwa, the NSDP principle would apply: "A network of vibrant regional development anchor towns, with strong rural-urban connections to strategically located rural service centres that act as regional-rural service providers"[381] In the NSDP, Springbok will serve as a regional development anchor, and Steinkopf and Port Nolloth as Rural Service Centres. [382]

[381] DALRRD 2022, National Spatial Development Framework, p. 103.
[382] DALRRD 2022, National Spatial Development Framework, p. 156.

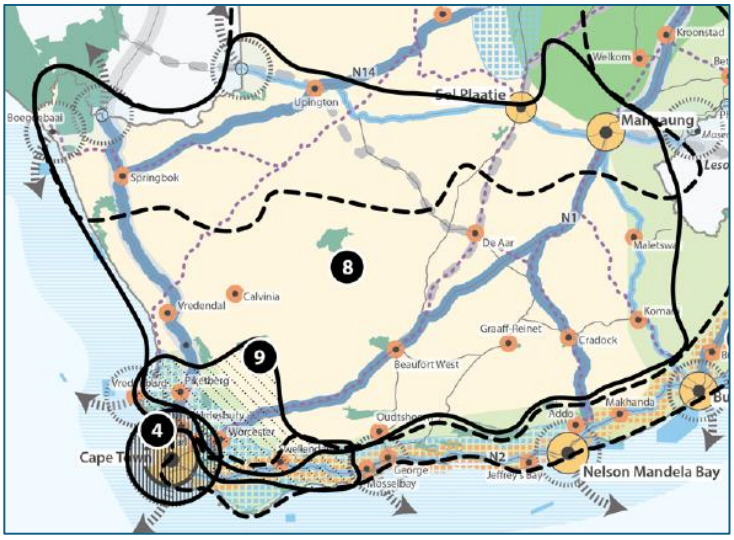
Right: The NSDP already makes provision for Boegoebaai as a key import/export node.[383] *This will be rolled out through the national and provincial departmental strategic plans, as well as municipal IDPs and SDFs.*





Left: The Port Nolloth-Springbok-Poffader area is part of the ***North-Western National Spatial Transformation and Economic Region (NSTETR),*** *one of three important spatial areas in the country.*[384]

The NSDP demarcates the Namakwa area as part of the ***"Arid-Agri innovation region*** *marked as "Region 8", with Springbok as a key hub.*[385]



383 DALRRD 2022, National Spatial Development Framework ,p. 113.
384 DALRRD 2022, National Spatial Development Framework, p. 149.
385 DALRRD 2022, National Spatial Development Framework, p. 126, 177.

With these important regional spatial plans, there will be pressure on the District Municipality to become a key arbiter and guide for spatial planning interventions. The pressures of the SEZ and Boegoebaai investments will make a strong planning department indispensable.

These spatial designs need to be seen in the light of the overarching principles of the NSDP, in terms of "focused rural development", which involves several key principles:[386]

- Targeted agrarian reform
- Tenure reform
- The promotion of agri-processing and logistic support hubs
- Diversification of the local economy
- Small-town redevelopment and regeneration in suitable locations
- Public works-led job creation programmes and the roll-out of core government social and municipal services
- The provision of grant support with the building and upgrading of housing, specific in identified regional development anchors and rural service centres
- Investment in restoring and maintaining ecological infrastructure in support of water security, food security and disaster risk reduction, and
- Development of the "wildlife economy".

The NSDP further notes that a key component of this vision will be rural land reform, which will release under-utilised commercial agricultural and state-owned land for use by new entrants to the farming sector. Rural small towns need to be supported. Agricultural support entities, cooperatives, equipment, fertilizer, market support, funding and research will need to be revived or introduced in rural areas.

Municipalities in the Namakwa District face considerable challenges in infrastructure planning and service delivery, largely stemming from limited resources and insufficient long-term planning. The region's diverse towns, each with unique socio-economic contexts, require tailored development strategies to address critical gaps in basic services, job creation, and infrastructure. Addressing these challenges is vital to ensure sustainable growth, improve living conditions, and unlock the economic potential of the district.

In the **Richtersveld Local Municipality**, these challenges will be amplified by anticipated population growth associated with green hydrogen development, which includes both induced and natural population increases, as well as net migration. Rapid development and population growth can create pressures that exceed a municipality's existing infrastructure capacity, especially in regions that experience "municipal development distress", i.e. rapid demographic and economic growth without a corresponding upgrade in physical and social infrastructure. To prepare for the Boegoebaai projects, RLM must address several key infrastructure needs: planning to prevent urban sprawl, additional housing, road upgrades, bulk infrastructure expansion, additional retail and commercial facilities, expansion of fibre communications; and educational facilities. The challenges arising from the Boegoebaai project are explicitly mentioned in the Richtersveld IDP.[387]

The **Richtersveld Conservation Development Framework (CDF)** includes the entire area of jurisdiction of the Richtersveld Local Municipality, with eight development objectives: Well-maintained roads; improved household and agricultural water security; improved accessibility and quality of education at all levels (childhood and adult); improved primary health care, hospital care and emergency medical services; improved communication and municipal services; sustainable job creation and small business development in all sectors; increase access to retail facilities, banks and petrol stations; ensure that the environment is properly protected, and training of local communities in conservation-linked knowledge and skills. [388]

[386] DALRRD, 2022, National Spatial Development Framework, p. 53.
[387] Richtersveld LM, *Integrated Development Plan,* 2024:88-89)
[388] Richtersveld LM Spatial Development Plan, 2024, p. 82.

The prospect of the nearby Port and GH2 projects will present opportunities and challenges to **Nama Khoi LM.** Deteriorating roads and energy systems can be addressed through investment in new technologies and upgrades. Local towns will benefit from fibre telecommunications. This could lead to improved service delivery and job creation in the region. As argued earlier, Nama Khoi LM and Namakwa DM should lobby for the upgrade of the Springbok airport to enable scheduled flights and car rental facilities. However, there will be rapid population movements and substantial traffic pressures in the region. The town of Springbok may need to accommodate more businesses as a result of the "induced impacts" of the Boegoebaai projects, which may require an expansion of the central business district. The TVET college will probably need to be expand, which may bring additional housing pressures.

The **Khai Ma LM** is important because it is a major hub in the SEZ. Pofadder will become a more important urban node for commercial and technical companies. The SEZ projects could stimulate investments in infrastructure, like roads, fibre and the energy grid, while offering job creation opportunities. However, without strategic alignment, these developments risk intensifying existing inequalities by diverting resources from basic services or excluding remote communities from benefits. To maximise positive outcomes, it is critical to incorporate inclusive planning that integrates non-urban areas, and enhance municipal capacity through training and updated management plans/

In **Kamiesberg LM,** several critical challenges related to water resources, ageing infrastructure, and revenue collection must be addressed to ensure that the municipality can play an important role as a tourist hub. The municipality's water supply is already under significant stress, and infrastructure is ageing and decrepit. Kamiesberg towns are likely to benefit from additional traffic on the N7 (servicing transport of materials for the Port and GH2 plant, as well as stay-overs for staff). Fibre-based communications may attract more "semi-grant" investors from the cities, who see opportunities in transport and tourism sectors. The town of Hondeklip Bay may grow as a tourist destination. This will place additional pressures on infrastructure. Additionally, the municipality faces ongoing challenges with revenue collection, which need to be addressed to ensure a stable cash flow.

Namakwa DM will need to play a crucial co-ordinating and planning role. As custodian of the District Development Model (DDM), it needs to "improve the coherence and impact of public and private sector investment and government service delivery within the Namakwa District, as a development space that can be used as a centre of service delivery and economic development", based on a collaborative style of governance.[389] The model seeks to create a unified, strategically focused "One Plan" for each district, ensuring coherence across all three spheres of government.

This is not an easy task. The failure of national and provincial agencies to engage with local government throughout the DDM process hinders these municipalities' capacity to fulfil their developmental roles.[390] In practice, this would require, at minimum, that the performance evaluations of provincial and national government departments include their active involvement in the DDM model. The DDM needs to influence a culture shift in the way government as a whole works and functions as a collective and how it works more effectively with private sector and civil society. The shift is away from "alignment of plans" between the three spheres of government towards a much more deeply collaborative planning process, where the One Plan is an expression of common understanding of the developmental situation and shared vision for the future with an agreed trajectory of logical interventions and actions to realize the desired future.

This lack of multi-level government coordination marginalises rural municipalities and highlights the centralisation of policy in South Africa's industrial planning, particularly through SEZs and REDZs. This centralisation is evident from the early stages of the green hydrogen agenda, including the development and investment processes.[391] It reflects a failure to learn from past renewable energy projects in the Northern Cape, which left municipalities economically strained and with inadequate infrastructure.[392] Many practical difficulties regarding the DDM still need to be ironed out. The absence of dedicated budgets for catalytic projects has left crucial initiatives underfunded, stalling their progress and undermining the model's potential to drive meaningful development outcomes. The DDM also faces challenges due to unclear leadership roles and lack of clarity on who is responsible for implementing the One Plan, complicating

[389] SALGA, 2021, District Development Model.
[390] CoGTA, 2022, Namakwa District Municipality District Development Model.
[391] Nzo, T., 2021, Whose Power Is It Anyway?
[392] Borchardt, S, 2024, Shedding light on energy poverty.

coordination and accountability. This leadership vacuum, coupled with inconsistent support from provincial and national governments, hampers local municipalities' ability to execute the model,[393]

The Namakwa District Municipality needs to play the crucial role of co-ordinating all three spheres of government and mobilize the capacity and resources of government and civil society, including business, labour and community, in pursuit of inclusive growth and job creation.[394] While the entire district will be influenced by this wave of industrialisation, the Namakwa DM needs to promote the key sectors of agriculture, agro-processing in tourism.

Regional social and economic cohesion is likely to changed markedly. The main centre of economic centre of gravity will move to Port Nolloth, and also Springbok, as the key government centre. The northern part of Namakwa will become more populated, and function as a locus of economic energy and innovation. The southern parts will remain more oriented to tourism, livestock agriculture, and small-town lifestyle.[395]

The technical expertise needed to support large-scale green hydrogen projects is currently lacking in the Namakwa District Municipality (NDM). Municipalities such as Khai-Ma, Nama Khoi, and Richtersveld are particularly affected by resource shortages and a lack of skilled staff, which makes it challenging to manage the sophisticated infrastructure demands associated with green hydrogen development. However, while the need for capacity-building is acknowledged, actionable plans to address these deficits remain underdeveloped.[396]

For ambitious green hydrogen projects to succeed in the region, targeted investments in training and institutional development are essential. This includes equipping local governments with the technical knowledge and administrative capabilities necessary to oversee planning and infrastructure provision for renewable energy projects.[397]

With the approval of these projects, the SPLUMA-based system of planning regulation will need to be implemented in earnest. The risk, in this regard, is that local municipalities are not familiar with these legal measures, and this may delay approvals. Municipal regulatory capacity will need to be built; in the interim, the District Municipality and Northern Cape COGTA may play a support role. Where municipal agreements with private and non-government organisations are entered into, these will need to be evaluated for effectiveness and fairness. Project-level authorisation conditions may be laid down by National and Provincial Government. In all these cases, a strong level of Collaborative Governance will need to be established, to protect municipalities' role in decision-making and to prevent national and provincial domination of the municipal sphere.[398]

A general caveat is that planning processes should not lapse into a heavily technocratic approach. In fact, the process may be held up by legal challenges. A public consultation approach will have to be very robust to avoid such obstacles.

A critical aspect of municipal functioning will be improved levels of disaster management capability. This is a complex sector, and will require a full assessment of the prevailing situation in the Richtersveld area specifically, and Namakwa District, in general. Institutional relationships, authority structures, funding systems, and skills sets, are often highly inadequate.[399] Richtersveld LM will be catapulted into a very modern industrialised setting, where risks and disasters may be technically challenging.

[393] Teti, M., Nzewi, O., & Lungisa, S. 2024. The district development model as a catalyst for improved integrated development planning.
[394] Namakwa DM, 2023, *Integrated Development Plan,* p. 23.
[395] This point was inserted in response to public reviewer comments.
[396] Wessso, R and Brandt, F, 2023, Beneficial Technologies (Bentec) Green Hydrogen Community Development Toolkit.
[397] DALRRD,2022, Spatial Development Framework, p. 143.
[398] This point was inserted in response to public reviewer comments.
[399] Atkinson, D, 2021, Preparing for the worst.

7.7 THE PUBLIC ENGAGEMENT PROCESS

With the prospect of Boegoebaai investments, the need for public engagement will become immense. In the past, renewable energy projects were often associated with exclusionary practices that resulted often in marginalised communities feeling disconnected from the planning and implementation of green hydrogen projects.[400]

There was no consultation with communities in the compilation of the SEA. The SEA relies on secondary sources, scholarly literature and consultants' reports, across several disciplines. The SEA argues strongly for a robust community participation process, not to "sell" the insights of the SEA, but to obtain communities' views on proposed projects and policy measures. This chapter emphasises that there must be opportunity for repeated iterations of community engagement, to obtain diverse views, preferences and options; to compile practical proposals around them; and to consult yet again about the usefulness of those suggestions, and further options.[401]

7.7.1 Public participation in a contested environment

7.7.1.1 Learning from the mining sector and renewable energy

In the rapidly emerging field of GH2 literature, the theme of effective public participation features strongly. This is based on a long experience of mining and renewable energy projects, where community engagement has often been honoured more in the breach than the observance. One of the lessons has been that, in Africa, the very nature of engagement processes can have counterproductive results. “People are often alienated by the focus of the energy reform design often framed within a restrictive language of technicalities such as technology transfer, industry competitiveness, cost recovery, financial risk or cost-benefit analysis, planning, private sector investment/finance, capacity building and other factors, with half-hearted commitments to genuine popular participation in the reform process”.[402]

“Extractivism” refers primarily to mining, but it is increasingly used as a critique of technicist and centralist approaches to renewable energy projects. It typically refers to the extracting of natural resources, providing local jobs while the enterprise lasts, and then departing (leaving communities holding the proverbial handful of feathers). The failure of the Department of Mineral Resources to hold companies to account for implementing social and labour plans and environmental rehabilitation schemes plays into this narrative. Furthermore, the orientation of GH2 towards exports appears to be oriented to international markets rather than domestic welfare – indicating that the widespread domestic use of GH2 has not been effectively explained to communities.

The proponents of the Boegoebaai projects should make it their goal to achieve a real, robust “Social Licence to Operate” (SLO) from the local communities. The mining sector has developed significant expertise in this field, and this can be harnessed for the sake of maximising the Boegoebaai projects’ chance of success. In mining operations, community dynamics have often been stressful, and painful lessons were learnt. There is a growing appreciation for context-specific development factors, guarding against “one size fits all” engagement approaches.[403] Key determining factors include existing socio-economic and demographic structures of towns, the political economy of the resource itself, the role and behaviour of companies, and regulatory and institutional structures.[404] Other key characteristics include climate, terrain, natural amenities, distance from metropolitan areas, local skills, leadership styles, poverty rates, age profiles,

[400] Nzo, T, 2021, *Whose Power Is It Anyway;* Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development.
[401] This point was added in response to public reviewers of the chapter.
[402] Nzo, T (2021) Whose Power Is It Anyway?
[403] Tonts, M et al, Socio-economic wellbeing in Australian mining towns
[404] Chapman, R. et al, Resource development, local adjustment, and regional policy.

educational attainment, population density, culture and lifestyle.[405] Social dynamics are profoundly influenced by human agency (whether that of leaders, followers or institutions).

In Namaqualand, the experience of diamond mine closures has been painful. Significantly, much of this anger stems the poorly managed Richtersveld diamond fields restitution claim, which some local residents maintain have not translated into any tangible benefits for the local communities. There is already a large inherited stock of grievances in Namaqualand which have never been fully addressed: Mines' use of traditional land, their failure to rehabilitate environmental damage, their century-old lack of proper engagement with communities or unwillingness to think about a "social licence to operate", the recent Richtersveld land claim with its apparently unimplemented outcome, the arrival of illegal miners on land which should be managed properly by government or mining companies, the unresolved emotional hurt caused by constraints on land ownership by coloured people under Apartheid, and the bedrock of ethnic Khoi and Nama cultural grievances in the face of white colonialism, western cultural domination and the loss of land for over a century – these deep-seated concerns will require a very different form of public engagement.

An additional complication is the language issue in Namaqualand. The use of Afrikaans in the public participation process will be important for almost all Namaqualand stakeholders. This will require the recruitment of a native Afrikaans speaker as facilitator. In addition, the challenge of technical and scientific terminology can be addressed by highlighting key points requiring strategic decision-making. This would include factors such as the kinds of jobs that may become available; possible options regarding employee housing and transport; possible training schemes; and ways in which outlying communities can benefit from these projects. It should also highlight the risks of the projects, and the communities' risk appetite for such issues, e.g. in-migration of workers from elsewhere, and pressure on housing. [406]

Where participants need additional information, subsequent iterations of the consultation process (e.g. local workshops) can be organised, presenting fresh information and options for public discussion. The point is important that "participation does not imply consent". It is also important that participants realise that any development process will involve risks and opportunities, and that any way forward will involve opportunity costs (i.e. development paths *not* chosen, and therefore the loss of certain benefits).

7.7.1.2 Difficulties envisaged in the Namaqualand region

There is already a reputational problem regarding the consultative process surrounding the Boegoebaai projects. This is not surprising, since any sophisticated high-tech proposal needs to involve several constituencies at different levels, ranging from the highest levels of government and investors to local communities. It is almost inevitable that such discussions will not become "out of synch" with one another. A great deal of behind-the-scenes technical research had to be done, before there is any "Go/No Go" commitment to the project. At the same time, rumours of potential projects start circulating at grass-roots level, without sufficient information to put it into context. Public representatives, such as Councillors, are caught between technicist consultations and community anxieties. It is very likely that mixed and incomplete messages will go out into the world, and will stimulate cycles of suspicion and resentment.

Mistakes have been made in the past, in various sectors. Public participation may be manipulated through the government and/or investors who cherry-pick individuals who are viewed as the 'people's representatives' on official structures but who do not enjoy popular representational legitimacy in the community. At the same time, the community maybe selectively consulted on a project according to an existing agenda that the community has not been given an opportunity to shape the formulation of the agenda. In this case, the community's input is only used to further endorse this existing agenda. After some fieldwork in the Richtersveld, Dr Thina Nzo found that "This practice has been observed in the public participation process in the green hydrogen development in Richtersveld LM". This is not an auspicious start.[407]

In the Richtersveld, previous consultation processes on the land restitution claim were uncertain and often muddy. The costs and benefits of that process still remain unclear to local people. The Boegoebaai proposals

[405] Hays, J et al, Considerations for the development of shale gas in the United Kingdom.
[406] This point was added in response to public reviewer comments.
[407] Nzo, T, Mahabir, J., 2023. Inclusive and decentralized renewable energy development, p. 47-51.

therefore land on a terrain that already has unresolved memories of conflict and even betrayal. In addition, there are concerns of ecologists about environmental damage, and other suspicions related to international trade, corporate profit, and possible economic exploitation. The situation could hardly be more complex; and it will require a concerted strategy to plan a genuine interactive process of consultation, where a real give-and-take of information and suggestions can take place.

Nzo (2023) found that, during a focus group discussion with community activists in Namakwa DM, many members expressed acute levels of disenchantment with the way in which the Northern Cape provincial government and local municipalities (in particular the Namakwa DM) have handled public participation concerning developments in the past as well as the present-day development of Boegoebaai port and green hydrogen development. Community activists view the Richtersveld community having a shared history of social and economic connections with neighbouring former 'coloured' communal areas in all parts of the district. Certain local people lamented the fact that their councillors do not even inform or distribute information widely to the communities about the consultative meetings. They spoke against the centralised approach adopted by local and national government departments when conducting public participation, where sites of public engagements are conducted in a central town, leaving out communities from neighbouring settlements. who are expected to use their own resources and transport to attend public consultation meetings.

Sometimes their criticisms take on a party-political flavour. Some local people claimed that certain members of the community of Richtersveld, who are known supporters of the African National Congress (ANC), are co-opted to participate in public consultation processes because they are likely to not question the development and issues related to long-term benefits for the community. *"They [local politicians] are using their comrades in the CPA and community to endorse the decision-making processes regarding the leasing of Boegoebaai land. They no longer want to work with the rest of the community because communities ask tough questions. That's why councillors mobilise branch members to attend these so-called consultative meetings. Sometimes they even bus them to these meetings… held by the NCEDA, OTP, Sasol and Department of Economic Development … When some of our activists came to the meeting, they were not allowed inside the venue and they were forcefully removed from the venue because they viewed as rabble rousers."*[408]

If such claims are circulating, then there are indeed local concerns about the integrity of the participation process. [409] Community activists claimed that there is no transparency in the consultation and negotiation process of the Boegoebaai land acquisition led by both local and provincial government. They felt that the Northern Cape provincial government is 'selling them out' instead of protecting their interests as a vulnerable community that has a history of colonial exploitation. They have alleged that institutions are making agreements behind closed doors with German investors and SASOL, and not involving them in decision making. They claim that these projects form part of a neo-colonial structure where much of the innovation and ownership for the development is perceived to belong to the investor — usually investors from the global North — with the South African government simply facilitating the investment.

These observations are cited here at length, because it illustrates the difficult terrain which any consultative exercise will encounter. Proponents of the Boegoebaai Port and GH2 will need to create a task team of facilitation experts to start the consultation process all over again. Certain basics will have to be addressed, like explaining what GH2 is, how it works, how the project will function, what kinds of jobs will be created, what training will be required and how it will be provided, how income flows are likely to be generated and funds spent. Ideally, this should be a people-driven process, in the sense that the task team should respond to community assertions and questions, in a process of shared understanding. Some meetings will need to be broadly open to the public, while it may also be valuable to create community discussion teams which can interrogate issues more closely.

This is a far cry from the "tick-a-box" methods of public participation typically used by municipalities, Departments, SOEs and renewable energy companies.

[408] Nzo, T., Mahabir, J., 2023. Inclusive and decentralized renewable energy development, pp 50-3.

[409] In 2022, Nama Khoi Productions, in collaboration with youth from the Richtersveld area, organised a theatrical performance as a response to widespread dissatisfaction with the public consultation process for the Special Economic Zone (SEZ) and the Boegoebaai Green Hydrogen project. See Koteli, T. 2022. Theatrical demonstration against government in Northern Cape, OFM.

Special effort needs to be taken to include women and young people in the public engagement process.

7.7.1.3 Current mobilisation in Namaqualand

The VVVT Namaqualand[410], an abbreviation for the Free, Prior, and Informed Consent group (FPIC), is advocating for greater transparency and respect for the rights of indigenous people in the decision-making process. The protests highlight the need for inclusive development to ensure that local communities, especially marginalised ones, benefit from such large-scale projects, and that their voices are heard in discussions about land use and environmental impacts.[411]

The VVVT argues that locals, who only recently received their land rights after decades of struggle, may face further land losses due to the development of green hydrogen on 45,000 hectares of land. They also question the promised jobs associated with the green hydrogen and Boegoebaai port development projects, stating that these opportunities are not suitable for local residents, who are predominantly farmers and fishers. Many of these individuals are not interested in retraining as port workers, nor do they possess the necessary skills for these jobs.[412]

The Right to Say No (R2SN), an activist network consisting of more than twenty organisations, connects different struggles against extractivism across Southern Africa, aiming to challenge a development model that operates in favour of profit and at the expense of people and the planet. R2SN questions the access to and distribution of energy, and also envisages a just energy transition that favours the rights and lives of the people. It also promotes the principle of FPIC, which would in fact entail envisaging alternative pathways to just and sustainable energy futures. "Shedding light on alternative practices and visions during this critical juncture contests capitalism's systematic obliteration of alternatives".[413]

Other activist and youth associations such as Environmental Traits (ET) a youth-led association established with support from the Environmental Justice Fund, focuses on addressing environmental and food security challenges in Port Nolloth and surrounding areas.[414] The group actively engages in protests against oil and gas activities along the West Coast, particularly in Port Nolloth, while also raising awareness about the potential socio-environmental impacts of green hydrogen projects and the development of the Boegoebaai Harbour. ET's mission is to empower youth to become agents of change within their communities, with a focus on promoting food sovereignty, environmental sustainability, and community-driven actions for a just transition.[415] Youth and future generations will have to bear the often-unintended consequences of project decisions.

These protests underscore the community's deep attachment to their land and cultural identity, highlighting their fears of losing not only land but also their heritage and way of life. The R2SN campaign is actively engaged in raising awareness about the risks of leaving communities behind in the energy transition. The campaign emphasises the potential environmental destruction and toxic impacts associated with energy developments. These concerns are rooted in past experiences with mining companies, which often neglected proper environmental rehabilitation.[416] The current impasse between communities, illegal miners and the new Lower Orange Mining company, which purchased several defunct diamond mines, creates an atmosphere which is not conducive to trust in either GH2 or the Port development. There is a growing concern about the legacy of environmental destruction left by previous companies, and the likelihood that this damage may never be repaired. Consequently, the R2SN movement calls for just and inclusive energy transitions that prioritise environmental protection while safeguarding the rights and interests of local communities.[417]

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410 Afrikaans: Vrywillige en Voortdurend Volledig Ingeligte Toestemmingsbeweging (VVVT)
411 Human, L. 2024. Namaqualand communities call for moratorium on all new mining rights.
412 Pier and Hlabane. 2024. Reclaiming power: Shifting geographies of extractivism in South Africa; Parkin, M. 2024. Perspectives on Green Hydrogen Development in the Richtersveld Local Municipality; Hendriks, U. 2022. Some Northern Cape coastal communities oppose multi-billion-rand development projects, SABC News.
413 Pier and Hlabane, 2024, Reclaiming power: Shifting geographies of extractivism in South Africa.
414 Website: https://www.facebook.com/people/Environmental-Traits/100089661501876/
415 Masifundise Trust, 2024. Youth group tackle environmental challenges in fishing community
416 Groenewald, Y. 2019. Richtersveld diamond deal leaves locals with the dirt; Hendriks, U. 2022. Some Northern Cape coastal communities oppose multi-billion-rand development projects, SABC News.
417 Pier and Hlabane, 2024, Reclaiming power: Shifting geographies of extractivism in South Africa.

The proposed Boegoebaai harbour development linked to green hydrogen production in the Northern Cape has sparked concerns among small-scale fishers. Many fear that corporate interests will take precedence, potentially harming marine ecosystems and undermining local livelihoods.[418] The Masifundise Development Trust argues that the project lacks proper public consultation and threatens the fishing economy, asserting that the port is primarily intended to serve mining activities rather than benefit local communities. [419] Small scale fishers pointed to the lack of public consultation regarding the proposed Boegoebaai port; this feeds into concerns related to off-shore oil and gas exploration.[420]

Environmental concerns have also attracted attention. Environmentalists, led by Pieter van Wyk, are actively working to protect the sensitive areas of the Richtersveld from development projects, including large-scale green energy initiatives like wind farms, solar farms, and the GH2 plant.[421] They argue that these developments pose a significant risk to the biodiversity of the Namaqualand region, home to many rare plant species.

It is not always easy to discern what the underlying concerns of mobilised communities are, and it takes time to "unpack" different strands of opinion within communities. There may be several layers of discontent. Some groups do not categorically oppose the development of green hydrogen projects but rather protest against exclusionary practices that may prevent them from benefiting economically. Their concerns centre on the lack of meaningful engagement, which may result in limited access to the economic benefits of large-scale development projects. For example, some community members believe that all jobs will be given to outsiders.

All four municipalities have raised concerns about the lack of youth participation in public consultation processes in their annual reports and IDP documents. This issue is particularly relevant for Boegoebaai-related engagement, where the inclusion of youth voices is crucial, as they may be the main focus for training and employment.[422] Engaging youth in local governance can foster social cohesion, build community capacity, and contribute to more innovative and inclusive policy outcomes.[423]

This is easier said than done. "The youth", as a category, is typically not well organised, and range from fairly well educated and employed people (e.g. working at a business or municipality) to young people not in education, training or employment. Where "the youth" are organised, it may be a small group of activists who have strong feelings about public matters, who are networked regionally and nationally, and influenced by broader debates. As with all blanket categories, it is likely that the youth cohort is also divided along several lines. Some may welcome the new projects, and trust that they may access training and jobs; others may worry that the community is going to be cheated out of its rightful share of benefits. Some young people may welcome engagement with corporates as an opportunity for growth and advancement, while others may be more prone to see relationships of economic exploitation.

Nevertheless, it is critical to engage as many players as possible, and to explore the various discourses they offer. There may be low-hanging fruit, in terms of finding points of consensus; but on more challenging matters, it is important to engage properly with various standpoints, in order to determine the veracity of facts and the normative underpinning of opinions. Many misunderstandings can be resolved through a process of explanation (e.g. what waste products are created by green hydrogen, and how will that be managed?) while others will require more in-depth discussion and negotiation (e.g. what kinds of training should be offered?)

7.7.1.4 Re-thinking institutional culture: Beyond technicism

The practical functioning of the political system at local level is often conflictual and contested. There is inter-party competition (often overlaid by racial identities), as well as ongoing intra-party conflicts within the

[418] Sinxo, Z., 2022. Boegoebaai harbour a bit fishy, fear small-scale fishers.
[419] Website: https://www.masifundise.org/
[420] Human, L. 2024. Stop new mining on West Coast, say fishers/
[421] Bakker, A. 2024. Flowers in the Desert: The Biggest Rescue Operation in Years in South Africa.
[422] Ansell, C., & Gash, A. (2008). Collaborative Governance in theory and Practice; Checkoway, B., et al, C., 2005. Youth participation in public policy at the municipal level.
[423] Cousins, B and Ruth H. 2011. Rights without illusions; Jacobs, P et al, 2003. Land redistribution, Evaluating Land and Agrarian Reform in South Africa.

majority party (the African National Congress). Local disputes are often affected by political party dynamics, creating a potentially volatile political environment. Given that municipalities are key role players, but are profoundly influenced by party politics, the scope for political influence (or impressions of political influence) looms large. Allegations of corruption and dysfunction within the community's governing bodies, such as the Communal Property Association, add to the discord.

At a deeper level, the protests are triggered by the style of intervention adopted by central and provincial government and other agencies. Typically, these proponents of new projects are technicist and task-oriented, focusing on the myriad technical details of these complex projects. Even when such projects proponents can credibly promise benefits such as jobs, their approach to the subject could be experienced as high-handed and excluding any real consensus-building.

Community members do not know whether to trust such "powerpoint styles of consultation", which may seem to be more of a glib public-relations exercise rather than a genuine give-and-take of ideas. The demand for the opportunity to imagine alternatives to the prepared script presented by government officials or corporations should be seen in this light. Thus far, policy documents pay lip-service to the need for public engagement. However, there is a lack of clarity on how this inclusion will be achieved. Effective community engagement requires a mind-set of genuine knowledge-sharing and problem-solving. "Knowing all the answers beforehand" is not a useful approach.

Technicists are often deeply uncomfortable in the messy world of opinion-sharing. For this purpose, a reputable agency which focuses on facilitation should be commissioned to participate in the entire planning and implementation process, and throughout the project life cycle.[424]. Such an agency would be able to facilitate the participation of the community members, and the give-and-take of ideas, in a way that does not obstruct technical decision-making. The relevant authorities (such as NCEDA) will need to be closely involved to listen and be genuinely responsive to community members' concerns. Win-win scenarios need to be explored in the Namakwa District generally and the Richtersveld area more specifically. There are numerous approaches available in different sectors, and it will require a team with experience in facilitation and mediation to manage the public engagement process. This has to be properly planned, institutionalised and funded by the Northern Cape Government.

In fact, effective community engagement is an asset, not only to identify potential conflicts and to allocate resources. It goes much further: The cohort of community leaders should be involved as much as possible in structured planning and decision-making. This takes time and courage, and is not an easy task. There may be issues on which a total and irrevocable conflict appears to emerge; but with sufficient engagement, such cases could be minimised. Even then, with creative thinking, some solutions may be found, either based on re-allocating budgets, changing spatial plans, establishing institutions, and creating new collaborative decision-making networks. Civil society organisations, such as a local chamber of commerce, a tourism forum, an agricultural association, a youth club, an environmental NGO or a heritage society can be coaxed into existence, to create platforms for meaningful exchanges of views, inputs and interests.

In principle, the Northern Cape Government has endorsed the importance of community engagement. The 2019 PDGP emphasises the requirement of inclusivity: "Development planning attempts, in principle, are to involve all those who are affected by it. Thus, integrated planning is in essence based on the principle of inclusivity.[425] The PGDP summarised the key interventions in the spatial planning sector, with community engagement included as an intrinsic element.[426] Significantly, it also emphasised the importance of facilitation change agents and NGOs in ensuring community development.

In the Boegoebaai context, the key drivers of such consultative processes must be the Northern Cape Government (NCEDA), with an overarching participatory plan; and as well as the new Port Authority and GH2 project management. The relevant municipalities need to be incorporated into high-level planning for the participatory process, to consider ways in which existing participatory structures (councillors, ward committees) and new fora (such as project site committees) can be used to structure public engagement.

[424] Borchardt, S. 2024. Shedding light on energy poverty: Household energy challenges in De Aar; Malope, B. 2024. A just transition in the Karoo?
[425] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 191.
[426] Northern Cape, 2019, Provincial Growth and Development Plan: Vision 2040, p. 194.

7.7.2 The difficult world of Community Property Associations (CPAs)

From the point of view of the proponents of Boegoebaai projects, effective consultations with affected community groups will be even further tested in the context of CPAs. The challenges facing Community Property Associations (CPAs) are multifaceted, because of a very long history of often inappropriate policies imposed by government authorities. The Richtersveld CPA, as the owner of the land earmarked for the Boegoebaai investments, is clearly a very important potential agency to engage.

Community Property Associations (CPAs) are pivotal in the development and management of land-based resources, especially within rural contexts. According to agricultural sector studies, CPAs are integral to the governance and sustainable use of communal land, as they oversee the management of common property, dispute resolution, and the fair distribution of benefits.

The Richtersveld community has already undertaken several court cases in the last few decades, thereby asserting a local identity and building confidence. During the 1980s, the South African state made a concerted effort to replace the system of communal tenure that has prevailed since the nineteenth century with various forms of individual tenure. People in several of the reserves, led by Leliefontein, took the state to court over this issue in the 1980. The experience that had been acquired in these instances stood the Northern Richtersveld people in good stead when the national park issue came to a head in the early 1990s.[427] This highlighted some of the fault lines in the Richtersveld community. When the park was set up, it was run by an authoritarian Management Committee. Local Nama residents, unhappy with this, formed their own Community Committee to resist the way the Management Committee handled the residents' interests. By 1991, the effectiveness of this peoples' group had increased, and they now play a major part in the management of the park, gaining the right to farm areas of the park's land, and increasing their standard of living and cultural identity.[428]

The history of the Richtersveld is particularly complex. It includes questions of land inheritance, dispossession and reclamation; Khoisan and Nama identity and culture[429]; mission history and the subsequent decline of these religious institutions; indigenous patterns of agriculture and controversial land tenure innovations; encroachment by diamond mines and white farmers; the in-migration of a group of "Baster" people in 1949 and their capture of the local Council; attempts by Government to impose grazing regimes; the shifting fortunes of migrant labour in the mines and elsewhere; the growing entrenchment of multiple livelihoods for local households; the changing class structures, particularly in the north and the south of Richtersveld; the complex local relationships of collaborating and reciprocity; the changing party-political and social identities of the residents[430]; and the establishment of the Richtersveld Park and the World Heritage Site.[431] This formidable list is just a superficial rendition of the complexity which underlies Richtersveld social organisation.

The Richtersveld Community Property Association (CPA) was formed after the community successfully pursued a land claim in 1998, that was finalised in 2007. This judicial decision recognized the community's traditional rights to land that had been taken during the apartheid era, particularly focusing on areas that had been used for mining, agriculture, and residential purposes. The restitution awarded significant land rights, including agricultural farms, the township of Alexander Bay, and mining areas, totalling 195,000 hectares. Winning this court case was far-reaching in its implications. Richtersveld Community and Others v. Alexkor Ltd and Another was the first case to consider whether aboriginal title is part of South African law. Aboriginal title means a proprietary interest in land recognized in common law jurisdictions such as Canada, the United States, Australia and New Zealand. It recognizes the prior occupation of those territories by aboriginal peoples before the arrival of settlers or colonization.[432] The developmental implications are immense.

The land restitution case in Richtersveld was a notable achievement for the CPA. In fact, compared to land restitution cases elsewhere, the Richtersveld CPA built a significant degree of social cohesion, and engaged

[427] Sharp, J and Boonzaier, E, 1994, Ethnic Identity as performance: lessons from Namaqualand.
[428] Boonzaier E.A. (1991) People, parks and politics.
[429] Sharp, J and Boonzaier, E, 1994, Ethnic Identity as performance: lessons from Namaqualand.
[430] Robins, S. 1997. Transgressing the borderlands of tradition and modernity: Identity, cultural hybridity and land struggles in Namaqualand (1980–94
[431] Boonzaier, 1987, From communal grazing to 'economic' units.
[432] Ulgen, O, 2002, Developing the doctrine of aboriginal title in South Africa.

fruitfully with Government and Alexcor.[433] This successful process was supported by NGOs and scholars – which sets an example of how complex technical negotiations can be managed in future.

The CPA's purpose is to manage the land and resources returned to the community, ensuring that it is used in ways that benefit all community members. The CPA is responsible for overseeing land management, economic development initiatives, and ensuring that resources are distributed equitably among the community. But this ostensibly straight-forward description of the role and purpose of the CPA is anything but straight-forward. In 1987, Boonzaier observed that "Management boards in many reserves (and, indeed, other decision-making bodies in other areas) are notoriously 'unrepresentative' and very often reflect only sectional interests".[434] Given the intractable challenges of social and economic issues in the communal areas, this is hardly surprising. Democratic representation is never easy, particularly in contexts of intense and multiple lines of contestation.

The implementation of the restitution settlement has been fraught with challenges, including internal conflicts, leadership disputes, and issues related to the management of land and resources. Disagreements over membership (originally there were 4 500 participants in the claim[435]) and the allocation of benefits led to court cases and disputes over governance structures. The High Court appointed a person to oversee its operations for a period.[436] There has been ongoing support from government agencies such as the Department of Rural Development and Land Reform (DRDLR), which has assisted in resolving disputes, managing membership lists, and ensuring that financial distributions are made to the community.[437]Efforts have been made to streamline the CPA's governance and improve communication with members, though the legacy of conflict and mistrust remains a significant challenge. The Richtersveld CPA has clearly gone through a process of organisational growth and maturing.

In the context of the Boegoebaai Green Hydrogen initiative, CPAs would be crucial in facilitating community-level engagement by acting as intermediaries between external developers and local communities. By involving CPAs in such projects, there is potential to create a structured platform for community members to voice concerns, participate in decision-making, and negotiate for fair benefits.[438] This involvement is essential to ensuring that development initiatives are inclusive, respect local governance structures, and align with the socio-economic priorities of the communities involved, ultimately promoting long-term sustainability and more equitable outcome.[439] There are also valid lessons to be learnt from Richtersveld's previous experiences with conflict management and negotiation, in the context of the Richtersveld Park, where mediators, facilitators, researchers and NGOs played a crucial role in finding common ground between seemingly intractable positions.[440]

However, CPAs face significant challenges, such as limited financial resources, inadequate technical expertise, and difficulties in attracting investment for large-scale projects, which can hinder their effectiveness. [441]

CPAs in Namaqualand face organisational difficulties. Understandably, these communities and farmers in one of the most remote parts of the world tend to have inadequate management and administrative skills among their committee members. Many members are elected based on popularity rather than competency, which is not surprising because trust is the essential element keeping under-resourced societies intact. Additionally, many CPAs struggle economically, relying on subsistence farming and lacking the operating capital needed for growth. They often face compliance burdens and may enter legal agreements without fully understanding their implications, risking their assets. Conflict can emerge among members where long-

433 EverinGH2am, M and Jannecke, C, 20026, Land Restitution and Democratic Citizenship.
434 Boonzaier, 1987, From communal grazing to 'economic' units, p. 488.
435 Everingham, M and Jannecke, C, 20026, Land Restitution and Democratic Citizenship.
436 Department of Government Communications. 2012. Department emphasises its commitment to Richtersveld Communal Property.
437 Department of Communications, 2012.
438 Walker, C, 2010, Land reform in Southern and Eastern Africa: Key issues for strengthening women's access to and rights in land.
439 Mnwana, S, 2021, Land struggles, class formation and social change in post-apartheid South Africa.
440 Glavovic BC 1996,Resolving People-Park Conflicts through Negotiation: Reflections on the Richtersveld Experience.
441 Hall, R, 2009. "Another Countryside? Policy Options for Land and Agrarian Reform in South Africa."

serving committees are resistant to holding elections, which heightens tensions between committee members and the broader community,[442]

The Richtersveld CPA has been accused of maladministration, with some members arguing that decisions regarding land use and community engagement are being made without proper consultation with the broader community. [443] These tensions are exacerbated by the lack of clarity about the potential benefits and risks of the proposed Boegoebaai investments. As the government continues to push for the project's development, these unresolved issues raise concerns about future community engagement and equitable benefits.

A pre-negotiation scoping should be undertaken by a reputable facilitator, to assess the ways in which each party to the discussions would prefer to participate. If necessary, some early obstacles may need to be addressed, such as people's time, resources, and general background information. The parties should each establish a trusted relationship with such a facilitator.

The effective functioning of the CPA may require a sustained and funded process of government support (from provincial level), with experienced and skilled facilitators, on a medium-term contract. Given the workload already with the provincial COGTA, one possibility is that this task be managed from the Premier's office, either directly, or through NCEDA. This would leave COGTA to focus on municipal support. The likely implementation of the Boegoebaai projects will make such interventions imperative.[444]

7.7.3 The Problem-driven Iterative Adaptation (PDIA) approach

The expansion of green hydrogen and other renewable energy initiatives in the Namakwa District Municipality has led to increased interactions between local communities, government agencies, and private investors. While these interactions offer opportunities for mutual benefit, they also present risks of exclusion, displacement, and unequal distribution of resources. New institutional mechanisms can foster cooperation and mitigate conflicts, with a particular focus on community-government partnerships, public-private collaborations, skills development programmes, multi-stakeholder land-use planning, and financial benefit-sharing models.

The (PDIA) approach to sustainable development emphasises adaptive problem-solving, stakeholder-driven decision-making, and continuous learning. This approach is also recognised in the *Provincial Growth and Development Plan* for the Northern Cape as a key tool for driving development in the region. The PDIA strategy "begins with generating locally nominated and prioritised problems and works iteratively to identify customised 'best fit' responses… in the process working with an expanding community of practice to share and learn at scale."[445]

The PDIA approach also encourages the state to ask four critical questions: "What drives action? How is action identified and carried out? What authority or leadership is required? Who needs to be involved?"[446] PDIA offers a flexible and adaptive methodology for addressing complex policy and organisational challenges.[447] Unlike rigid, pre-planned solutions, PDIA focuses on learning through experimentation and local adaptation to tackle "wicked" problems.[448]

Key Features of PDIA are:

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442 Cousins, B. & Hall, R. (2011) Rights without Illusions.

443 Human, L. 2024. Green hydrogen mega-project stokes community fears.

444 This point was added in response to public comments.

445 Andrews, M., Pritchett, L. & Woolcock, M. J. V. 2017. *Building State Capability: Evidence, Analysis, Action*, p. 5.

446 Northern Cape Province, 2019, *Provincial Growth and Development Plan,* p. 160.

447 Samij, Andrews, Pritchett and Woolcock, 2018, Samji, S., Andrews, M., Pritchett, L. and Woolcock, M. (eds.). 2018. *PDIA Toolkit – A DIY Approach to Solving Complex Problems*.

448 The term "wicked problem" refers to complex social issues that are poorly defined, involve conflicting values among multiple stakeholders, and have confusing consequences across the system. The term "wicked" highlights the tricky nature of these problems, where solutions often worsen the situation rather than resolving it (Lönngren, and van Poeck, 2020).

- Locally Defined Problems: PDIA starts with identifying and prioritising challenges as defined by local actors, ensuring relevance and ownership.
- Iterative Experimentation: Solutions emerge through repeated trial and error, rather than relying on predefined blueprints. Each iteration refines the approach, drawing lessons from past efforts.
- Authorising Environment: PDIA fosters a governance environment that encourages innovation and risk-taking, rather than strict compliance with static plans.
- Broad Participation: Engaging diverse stakeholders ensures that solutions are politically viable, legitimate, and sustainable.
- Maintaining motivation is crucial—leaders and implementers must stay engaged by continuously seeing the value of their efforts.
- Complex challenges require flexibility, cross-disciplinary engagement, and adaptive problem-solving.

PDIA recognises that development is not a linear process but rather a continuous journey of discovery and adaptation. People's views may change somewhat during the consultation process. Communities may well have mixed feelings, in two senses: Firstly, communities may be divided: Some people may support the project (e.g. for jobs) and others may oppose it (e.g. for heritage conservation). Secondly, individuals may have their own mixed feelings about it, e.g. appreciate the advantages of possible jobs and training, while also worried about the impacts on the local economy. After an in-depth consultation process, in which the potential advantages can be identified and strengthened, and the potential dangers identified and possible mitigation strategies considered, community members may come to different insights. People who were initially opposed to the projects may develop a cautious support of them; and those who initially supported the projects may become more concerned. This is a fluid process of evaluation and adjustment, which should be captured in the public consultation process. Eventually, however, democratically elected governments (national, provincial and municipal) need to make a decision, one way or the other, presumably while keeping their residents' feelings firmly in their mind.[449]

It is unrealistic to expect that a consensus will be reached at stakeholder level. There will be community members who are in favour of new opportunities, and are not put off by potential risks; there will be others who will want to protect the status quo, or to send development trajectories in other directions (e.g. heritage tourism or eco-tourism). These are legitimate positions on the likely *continuum* of views. It is impossible to predict either the ultimate views of community members, or the decisions of democratic authorities regarding the merits of proceeding with these projects. The Richtersveld CPA's role as custodians of the land clearly gives their views great importance, but it is quite likely that the members of the CPA (at all levels) will be divided on the merits of the Boegoebaai projects. The best one can probably hope for is to achieve "sufficient consensus", with as many proactive steps to address the concerns that people may have. What is quite unclear will be the outcome of the CPA and the Richtersveld LM fundamentally disagreeing about the way forward. Such an eventuality will test the creativity of the facilitator to find some points of agreement, and to present them to Government for a final decision.[450]

PDIA is not a one-size-fits-all solution but a strategic mindset that empowers policymakers, organisations, and reformers to navigate uncertainty, build state capability, and foster meaningful change. [451] Instead of implementing large, rigid interventions, PDIA focuses on trialling small solutions, learning from what works, and scaling up effective strategies. For example, In Richtersveld, a pilot project could explore how local businesses and cooperatives might supply services to the Boegoebaai project, rather than large external contractors.

As a complement to the PDIA approach, the "Sustainable Livelihood Analysis" (SLA) can be developed to focus on the capacities and strengths of the local communities.

[449] This point was included in response to the public review process.
[450] This point was included in response to the public review process.
[451] Northern Cape Government, 2016, *Provincial Growth and Development Plan,* p. 16, 63.

7.7.4 The Green Hydrogen Community Development Toolkit

The *Green Hydrogen Community Development Toolkit* (July 2023) is a guide for project developers in the green hydrogen sector, providing a structured approach to community development. It draws on the mining sector's Community Development Toolkit to address green hydrogen's specific socio-economic and environmental challenges.[452] Significantly, this helps companies secure a "social license to operate" (SLO) by ensuring meaningful local participation.

The toolkit is divided into five phases, each with specific tools for project implementation:

- Preparation/ Getting Companies Ready – Ensuring companies have the necessary competencies and management systems in place.
- Relationships – Stakeholder identification, analysis, and engagement strategies.
- Planning – Community mapping, institutional analysis, and impact assessments.
- Programme Implementation – Development of action plans, conflict resolution mechanisms, and local economic investment strategies.
- Monitoring, Evaluation and Learning – Developing indicators and log frames for assessing project success and community impact.

The toolkit is not meant to be used sequentially from Tool 1 to Tool 5, as some tools overlap and using them all at once can overwhelm both the project team and the community. A more effective approach is to remain flexible, selecting tools that align with the project's current objectives and phase of development.

Stakeholders have varied needs and preferences regarding participation. There should be different ways in which people can engage - whether they prefer to receive information, be involved in meetings, actively contribute to planning, or take part in monitoring and development programs. Establishing Stakeholder Advisory Committees will ensure that historically marginalised voices are represented in decision-making. Digital engagement tools, such as WhatsApp groups, SMS alerts, and local radio, can reach communities with limited access to traditional public meetings.

A Social Impact and Opportunity Assessment (SIOA) is an essential tool for evaluating the social impacts and opportunities of a project. It helps update or establish baseline social data, particularly when no baseline study has been conducted. The SIOA assesses potential impacts, identifies development opportunities, and collects data for monitoring and evaluating specific projects. It also facilitates engagement among stakeholders, including marginalised groups like women, to share views and build consensus on the project's impacts. Conducting SIOAs periodically, especially during key project stages such as construction or closure, is essential to track changing social dynamics and ensure the project remains responsive to community needs.

Community Environmental Monitoring Boards, composed of trained local representatives, can oversee compliance with environmental standards. Dispute Resolution and Grievance Mechanisms must be clear, fair, and transparent to maintain good relations between developers and communities. Participants can draft and implement legally binding Community Benefit Agreements (CBAs) to guarantee that commitments made to local communities are honoured and upheld.

To ensure that green hydrogen projects continue to deliver tangible benefits to local communities, it is essential to establish mechanisms for long-term monitoring and adaptive management. These strategies promote sustainable development by providing ongoing oversight and facilitating adjustments to projects as needed. The following approaches are useful for achieving effective long-term success:

- Conducting independent third-party evaluations to assess social and economic impacts.
- Integrating adaptive management strategies, allowing policies and project operations to evolve based on feedback and changing socio-economic conditions.

[452] Wesso, R and Brandt, F (2023). Beneficial Technologies (Bentec) Green Hydrogen Community Development Toolkit.

- Developing community-led monitoring programmes, where local stakeholders play an active role in tracking project outcomes and holding developers accountable.
- Appoint independent watchdog organisations to audit municipal spending and project compliance.
- Require that a percentage of project revenues be reinvested into local infrastructure, including roads, clinics, and water systems. This model aligns with large-scale renewable energy projects, which are mandated to contribute to socio-economic and enterprise development. Important lessons have already been learnt from community development efforts by renewable energy companies in South Africa.[453]
- Implement anti-corruption safeguards, including third-party monitoring of financial transactions related to community benefit programmes.

Incorporating these strategies will help create a framework for continuous improvement, ensuring that the projects remain responsive, sustainable, and beneficial to local communities over the long term. These approaches not only contribute to the success of individual projects but also provide valuable lessons for future renewable energy initiatives in similar contexts.

7.7.5 Free, Prior and Informed Consent (FPIC)

In the mining sector, painful experience of destructive relationships between mines and communities has led to a refinement of what "free, prior and informed consent" actually means. This is particularly relevant to indigenous groups who may be impacted by large investments.[454] For IRMA, FPIC is not simply an isolated tool of engagement. It is part of a broad suite of normative principles, affecting all aspects of mining investments:

FPIC is based on a recognition that indigenous peoples have the right to self-determination, including their political status, and their economic, social and cultural development. They have rights to property, culture, and religion and natural resources, including sacred places and objects. They have rights to health and physical well-being, in relation to a clean and healthy environment; to pursue their own priorities for development; and to make authoritative decisions about external projects or investments.

In terms of this framework, communities have strong rights: "If indigenous people's representatives clearly communicate, at any point during engagement with the operating company, that they do not wish to proceed with FPIC-related discussions, the company shall recognize that it does not have consent, and shall cease to pursue any proposed activities affecting the rights or interests of the indigenous peoples. The company may approach indigenous peoples to renew discussions only if agreed to by the indigenous peoples' representatives".

In terms of consultation procedures, the framework provides robust suggestions to promote constructive engagements:

- Identify the appropriate means of engagement for each group of indigenous peoples (thereby implying that different groups may prefer different modes of engagement)
- Identify indigenous people's rights and interests that may be affected by the proposed activities (this should be a joint exploration of what the community's key concerns are)
- Identify additional studies or assessments needed to determine the range and degree of potential impacts on indigenous people's rights or interests (the parties can jointly decide to engage researchers or investigators who can provide new information or insights)

[453] Borchardt, S.P., 2023. Illuminating Energy Poverty; Malope, B. 2024. A just transition in the Karoo?

[454] These FPIC standards have been developed by The Initiative for Responsible Mining Assurance (IRMA). IRMA is a coalition of NGOs, affected communities, purchasers, investors, mining companies, and labor unions. Each sector has equal voice in IRMA governance. IRMA's ultimate goal is for mines to leave **positive legacies.** https://responsiblemining.net/wp-content/uploads/2022/04/FPIC_IRMA-Community-Toolkit_21Sept27.pdf; https://responsiblemining.net/what-we-do/standard/.

- Identify if there are capacity issues that may prevent full and informed participation of indigenous people (the company shall provide funding or facilitate other means to enable the local people to address capacity issues in their preferred manner; this could include technical workshops, demonstrations, site visits, and other joint learning exercises)

- Ensure that the community as a whole has meaningful opportunities to be involved in these processes (there is a danger that representatives may become, or become seen as, "co-opted" by the project imperatives).

In the mining sector, mines can obtain IRMA certification that it has undertaken these measures.

These guidelines point to important procedural requirements, which will be challenging and onerous. They may also be interesting and rewarding, for all parties concerned, if approached in the right spirit. But the challenges are not simply procedural ones. There are three critical possibilities which raise profound philosophical issues.[455] Firstly, what would be the future of the Port and the GH2 complex if the Richtersveld CPA decides that – after due reflection – it would like to preserve its pristine environment with all its symbolic significance, and would prefer that the entire project is cancelled?[456] Can (or should) the Richtersveld community block a large investment which could have major beneficial implications for investors, work-seekers, employers, government agencies and other citizens in the region?

Secondly, what would be the status of a CPA objection to the project, if it is unclear that they do not represent *all* the Richtersveld residents? A minority of residents may well be enthusiastic about the potential benefits of the Boegoebaai project.

Thirdly, if the Richtersveld CPA were to block the investment project, their descendants (or young residents, who are not old enough to debate or to vote) may, in future, regret that turn of events. The CPA does not only speak for the current adult community (many of whom are elderly and have no prospect of getting jobs at Boegoebaai). They must also speak for the young generation, who may have important desires for material benefits, modernisation and career options. Whose voice should prevail?

With FPIC, the key challenge is to enable "informed consent", i.e. that local people have enough information to debate the advantages and disadvantages of the projects. This would require an iterative process of consultation, i.e. not simply a once-off procedure. As community representatives engage with these alternatives, their observations will affect other community representatives; who then need to apply their minds to these fresh insights. This is a lengthy process, and should be done with the utmost openness, transparency, inclusiveness, and good faith. Anything short of such an approach would create the danger and perception that Government rushed the project without a proper appreciation of local communities' sentiments. On the other hand, there should also be some time limit on the consultation process (it should not be endlessly extended), so that democratic governments can finally take a decision on both the project in principle, as well as possible amendments which arose in the process of public consultation.[457]

At this point, the chemistry of consultations may have to be utilised over and over again, to find some point of agreement as a bedrock for future collaboration. These questions illustrate the point that community negotiations are not simply procedural niceties. They are about absolute bedrock values. The challenge is to find ways to match up those bedrock values, and to see if there are potential constructive overlaps. South Africa has proven its ability for compromise and pragmatism. Our skill lies in finding compromises before potential benefits become derailed.

[455] See Barry, M, 2004, Now Another Thing Must Happen: Richtersveld and the Dilemmas of Land Reform in Post-apartheid South Africa.

[456] Note that such negotiations among proponents should not be interpreted as being insensitive to the Richtersveld community. It simply illustrates that any investment proposition requires a lot of conceptual spadework before it can be floated as a meaningful idea. This is quite compatible with a still-to-ensure public consultation and engagement process.

[457] This point was included in response to the public reviewer process.

7.7.6 Conclusion: Positive legacies or a "sacrifice zone"?

Marginalised areas engage with new projects from the standpoint of a power deficit. Impressive new infrastructural and technical projects can be "rushed through" despite local communities' concerns and objections. But there is a real danger that Richtersveld may become a "sacrifice zone"[458] – an area disproportionately burdened with environmental, social and economic harm due to large-scale industrial projects. The Boegoebaai project does not have to fall into this trap. There are many potential benefits, from South Africa as a nation to Richtersveld as a remote community. But this will require effective engagement, in good faith, using well-tried facilitation skills to open up communication channels.

7.8 RISK ASSESSMENT

This risk assessment includes BOTH the Green Hydrogen project and the Port, as they are being planned together.

Mitigation efforts would have to be planned and co-ordinated by an inclusive regional strategic planning and management team. In the case of the Boegoebaai projects, mitigation efforts may also take the form of **CSI investments.** The most effective form of mitigation efforts will be those that are the result of community participation, buy-in and active support. The umbrella term *"management"* refers to efforts to mitigate risks as well as respond positively to opportunities.

In this very complex socio-economic analysis, it is challenging to outline all the potential risks and opportunities. Methodology is impressionistic at this stage, given that this is a broad-scope analysis. Specific project-related decisions would have significant impact on the risks and opportunities. The purpose of the risk and opportunity assessment is not to achieve exact findings, but to guide policy makers and programme managers about the likely scale of trade-offs that should be investigated as part of their planning processes, and through-out construction and operations.[459]

With each variable, there is a wide margin of error regarding uncertainty (e.g. different policy choices by municipalities), implementation failure (on the part of private companies or governments) or uneven benefit distribution (e.g. due to different types of responses by local communities to work and training opportunities). Each variable could have been analysed in much greater detail, and this must be done at a finer-grain stage of planning (e.g. if the project is improved in principle, and different sectoral agencies gear up to assess the implications for their particular mandate). The SEA is a higher-order analytical instrument, which will be available to guide sectoral experts in their more detailed scoping and analysis.[460]

Scenario 0 considered the level of government functionality as similar to current levels (i.e. facing difficulties, particularly in the Richtersveld). This raises the possible worst-case scenario: That the presence of the projects create such pressure on local municipalities, political parties, and agencies such as police and health that there is a virtual collapse of services, possibly accompanied by profound political conflict. A *further decline in institutional capacity* scenario was not considered, because one can assume that the presence of the projects will focus national and provincial attention on this region in a way never before experienced, and this would presumably work to undergird the current local government system.[461]

There are often problems of unintended or unanticipated consequences, which will require conscientious and responsive management interventions. However, we can list the most obvious risks and opportunities:

Risks:

1. Rapid "boom" conditions will bring destabilising impacts in the economy and society.

[458] A **sacrifice zone** refers to an area that is disproportionately burdened with environmental, social, and economic harms due to industrial or development activities, such as pollution or displacement, are borne by vulnerable and marginalised communities (Juskus, 2023, Sacrifice Zones).

[459] This point was included in response to public reviewer comments.

[460] This point was included in response to public reviewer comments.

[461] This point was included in response to public reviewer comments.

2. Disaster management capabilities may be insufficient and have to be expanded.
3. Road-based ore transport will hold major dangers for communities, road users, agriculturalists, and the tourism industry, and the construction of a railway line for ore transport will be imperative.
4. Ore-based dust at the airport would be a major problem for agricultural exports.
5. Construction transport will place pressure on local district roads.
6. In-migration of work-seekers and workers may crease social instability.
7. Local prices of goods and services are likely to increase, and this may be beyond the purchasing power of local people.
8. Housing shortages are likely to worsen in the short term, due to in-migration.
9. Industrialisation and increased traffic pressures would detract from the sense of space, remoteness and rich biodiversity of the region.
10. The port could promote copper exports.
11. Municipalities would face significant pressure to cope with developmental and planning challenges associated with the projects.
12. A major process of public consultation needs to be undertaken by effective and known specialists, able to manage a very delicate process effectively.
13. New systems of intersectoral and intergovernmental regional planning in the SEZ can promote economic development in the area.

Opportunities:

1. Job creation in the transport and green energy sector will expand rapidly, at all skills levels.
2. Property values are likely to increase.
3. Economic multipliers in the region will be stimulated, and small businesses may benefit from new opportunities.
4. Telecommunications will be improved significantly to the entire region.
5. The GH2 development may increase energy security for farmers, municipalities and households in the region, if renewable energy facilities are oversized and electricity grids expanded / strenghtened.
6. The GH2 development may make new water sources available to local communities, if desalination facilities are oversized.
7. The Port and GH2 projects will entail improved health services in the region, including hospitals, ambulances and specialised health care.
8. The Boegoebaai port could become a tourist destination in its own right.
9. The Boegoebaai projects could be stimulus for an expansion of the Springbok airport, to offer scheduled flights, which would, in turn, stimulate tourism and business in the region.
10. Erstwhile Namaqualand residents, especially skilled people who are now living elsewhere, may return to the region to participate in these projects

The following table provides a breakdown per locality and per intensity of risks and opportunities:

Theme	NEGATIVE CONSEQUENCES (RISKS)				
	Slight	Moderate	Significant	Drastic	Extreme
Population growth	In-migration of a few professional people and artisans	In-migration of some professional people, artisans and manual workers	In-migration of substantial numbers of professional people, artisans, manual workers and family members of working people	Rapid influx of large numbers of professional people, artisans, manual workers, family members, new businesses, and work seekers	Influx of people which is greater than housing or infrastructure can manage; some informal settlements develop
Housing and municipal services	Some pressure on existing facilities, but still within existing ability of local communities to cope with demand	Substantial pressure on existing facilities, and some price increases in rentals	Rapid and sustained demand for housing, water, electricity and sanitation, significant increase in rentals, and local people enter the rental market, tourism accommodation booked out by professional and technical staff; tourism starts declining	Strong demand for housing, increased rentals, no tourism accommodation available and therefore decline in tourism activities	Heavy pressure on available housing, rental prices increase significantly, new formal and informal structures built to accommodate new-comers, infrastructure not adequate to cope with demand.
Health services	Slight pressure on existing clinics and hospitals	More demand for medical services; waiting times at state facilities increase; some private doctors attracted to the area	Rapid increase in demand for medical services at hospitals and clinics; ambulance services have to be introduced for specialised referrals and workplace accidents; more private sector professionals enter the area; increased HIV/AIDS services required	Substantial increase in demand; and upscaling of medical services required, which takes time and cannot keep up with demand; increased HIV/AIDS services required	Constant heavy pressure on facilities, outweighing the ability of state facilities to cope timeously with cases; private sector becomes major player to cope with work-place health needs
Social ills in boomtowns	In-migration of professionals lead to local people engaging in petty crime and attacks on property	In-migration of workers and work-seekers cause an increase in prostitution, teenage pregnancies, crime	Rapid in-migration of staff, workers, and work-seekers cause prostitution, teenage pregnancies, noise, crime and increased sense of insecurity	Increased crime and sense of insecurity lead to alienation and anonymity, disintegration of some families due to social habits of workers and work-seekers, established local people start leaving the area	Crime intensifies significantly; general sense of insecurity; social pathologies become prevalent (teenage pregnancies, school drop-outs, petty crime, property crime), more local people leave the area causing

					further fraying of the social fabric
Tourism	Some in-migration of professionals and artisans create pressure on tourism accommodation	Tourism accommodation increasingly difficult to find; accommodation prices escalate; traffic and petty crime escalate and detract from tourist enjoyment	Local ambience changes; accommodation facilities largely utilised by project staff; traffic and crime intensify; local towns' reputation start to suffer	Major disruption due to construction, heavy traffic, and crime; guest houses now exclusively cater for project staff; tourists reduce time spent in the area	The towns are now industrial hubs, and unsuitable for tourism
Agriculture	Some increase in traffic causes pressure on roads for agricultural trucks	Traffic increases and roads increasingly unsafe; some pollution and dust caused by ore trucks and other vehicles.	Some ore dust exposure - Ore trucking impacts on high-value agricultural export commodities; Traffic becoming unsafe	Ore dust exposure increases due to larger number of ore trucks; air pollution along highways; traffic and transport increasingly unsafe	Ore dust at the port makes agricultural exports impossible; agricultural producers resort to markets in Western Cape, and find other routes to avoid heavy traffic pressure.
Municipal capacity - technical	Some additional workload for municipal technical staff due to in-migration of some project staff	Technical staff confronted with issues they are not trained for; consultants brought in as advisers, new vehicles required	Technical and professional staff inadequate for rapid planning and maintenance challenges; new posts have to be created and staffed; more technical equipment and vehicles required	Rapid escalation of technical demands; more new posts have to be created, salaries have to be increased to attract professionals from elsewhere; more technical equipment and vehicles required; increasing pressure on municipal budgets	Municipalities under severe strain as planning challenges and maintenance problems escalate rapidly; staff have to be seconded from city municipalities; additional consultants required; more jobs have to be created; strong pressure on municipal budgets.
Municipal Governance and Public participation	Local people become aware of challenges and make their voices heard; ward committees and councillors still capable of engaging with new challenges	Increasing local concerns place more pressure on councillors; municipalities have to create posts for public engagement	Strong pressure for timeous community engagement, local political conflicts emerge, some issues become politicised	Increasing social and economic problems lead to local dissatisfaction and concerns; councillors and staff have to spend significant time creating new platforms to engage with citizens	Negative reports escalate in local and regional media; councillors and staff spent much time engaging with residents; problems become more complex and difficult to solve; politicisation leads to new political formations and conflict on councils, with electoral impacts

	POSITIVE CONSEQUENCES (OPPORTUNITIES				
	Slight	Moderate	Significant	Drastic	Extreme
Job creation	Jobs are created for some professionals and artisans	Increasing demand for professionals, artisans and labourers	Strong demand for workers in all categories, particularly construction, salaries increase, some local technical training services	Strong demand for skilled workers, local training services improve, new graduates find work on the projects	Large number of jobs in all categories, better paid jobs, stable employment, creates inequalities in the community, large-scale local technical training established
Tourism	Slight increase in tourism due to curiosity factor; some business tourism for the Boegoebaai projects	More tourists arrive due to curiosity factor; more business tourism involving professionals, some from overseas countries	More pressure on tourist accommodation leads to increased supply of accommodation (however, this is counteracted by problems such as crime, traffic and social ills)	Rapid expansion of accommodation services brings some curiosity factor tourism; tourism sector mainly relies on business tourism	The port and GH2 projects become tourist sites and offer educational tours; business tourism remains strong
Skills development	Some training improvements at existing TVET college	More demand for technical jobs (from projects and work-seekers), additional training provided by private trainers	TVET college expands offerings; more private training services offered	TVET college established near project site, increased access to technical training for local people	Local TVET college expands and offers increasingly sophisticated courses to meet demand of projects as well as spin-off businesses
Telecommunications	Slight improvements in existing infrastructure	Introduction of fibre to main centres and project site	Expansion of fibre to more towns near main centres and project site	Expansion of wifi telecoms to outlying villages	Almost complete saturation of wifi in Namaqualand towns and villages

Impacts can be very different, if there is a concerted attempt to anticipate, pre-empt and manage risks. This can be done in effective or less-than-effective ways, and it will depend significantly on the focus, energy, creativity and sustained work of management agencies – as well as their responsiveness to key stakeholders. In sum, management interventions can affect both the likelihood and severity of risks. (In fact, there may be cases where negative outcomes may be turned in the direction of positive developments; or vice versa, where the likelihood of positive development may be undermined and even become a risk, if managers are lax or do not understand issues adequately).

Corporate social investment is one way of either reducing risks or amplifying potential benefits. In the table below, "with management" refers to either of these possibilities.[462]

A risk analysis is a high-level analytical method for policy makers and programme planners to create a conceptual "dashboard" of likely negative or positive outcomes, and therefore potential areas of intervention. Significantly, there has been very little community participation at this stage, and such a risk/opportunity matrix *may well need to be adapted* (possibly several times) after such a robust engagement process has begun.

In the tables below, "S0" (S Zero) refers to the current baseline situation, with no investment taking place. "S1" refers to a small Green Hydrogen Project, as well as the establishment of the Port. "S2" refers to a large Green Hydrogen Project, alongside the Port.

The areas are described in the most impacted area (Port Nolloth and Alexander Bay); then the Springbok area (which is further afield, but is the main economic centre in the region); the much larger SEZ area (stretching as far as Aggeneys); and finally, the rural villages around Port Nolloth, which will experience their own distinctive impacts.

In the Risk Analysis, the Risk is a composite of Extent of Impact ("Consequence"), and the Likelihood of Impact. If a potential Risk Impact is very low, with slight likelihood, then of course it will carry a Very Low Risk. In contract, if a Risk Impact is very high, and it is almost certain to happen, then the Risk is High. The same logic applies to potential positive outcomes, called "Opportunities".

These Risk outcomes are marked in different colours, ranging from light yellow (very low risk) to dark brown (very high risk). The potential Opportunities are colour-coded in green, ranging from light green (very small potential opportunity) to dark green (very likely and very impactful potential opportunity).

Note that these Risk/Opportunity are very high-level comparisons, without specific details provided. "Housing", for example, could include a range of risks and opportunities. This table does not examine the various components of each Risk or Opportunity.

[462] For this reason, we refer to "risk management" instead of "risk mitigation". Management refers to potential positive and negative outcomes, whereas "mitigation" refers to minimising *negative* outcomes.

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Population shifts	S0: Baseline	Port Nolloth, Alexander Bay	Very low	Slight	Very low	Very low	Slight	Very low
	S1: Small GH2 (and Port)		High	Definite	High	High	Definite	High
	S2: Big H2 (and Port)		High	Definite	High	High	Definite	High
	S0: Baseline	Springbok area	Very low	Slight	Very low	Very low	Slight	Very low
	S1: Small GH2		Slight	Likely	Moderate	Slight	Likely	Moderate
	S2: Big H2		Moderate	Likely	Moderate	Moderate	Likely	Moderate
	S0: Baseline	SEZ area	Moderate	Likely	Moderate	Moderate	Likely	Moderate
	S1: Small GH2		Moderate	Likely	Moderate	Moderate	Likely	Moderate
	S2: Big H2		Moderate	Likely	Moderate	Moderate	Likely	Moderate
	S0: Baseline	Rural settlements	Very low	Slight	Very low	Very low	Slight	Very low
	S1: Small GH2		Very low	Slight	Very low	Very low	Slight	Very low
	S2: Big H2		Very low	Slight	Very low	Very low	Slight	Very low

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Pressure on housing and municipal services	S0: Baseline	Port Nolloth, Alex Bay	Moderate	Unlikely	Low	Slight	Unlikely	Low
	S1: Small GH2 & Port		Significant	Definite	Moderate	Moderate	Likely	Moderate
	S2: Big H2 & Port		Drastic	Definite	Very high	Moderate	Likely	Moderate
	S0: Baseline	Springbok area	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S2: Big H2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S0: Baseline	SEZ area (Pofadder)	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Slight	Likely	Low	Slight	Very unlikely	Very low
	S2: Big H2		Slight	Likely	Low	Slight	Very unlikely	Very low
	S0: Baseline	Rural settlements	Slight	Unlikely	Low	Very low	Unlikely	Low
	S1: Small GH2		Slight	Unlikely	Low	Very low	Unlikely	Low
	S2: Big H2		Slight	Unlikely	Low	Very low	Unlikely	Low

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Pressure on health services	S0: Baseline	Port Nolloth, Alex Bay	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Significant	Definite	Very high	Moderate	Likely	Moderate
	S2: Big H2		Drastic	Definite	Very high	Moderate	Likely	Moderate
	S0: Baseline	Springbok area	Low	Unlikely	Very Low	Slight	Very unlikely	Very low
	S1: Small GH2		Low	Unlikely	Very Low	Slight	Very unlikely	Very low
	S2: Big H2		Low	Unlikely	Very Low	Slight	Very unlikely	Very low
	S0: Baseline	SEZ area	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Significant	Likely	Moderate	Slight	Very unlikely	Very low
	S2: Big H2		Significant	Likely	Moderate	Slight	Very unlikely	Very low
	S0: Baseline	Rural settlements	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S2: Big H2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Social ills due to boomtown conditions	S0: Baseline	Port Nolloth, Alex Bay	Moderate	Likely	Moderate	Moderate	Unlikely	Low
	S1: Small GH2		Moderate	More Likely	High	Moderate	Unlikely	Moderate
	S2: Big H2		Moderate	More likely	High	Moderate	Likely	Moderate
	S0: Baseline	Springbok area	Slight	Likely	Low	Slight	Unlikely	Very low
	S1: Small GH2		Slight	Likely	Low	Slight	Unlikely	Very low
	S2: Big H2		Slight	Likely	Low	Slight	Unlikely	Very low
	S0: Baseline	SEZ area	Moderate	Likely	Moderate	Slight	Unlikely	Very low
	S1: Small GH2		Moderate	Likely	Moderate	Slight	Unlikely	Very low
	S2: Big H2		Moderate	More likely	High	Moderate	Likely	Moderate
	S0: Baseline	Rural settlements	Slight	Likely	Low	Slight	Unlikely	Low
	S1: Small GH2		Slight	Likely	Low	Slight	Unlikely	Very low
	S2: Big H2		Slight	Likely	Low	Slight	Unlikely	Very low

Negtive & positive impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk /Opportunity	Consequence	Likeli-hood	Risk
Tourism (includes ore rail transport as key managemnet option)	S0: Baseline	Port Nolloth, Alex Bay	Significant opportunity	More likely	Opportunity: Moderate	Significant	More likely	Opportunity: High
	S1: Small GH2		Significant	Likely	Very high	Moderate	Likely	Moderate
	S2: Big H2		Drastic	Definite	Very high	Significant	More likely	High
	S0: Baseline	Springbok area	Significant opportunity	More likely	Opportunity: Moderate	Significant	More likely	Opportunity: High
	S1: Small GH2		Slight	Likely	Very high	Slight	Unlikely	Moderate
	S2: Big H2		Slight	Likely	Very high	Slight	Unlikely	Moderate
	S0: Baseline	SEZ area	Slight opportunity	Unlikely	Opportunity: Low	Slight	Likely	Opportunity: Low
	S1: Small GH2		Slight	Likely	Very high	Slight	Unlikely	Moderate
	S2: Big H2		Slight	Likely	Very high	Slight	Unlikely	Moderate
	S0: Baseline	Rural settlements	Moderate opportunity	Likely	Opportunity: Low			Opportunity: Moderate
	S1: Small GH2		Slight	Likely	Moderate	Slight	Unlikely	Moderate
	S2: Big H2		Slight	Likely	Moderate	Slight	Unlikely	Moderate

Negative & positive impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk/Opportunity	Consequence	Likelihood	Risk
Export Agriculture (includes railway as management option)	S0: Baseline	Port Nolloth, Alex Bay, Orange River	Significant	Likely	Opportunity: Moderate	Significant	More likely	Opportunity: High
	S1: Small GH2 (PORT)		Drastic	More likely	Risk: Very high	Slight	Unlikely	Very low
	S2: Big H2		Drastic	More likely	Risk: Very high	Slight	Unlikely	Very low

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Municipal capacity - technical	S0: Baseline	Port Nolloth, Alex Bay	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Drastic	More likely	High	Moderate	Likely	Moderate
	S2: Big H2		Drastic	More likely	High	Moderate	Likely	Moderate
	S0: Baseline	Springbok area	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S2: Big H2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S0: Baseline	SEZ area	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S2: Big H2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S0: Baseline	Rural settlements	Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low
	S2: Big H2		Moderate	Unlikely	Low	Slight	Very unlikely	Very low

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Municipal capacity - political engagement and facilitation	S0: Baseline	Port Nolloth, Alex Bay	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Extreme	Very likely	Very high	Moderate	Likely	Moderate
	S2: Big H2		Extreme	Very likely	Very high	Moderate	Likely	Moderate
	S0: Baseline	Springbok area	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S2: Big H2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S0: Baseline	SEZ area	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S2: Big H2		Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S0: Baseline	Rural settlements	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2	Extreme	Very likely	Very high	Moderate	Moderate	Likely	Moderate
	S2: Big H2	Extreme	Very likely	Very high	Moderate	Moderate	Likely	Moderate

Pos impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Job creation	S0: Baseline	Port Nolloth, Alex Bay	Slight	Very unlikely	Very low	Slight	Very low	Very low
	S1: Small GH2		Moderate	Definite	Very high	Extreme	Definite	Very high
	S2: Big H2		Moderate	Definite	Very high	Extreme	Definite	Very high
	S0: Baseline	Springbok area	Slight	Very unliekly	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	More likely	High	Significant	More likely	High
	S2: Big H2		Significant	More likely	High	Significant	More likely	High
	S0: Baseline	SEZ area	Slight	Very low	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	More likely	High	Significant	More likely	High
	S2: Big H2		Significant	More likely	High	Significant	More likely	High
	S0: Baseline	Rural settlements	Slight	Very unlikely	Very low	Slight	Very unlikely	Very low
	S1: Small GH2		Moderate	More likely	High	Significant	More likely	High
	S2: Big H2		Significant	More likely	High	Significant	More likely	High

Neg impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Skills development	S0: Baseline	Port Nolloth, Alex Bay	Slight	Unlikely	Very low	Slight	Unlikely	Very low
	S1: Small GH2		Moderate	Likely	Moderate	Drastic	More likely	High
	S2: Big H2		Moderate	Likely	Moderate	Drastic	More likely	High
	S0: Baseline	Springbok area	Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S1: Small GH2		Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S2: Big H2		Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S0: Baseline	SEZ area	Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S1: Small GH2		Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S2: Big H2		Moderate	Unlikely	Low	Moderate	Likely	Moderate
	S0: Baseline	Rural settlements	Slight	Unlikely	Very low	Slight	Unlikely	Very low
	S1: Small GH2		Moderate	Likely	Moderate	Drastic	More likely	High
	S2: Big H2		Moderate	Likely	Moderate	Drastic	More likely	High

Pos impact	Scenario	Spatial receiving environment	WITHOUT MANAGEMENT			WITH MANAGEMENT		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Regional broadband roll-out	S0: Baseline	Port Nolloth, Alex Bay	Slight	Unlikely	Very low	Slight	Unlikely	Very low
	S1: Small GH2		Extreme	More likely	High	Extreme	Definite	Very high
	S2: Big H2		Extreme	More likely	High	Extreme	Definite	Very high
	S0: Baseline	Springbok area	Slight	Unlikely	Very Low	Moderate	Unlikely	Low
	S1: Small GH2		Extreme	More likely	High	Extreme	Definite	Very high
	S2: Big H2		Extreme	More likely	High	Extreme	Definite	Very high
	S0: Baseline	SEZ area	Moderate	Unlikely	Low	Moderate	Unlikely	Low
	S1: Small GH2		Extreme	More likely	High	Extreme	Definite	Very high
	S2: Big H2		Slight	Unlikely	Very Low	Moderate	Unlikely	Low
	S0: Baseline	Rural settlements	Slight	Unlikely	Very Low	Slight	Unlikely	Very low
	S1: Small GH2		Moderate	Likely	Moderate	Significant	Likely	Moderate
	S2: Big H2		Moderate	Likely	Moderate	Significant	Likely	Moderate

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7.10 DIGITAL APPENDICES 7-A & 7-B

SEPARATE DIGITAL DOCUMENTS

Appendix 7-A: Socio-economic and institutional data
Appendix 7-B: Economic data

APPENDIX 7-A

Social and Economic Impact Social and Institutional Issues

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1: Northern Cape Development Targets for 2030

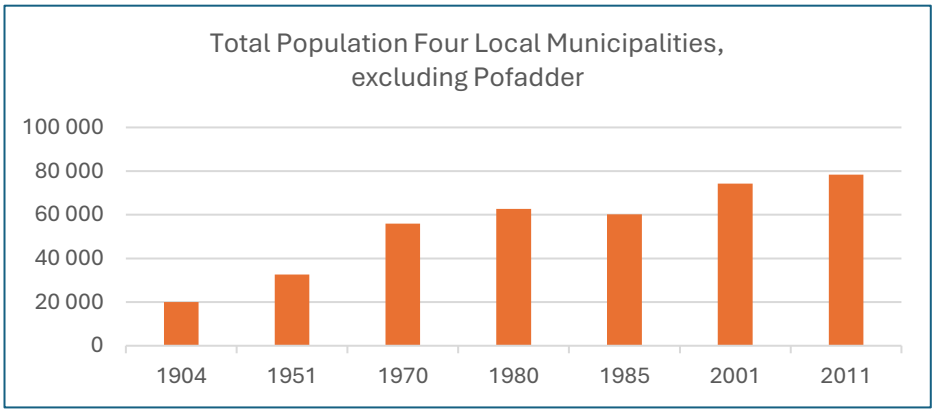
Northern Cape Provincial Growth and Development Plan, 2014 development targets for 2030 [1]

National Development Plan: Vision 2030			NC Provincial Growth and Development Plan		
NDP Poverty, Inequality and Unemployment related targets: BY 2030	**National Baseline 2014/2015**	**National Target 2030**	**NC Baseline 2014/2015**	**NC Target 2024**	**NC Target 2030**
1. **Reduce the proportion of persons living below the lower-bound poverty line from 39% (in 2009) to 0**	40,0% (2015)	0%	% (40.7% - 2015)	21,4%	0%
2. **Reduce poverty-induced hunger to 0%**	25,2% (2015)	0%	31,3% (2015)	16%	0%
3. **Reduce income inequality from 0,7 in 2010 to 0,6**	0,68 (2015)	0,60	0.67 (2015)	0	0.60
4. **Halve Unemployment**	25,3% (2015)	12%	29% (Q1 2014)	21%	14,5%
5. **GDP Growth (Average growth of 5.4% per year between 2012 and 2030)**	1,8% (Q1 2014)	5.4%	3% (2014)	3,5%	5%

StatsSA: Poverty Trends in South Africa 2006-2015

2: Population growth in Namakwa Local municipalities

Population growth 1904-2011 in four Local Municipalities (except Pofadder)[2], over a period of over a century

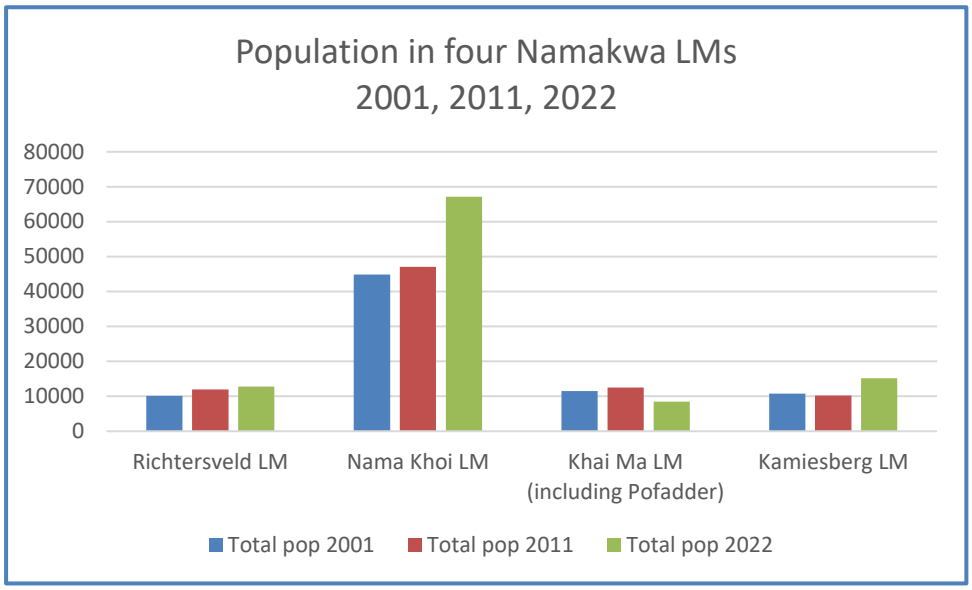


1 Northern Cape (2020), Office of the Premier, *Strategic Plan 2020-2025,* p. 31.

2 The earlier data excluded Pofadder, because that was demarcated as part of Bushmanland. Since 2006, Pofadder and Aggeneys have been counted as part of Namakwa DM, which has created some difficulties for comparison with pre-1990 data.

	Total pop 2001	Total pop 2011	Total pop 2022
Richtersveld LM	10125	11982	12791[3]
Nama Khoi LM	44900	47041	67089
Khai Ma LM (including Pofadder)	11469	12465	8510
Kamiesberg LM	10754	10187	15130

Population shifts, 2001-2022



Over the last twenty years, population has grown in three of the four municipalities. The exception is Khai Ma LM.

Population growth rates per municipality, 2001-2022

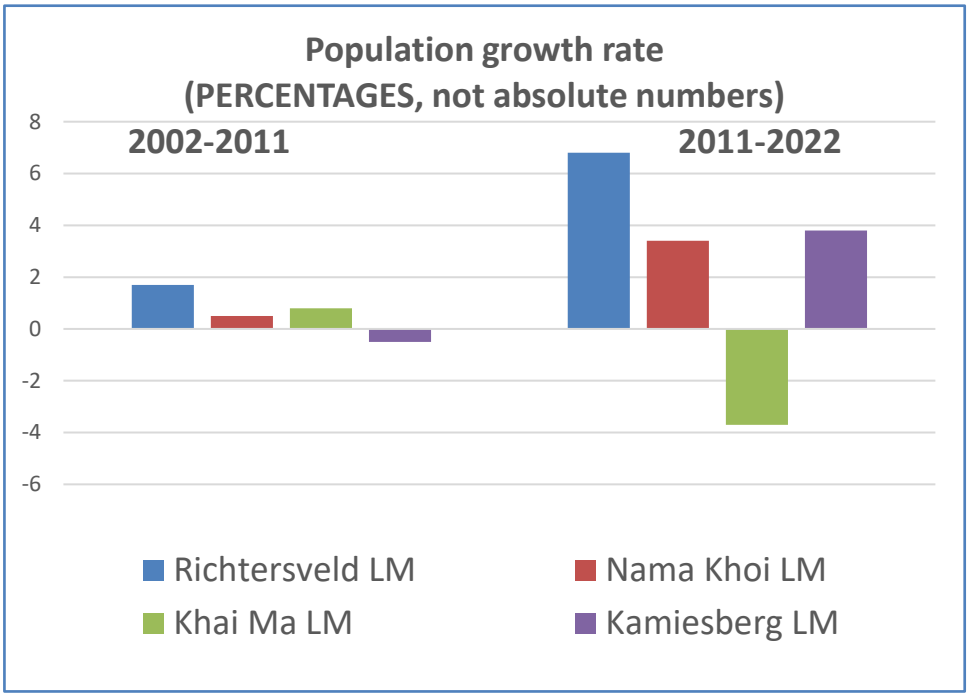
	Population growth rate[4]	
	2001-2011	2011-2022
	%	%
Richtersveld LM	1,7	6,8
Nama Khoi LM	0,5	3,4
Khai Ma LM	0,8	-3,7
Kamiesberg LM	-0,5	3,8

The same data is illustrated in the table below:

[3] The figures for Richtersveld LM are somewhat debatable. The 2022 Census figure is provided as 24 365, which is more than double the figure for 2011. The figure is clearly wrong. However, the population growth rate is provided as 6,8%, which seems realistic. With this growth rate, a more appropriate population figure for 2022 can be calculated (i.e. 12 781).

[4] Source: StatsSA, *Municipal Fact Sheet*, 2022. www.statssa.gov.za

Population growth rate percentages



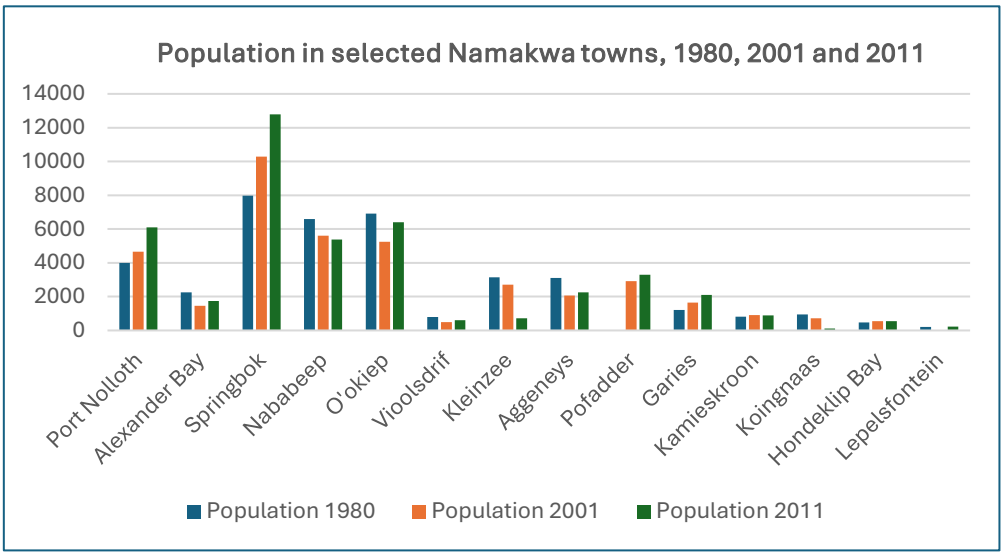
Increasing population and urbanisation in Namakwa region

Year	Notes and Calculations	Total Population	Urban population	Urban pop as % of total pop	Rural population
1904	Namaqualand excluding Pofadder[5]	20 041	6 717	34 %	13 324
1951	Namaqualand excluding Pofadder	32 633	19 229		22 404
1970	Namaqualand excluding Pofadder	56 009	24 436	44 %	31 573
1980	Namaqualand excluding Pofadder	62 686	26 069		36 617
1985	Namaqualand excluding Pofadder	60 234	24 811	41%	35 423
2001	Nama Khoi, Richtersveld, Kamiesberg, Khai Ma, excluding Pofadder	74 325	Not available	Not available	Not available
2011	Nama Khoi, Richtersveld, Kamiesberg, Khai Ma, excluding Pofadder	78 388	72483	92,5[6]	3287

5 Earlier figures are drawn from Dunne (1986),p. 86. That study focused on Namaqualand, which excluded Pofadder, which was considered to be part of Bushmanland. Consequently, we removed the Pofadder figures from the Khai-Ma population figures, to ensure general comparability. The old "Namaqualand" was also understood differently from the modern Namakwa District Municipality, which includes Karoo towns such as Calvinia, Sutherland, Fraserburg and Williston.

6 All four municipalities in the study area now have an urbanisation rate higher than 90% (Northern Cape SDF, p 218.

Population shifts in key Namakwa towns, 1980-2011[7]



Town-based population figures

Using Dunne's figures (drawn from 1980) and Census 2011 data, we can compare the population levels of selected towns over a thirty-year period:[8]

Growth trends in selected Namakwa towns, 1980-1911

Municipality	Settlement	Population 1980	Population 2011	Trend
Richtersveld LM	Port Nolloth	3999	6092	Strong increase (municipal HQ)
	Alexander Bay	2263	1736	Decline (due to mining decline)
Nama Khoi LM	Springbok	7969	12790	Strong increase (municipal HQ)
	Nababeep	6584	5374	Decline
	O'okiep	6912	6394	Slight increase
	Vioolsdrif	803	599	Decline
	Kleinzee	3153	728	Strong decline (mining decline)
Khai-Ma LM	Aggeneys	3102	2262	Decline
	Pofadder	Not available	3287	N/A
Kamiesberg LM	Garies	1209	2106	Strong increase (municipal HQ)
	Kamieskroon	818	893	Static
	Koingnaas	942	105	Strong decline
	Hondeklip Bay	464	543	Slight increase

7 Town-based figures from the 2022 census appear not to be available yet.

8 This overview excludes the villages in the Coloured Rural Areas (drawn from Dunn 1986). The 2001 data is drawn from https://census2001.adrianfrith.com

Today, Nama Khoi LM is the most populous municipality, with a population of just more than 55 000 in 2019 and almost 58 000 in 2023. Richtersveld LM and Khâi-Ma LM have population numbers of around 15 000 in 2023, and Kamiesberg is the smallest in terms of population. The population distribution in these towns is very similar to that of Nama Khoi, although the African population in Richtersveld and Khâi-Ma now exceed 10%, due to in-migration.

Rural population in four municipalities

	Non Urban population 2011	Non-urban population as % of total population
Richtersveld LM	139	1.1%
Nama Khoi LM	2909	8.1%
Khai Ma LM (including Pofadder	2148	17.2%
Kamiesberg LM	709	6.9%
TOTALS	**5 905**	

3: Social indicators in Namakwa municipalities

Various social indicators in four Namakwa municipalities, compared to Sol Plaatje LM (Kimberley) [9]

	Richters-veld	Nama Khoi	Khai-Ma	Kamies-berg	Sol Plaatje (comparative purposes)	Notes
Physical size of jurisdiction	9 607 km2	17 988 km2	16628 km2	14 210 km2	3145 km2	Richtersveld smallest; Nama Khoi almost double the size
Number of people per km2	1,2	2,7	0,8	0,7	85,8	Very sparse in Khai-Ma and Kamiesberg
Sex ratio: Men to women	50%	49%	50%	49%	49%	Balanced
Children aged under 14 years	23%	23%	25%	26%	28%	% of children very low in Richtersveld – why?
Working age people: 15-65	71%	69%	69%	63%	65%	Relatively large working age population in Richtersveld
Elderly – over 65%	6%	8%	6%	15 %	7%	High proportion of young and elderly in Kamiesberg
Life expectancy: Years	63,8	64,7	63,1	64,8	59,1	Life expectancy higher than in urban area
Healthcare facilities	13	26	13	21	57	Nama Khoi is better served than the other LMs; but its jurisdiction is larger.
Mean years schooling	8,2	8,57	8,1	7,6	8.8	Levels of schooling generally low, particularly Kamiesberg. However, Namakwa DM average is even lower, at 7,8.
Adult literacy rate	76,5%	79,5%	75,6	70,9%	78,6%	At least 25% of adults illiterate
Regional GDP per capita	R165,079	R187 587	R112,801	R94,054	R113 336	High per capita GDPR in Richtersveld (skewed by diamond mining?)
Average monthly household income	R528	R2 239	R420	R378	10,146	Higher in Nama Khoi, but very low compared to urban area. Very low in Kamiesberg and Khai Ma.
Income inequality 2016	0,6 (improving trend)	0,62 (improving trend)	0,59 (deteriora-ting trend)	0,58 (improving trend)	0,67 (deteriora-ting trend	Generally improving, except Khai Ma, due to intensive commercial agriculture that does not filter to broader population?
Human Development Index 2016	0,662 (improving trend)	0.675 (improving trend)	0,652 (improving trend)	0,678 (improving trend)	0,589 (improving trend)	Stable and improving; indicates improving government services
Indigent households	1129	5332	Not provided	1239	14662	At least 7700 indigent households that could benefit from low-skilled jobs (Khai Ma not included here).

[9] National Treasury, MSEP reports, Richtersveld, Nama Khoi, Khai-Ma and Kamiesberg. https://lg.treasury.gov.za/ibi_apps/portal/Municipal_Socio_Economic_Profiles; Quantec figures 2020.

- The **gender ratio** is fairly balanced. This may, however, change significantly if there is rapid in-migration of male workers, due to the Port and GH complex.

- The proportion of **elderly** in the communities are all in the 6-8% range, similar to Sol Plaatje LM (7%). However, Kamiesberg LM is an outlier, at 15%. This suggests that a large number of working-age people have migrated away from Kamiesberg. This is one of the several indicators showing the economic decline of Kamiesberg.

- **Life expectancy** in our four municipalities is around 63-64 years, somewhat higher than Sol Plaatje at 59%. This suggests that, while poverty is rife in our municipalities, there may be fewer other risks (such as travel accidents or epidemics).

- **Mean years of schooling** vary from a low of 7.6 in Kamiesberg to a high of 8.57 in Nama Khoi – somewhat lower (but not much) than the 8.8 years of schooling in Sol Plaatje. This is surprising, given the very small number of high schools in the Namakwa area. It suggests that school learners may migrate to access high schools.

- The **adult literacy rate** ranges from a low of 71% in Kamiesberg (again showing its relative poor performance) to a high of 79,5% in Nama Khoi. This is very similar to the 78.6% in Sol Plaatje LM. The disturbing point, however, is that almost 30% of adults are not literate, which would only make them suitable for unskilled work.

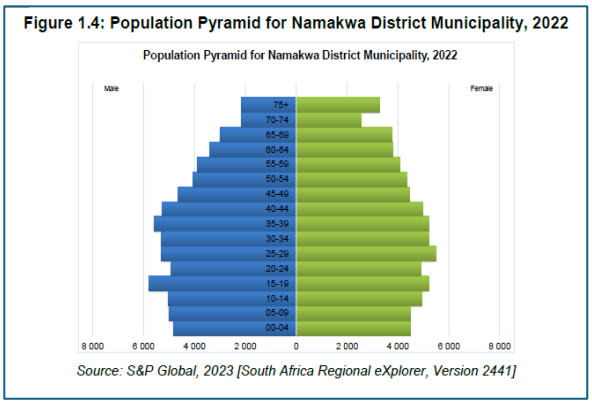
- **Average income inequality** is around 0,58-0,6 on the Gini Co-efficient scale. This is in fact better than Sol Plaatje at 0,67. However, it may indicate that a large number of people in the Namakwa municipalities are universally poor, creating a greater level of equality.

- The **Human Development Index (HDI)**[10] in the four Namakwa municipalities range from a low of 0,652 in Khai-Ma LM to a high of 0,678 in Kamiesberg (which is surprising; this may be due to a larger number of pension recipients in Kamiesberg). The HDI levels are improving. These figures are better than the HDI of 0,589 in Sol Plaatje LM.

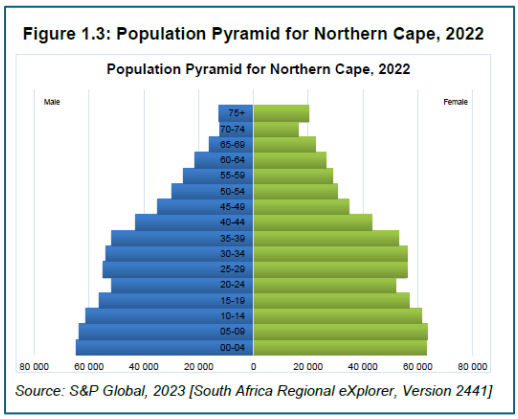
- The **dependency ratio** (dependence of non-income earners on income earners) ranges from a fairly balanced 42 in Richtersveld and 43,7 in Kamiesberg, to a fairly high 56,6 in Khai-Ma. Generally, the Namakwa municipalities are better than Sol Plaatje, at 54,7.

10 This measure combines a long and healthy life (health), being knowledgeable (education) and having a decent standard of living (income).

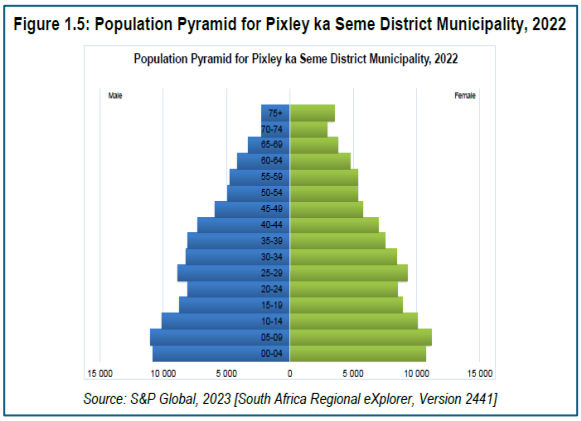
Population pyramid: Namakwa DM



Population Pyramid, Northern Cape



Population pyramid, Pixley ka Seme DM



Dependency ratio (young and elderly in relation to working-age people, 2016

	Richtersveld	Nama Khoi	Khai Ma	Kamiesberg	Sol Plaatjie (Kimberley, for comparative purposes)
2011 census	42,5	49,4	45,7	57,9	51
Quantec 2020	42	45	43,7	56,6	54,7
2022 census	45	46,7	45,1	51,6	49,8

4: Household income levels

The National Treasury MSEP reports compared household income levels in the four municipalities, as well as Namakwa DM and national levels:[11]

Household income levels: Municipalities in Namakwa district

	Average household income per month (2019)	Average trend regarding household income growth (2016-2019)	Indigent households 2019	Indigent households as % of households
Richtersveld LM	R43	0,9%	1128	33,7%
Nama Khoi LM	R186	1,96%	5327	40,3%
Khai Ma LM	R35	1,39%	Not available	Not available
Kamiesberg LM	R31	-1,39 %	1,238	40,9%
Namakwa DM	***R379***	***1,63%***		
Republic of SA	***R11 907***[12]	***1,83%***		

5: Infrastructure earmarked for the four municipalities

amakwa Spatial Framework (2023, p. 101): The projects earmarked are: "Steinkopf 1500": R1 308 261; Town planning; O'kiep: R6 million for top structures; Pofadder: Town planning, R3,5 million; Kharkams (Kamiesberg LM), MIG funding, upgrading of sport facilities phase 2: R10 million; Kamieskroon (Kamiesberg LM), MIG funding, R8 million (sanitation); Kamieskroon (Kamiesberg LM), MIG funding, R21 million: Ground water desalination, bulk water, boreholes, reservoir: Access to water for 400 households; Rooifontein (Kamiesberg LM), MIG, R12 million: Ground water desalination, bulk water, borehole development for 190 households; Kharkams (Kamiesberg LM), MIG, R30 million: Water supply for 383 households; Pella (Khai-Ma LM), Bulk Water Infrastructure reticulation, MIG, R20 million: Water for 712 households; Komaggas (Nama Khoi LM), MIG R44 million: 847 households access to water; Okiep (Nama Khoi LM), Sewer reticulation, MIG, 272 households; Port Nolloth (Richtersveld LM), Waste water treatment works), R20 million: Sanitation improvements for 22 49 households.

Office of the Premier, Memorandum to NCOP. The proposed housing schemes were identified as: Khai-Ma LM: 90 houses in Onseepkans: 30 in RK Sending, 30 in Melkbosrand, and 30 in Viljoensdraai; Khai-Ma LM: 30 houses in Pella, 30 in Witbank and 30 in Pofadder; Kamiesberg LM: 30 houses in Spoegrivier, 30 in Kheis, 30 in Tweeriviere, 30 in Garies, and an additional 15; Nama Khoi LM: 105 houses in Bergsig and 29 in Concordia.

Richtersveld LM, *Spatial Development Framework*, 2024, p. 75. The projects are: Kuboes and Eksteensfontein water supply; refurbishment of MILE 8 boreholes (Port Nolloth); Lekkersing water supply; Port Nolloth bulk water supply; and oxidation ponds for Port Nolloth (MIG).

6: People receiving Anti-retroviral treatment

The table below shows the high number of people receiving ART already, and the steady number added to this total:[13]

11 National Treasury, MSEP reports, Richtersveld LM, Nama Khoi LM, Khai-Ma LM, Kamiesberg LM.
12 The Broadcast Research Council of South Africa, The Establishment Survey, March 2019 release, https://brcsa.org.za/wp-content/uploads/2019/04/ES_Mar19-release_26032019-v4.pdf.
13 Nasional Treasury, MSEP Richtersveld LM, Nama Khoi LM, Khai Ma LM and Kamiesberg LM.

Number of patients receiving HIV/ART treatment

	Patients on ART		Patients starting on ARV treatment (HIV prevalence)			
	2016	2019	2016	2017	2018	2019
Richtersveld LM	3 728	4228	64	46	45	37
Nama Khoi LM	10232	12275	166	116	134	149
Khai Ma LM	4550	6458	83	83	112	99
Kamiesberg	1940	2414	34	23	21	19
Namakwa DM	27 741	34 992	502	350	415	420

7: Proposed health expenditures for Transnet Corporate Social Investment

Proposed Transnet Health CSI funding for the Richtersveld area[14]

	Port Nolloth	Alexander Bay	Kuboes	Lekkersing	Sanddrif
Mobile clinics	Currently 3, increase to 5 during construction, then decline to 4	Currently 1, then increase to 2 during construction, then decline to 1	Currently 1, remain static	0[15]	Currently 1, remain constant
	Proposed CSI: Support the existing mobile clinic programme in the villages to provide the services more frequently and of an improved quality of service.[16]				
Satellite clinic	Currently 1, remain static	0	0	0	0
	Proposed CSI: Support the satellite clinic programme to provide the services more frequently and of an improved quality of service				
Primary health facilities	0 (*this is debateable)*	0	0	0	0
	Proposed CSI: Contribute to the upgrading of the primary health clinics in Port Nolloth and Alexander Bay				
Substance abuse programme	**Proposed CSI:** Support the existing younger population's prevalence of substance abuse programme Facilitate the Community Awareness programmes on Foetal Alcohol Syndrome through the existing clinic structures				
Global health threats	**Proposed CSI:** Inform and advise communities about global health threats such as COVID-19, HIV/AIDS and Mpox by means of care-giver support and training programmes.				

14 Transnet, 2024, *Boegoebaai Port Development SEB Report*, p. 63, p. 75.
15 It is surprising that there is no mention of mobile clinics in future.
16 The Namakwa SDF has proposed a Mobile Health Clinic at Sanddrift Cited in Richtersveld LM, *Spatial Development Framework*, 2024, p. 74.

Transnet CSI proposals for educational projects[17]

	Port Nolloth	Alexander Bay	Kuboes	Lekkersing	Sanddrif
Creches	Currently 5, increasing to 7 in 2050	Currently 2, increasing to 3 during construction; later reduce to 2	Currently none; 1 by 1950	Currently none, 1 by 2040	Currently 2, 2 by 2050
	Proposed CSI: Support existing local community creches and 5 newly established creches with the formulation of ECD programmes, which could be rolled out into the broader communities				
Primary school	Currently 4, 5 during construction, 5 by 2050	Currently 1, 2 during construction, 1 by 2040	Currently 1, remains static	0	Currently 1, remains static
	Proposed CSI: Support and partake in intervention programmes for educational development and improved subject performance				
Secondary school	Currently 1. Another built during construction, remains at that level[18]	0	0	0	0
	Proposed CSI: • Assist learners from the villages to gain access to high school • Improved subject performance focusing on Maths, Science and Technology • Assist and facilitate in the establishment of at least one more high school • Excursion tours and career exposure • School sport facilities and equipment.				
Tertiary facility	Currently none; one built during construction phase agricultural training)	0	0	0	0
	Proposed CSI: Facilitate access to tertiary training facilities and systems				
ABET	Support and facilitate the introduction of Adult Basic Education and Training programmes.				
Entrepreneur-ship & skills	**Proposed CSI**: Entrepreneurship and youth skills development • Liaise with existing management, business and technical programmes, e.g. SEDA and SETAs. • Align with the TNPA artisan employee training programme but extended to involve external unemployed persons.				

17 Transnet, *Boegoebaai Port Development Socio-economic Studies,* p. 63. And 78.

18 The Transnet report wrongly states that there are currently 2 high schools in Port Nolloth. In fact, there is only the Port Nolloth High School. This suggests that another secondary school will have to be built.

Skill levels, Namakwa District, 2016 and 2019

	Low-skilled workers		Semi-skilled workers		Skilled workers		TOTALS		TREND
	2016	2019	2016	2019	2016	2019	2016	2019	
Richtersveld	1069	1116	1676	1719	740	786	3487	3621	Number of workers in all categories increased
Nama Khoi	3646	3661	5932	5989	2505	2599	12083	12249	Number of workers in all categories increased
Khai Ma	1691	1668	1388	1433	434	444	3513	3545	Number of workers in all categories increased slightly
Kamiesberg	718	731	1014	1028	308	301	2040	2060	Number of workers largely static
TOTALS	7124	7176	10010	10169	3987	4130	21123	21475	

According to this table, the number of skilled workers had increased somewhat, although the level is still very low.

8: Courses available at the Springbok/Okiep TVET College

- Pre-matric business studies (NCV – National Vocational Certificate): Pre-vocational learning programme; hospitality; office administration; safety in society; Transport and Logistics
- Pre-matric Engineering (NCV) – National Vocational Certificate): Electrical Infrastructure Construction; Automotive; Fabrication; Fitting and Turning
- Post-matric Business Studies (NATED – National Accredited Technical Diploma): Public Management; Human Rsource Management; Management Assistant; Financial Management; business Management; Tourism; Legal Secretary
- Post-matric Engineering (NATED – National Accredited Technical Diploma): Mechanic; Electrical; Fitting and Turning; Boiler Marker; Auto Electrical; Millwright; and Welding.

9: Proposed Transnet CSI expenditure for social services

Proposed Transnet CSI social interventions for social services[19]

	Port Nolloth	Alexander Bay	Kuboes	Lekkersing	Sanddrif
Multi-purpose centre	1 Currently, increase to 2 during construction until 2050	None currently, then 1 built during construction, until 2050	0	0	0
	Proposed CSI: Accelerate and support the provision of 10 community halls and multi-purpose centres. Facilitate the provision of basic equipment for community halls and multi-purpose centres.				
Library	1 currently, 2 built during construction	None currently, 1 built during construction	0	0	0
	Proposed CSI: Accelerate and support the provision of three libraries. Facilitate the provision of books, digital reading tools, magazines and articles to the existing and future libraries.				
Community sport field	None currently, 1 built during construction	None currently, 1 built during construction	0	0	0
	Proposed CSI: In alignment with the school sport programme, provide 3 community sport fields to the impoverished communities. Provide sport equipment in support of the community sport fields. Facilitate sport training and arrange community sport events and competitions.				
Play areas	3 currently, then static	1 today, remain static	0?	0?	1 currently, then static
	Proposed CSI: Provide and maintain 10 children's play areas within the impoverished communities.				
Places of workshop	Currently 6, increase to 9 during construction	Currently 2, then increase to 3 during construction	Currently 1, then static	Currently 1, then static	Currently 2, then static

19 Transnet, *Boegoebaai Port Development Socio-economic Studies: SEB Report*, 2024, p. 77.

10: Proposed Transnet CSI expenditure for livelihoods and economic projects

Transnet SEB CSI proposals for livelihoods and economic projects[20]

	Port Nolloth	Alexander Bay	Kuboes	Lekkersing	Sanddrif
Market garden	Currently 3, increase to 4 during construction	Currently 1, then static	0	0	Currently 1, then static
	Proposed CSI: Establish, facilitate and provide management support to five community garden initiatives.				
Community farmers' market	Currently 3, increase to 4 during construction	Currently 1, then static	0	0	Currently 1, then static
	Proposed CSI: Establish, facilitate and provide management support to 5 off-set areas through farmers' markets for the community market gardens.				
Community retail centre	Currently 1, then increase to 2 during construction	Currently 0, then static	0	0	0
Mini factory	Currently 1, then static	0	0	0	0
	Proposed CSI: • Establish, facilitate, and provide management support for 4 mini-factories • Align with the Entrepreneurship and Youth unemployment skills development.				
Agricultural projects	**Proposed CSI**: Establish, facilitate and provide management support to an Agricultural Training Facility Project (an Agri-preneur project), localities to be determined				
Tourism	**Proposed CSI:** • Provide management and admin support to the tourism association • Provide support to tourism development and marketing initiatives through the tourism association • Training of responsible marine (fishing and angling) tour operators and guides in the Richtersveld.				

11: Party-political dynamics in Namakwa municipalities

12: Municipal political profiles

Political trends in the four municipalities can have a significant impact on various sectors. Richtersveld LM is clearly the most significant, as it is the jurisdiction in which the Boegoebaai projects will be located, and Nama Khoi, which is the main economic centre and the seat of Namakwa DM. Khai-Ma, as the focal point of the Namakwa SEZ, is also important, and decision-making in the main town of Pofadder can decisively influence the progress of the SEZ. Kamiesberg is an important tourism area, which may become an important gateway to travel to the coast and Port Nolloth, thereby avoiding the potential traffic congestion around Springbok and Steinkopf.

20 Transnet, *Boegoebaai Port Development Socio-economic Studies: SEB Report*, 2024, p. 78.

12.1 Richtersveld Local Municipality

Richtersveld local election, 1 November 2021								
Party	Votes				Seats			
	Ward	List	Total	%	Ward	List	Total
African National Congress	2,066	2,116	4,182	47.3%	6	0	6
Democratic Alliance	1,129	1,379	2,508	28.4%	0	3	3
Economic Freedom Fighters	324	329	653	7.4%	0	1	1
Independent candidates	522	–	522	5.9%	0	–	0
National Economic Fighters	143	293	436	4.9%	0	1	1
Namakwa Civic Movement	147	193	340	3.8%	0	0	0
Freedom Front Plus	108	94	202	2.3%	0	0	0
Total	**4,439**	**4,404**	**8,843**		**6**	**5**	**11**

Party-political representation on Richtersveld LM Council[21]

In 2021, the ANC won a majority of six seats on the council (which notably included all six wards):[22] However, the ANC's proportion of the vote (47%) does not represent an absolute majority of all the votes cast. The opposition parties are fragmented, and therefore could not win any of the wards. All the PR seats were captured by opposition parties. The largest opposition party is the Democratic Alliance, which attracted just under 30% of the vote. One seat is held by the EFF, and one by the National Economic Fighters (NEF).

This is a significant shift from the municipal elections in 2016, when the ANC received an absolute majority (53%), the DA received 46%, and the EFF received 1%.[23] Since 2016, the ANC has dipped below 50%, the DA has declined from 46% to 28%, and the EFF has increased its share from 1% to 7%. The decline of the DA has been accompanied by the rise of the Namakwa Civic Movement (NCM) and the National Economic Fightters (NEF).

The 522 votes for Independents in Richtersveld LM may be significant. It suggests that key local leaders[24] have some confidence and traction with the local communities, and may be influential in future discussions about Boegoebaai projects.

21 https://en.wikipedia.org/wiki/Richtersveld
22 https://en.wikipedia.org/wiki/Richtersveld_Local_Municipality
23 https://results.elections.org.za
24 The Independent candidates were Demitri Farmer, Dicolene Cloete, Devald Links, Johannes Moos, Gabriel Swarts, James Malgas, Arthur Ovies, and Anthony September (https://www.elections.org.za/pw/Documents/CandidateLists/NC081021.pdf).

12.2 Nama Khoi Municipality

The Nama Khoi municipality consists of nine wards, and an additional eight PR Councillors

Ward	Town/ Suburb
1	Concordia
2	Steinkopf (Vioolsdrift, Rooiwal)
	Steinkopf (Goodhouse, Bulletrap, Rooiwinkel)
4	Springbok (Carolusberg, Fonteintjie)
	Springbok (Bergsig)
6	Okiep (Skietbank, Kouroep)
7	Matjieskloof, Vaalwater
8	Komaggas, Buffelsrivier/ Kleinzee
9	Nababeep

During the 2021 Local Government Elections (LGE), the ANC won the largest share of the vote (42%), but did not achieve an absolute majority. Consequently, the Democratic Alliance (DA) and the Namakwa Civic Movement (NCM) formed a coalition government. On the Council, the overall party representation is as follows: ANC: 7 councillors; DA: 5; NCM: 4; FF+: 1.

This was a significant shift from the municipal elections in 2016.[25] Significantly, the new show in town was the Namakwa Civic Movement (NCM), with a debut performance of 21% in 2021. This suggests a strong "turn to the local", i.e. a focus on local leaders with credible local networks and an understanding of local conditions.

Since 2016, the ANC declined, from 47% to 42%; and the DA declined from 40% to 30%. Even the Khoisan Social Revolution Party declined from 5% to 1%. The other national parties declined too: COPE from 3% to 1%, and the EFF from a miniscule 2% to 1%. The Freedom Front Plus doubled its vote, but remains marginal: 0,5% to 1,5% (although it managed to get one seat in the 2021 Council, which gives it a platform for the first time).

A remarkable shift in political culture has taken place on the Nama Khoi Council, away from "winner take all" politics, towards the politics of coalitions. The DA and NCM signed a formal agreement outlining the rotation of key leadership roles.[26] The July 2024 leadership transition, where the incumbents of the positions of Mayor and Speaker were rotated, aligns with this agreement. Initially, the DA held both positions, but as stipulated, the NCM assumed these roles in the second half of the term, demonstrating the coalition's commitment to shared governance.

According to the municipality's 2024 Annual Report, the DA/NMC coalition has remained stable, and there are no reports of instability on social media or other public platforms.

25 https://results.elections.org.za
26 McGluwa, H. 2024. DA takes up mayoral position in Nama-Khoi coalition municipality.

12.3 Khai-Ma Local Municipality

There are six wards in Khai-Ma LM jurisdiction:

Ward	Town/Suburb
1	Onseepkans,
2	Blyvooruitsig
3	Pella
4	Aggeneys
5	Pella, Witbank, and Klein Pella
6	Pofadder town area, Eastern Part of Blyvooruitsig, Vrugbaar, Raap & Skraap, Dwaggasoutpanne.

The municipality consists of the following political representation: [27] ANC: 6 (all the wards); NCM: 2 PR seats; COPE: 1 PR seat; DA: 1 PR seat; and EFF: 1 PR seat.

The national parties did relatively poorly in 2021, compared to 2016.[28] The ANC dipped from 57% to a borderline absolute majority of 50%. The DA also declined, from 24% to only 12%. COPE declined from 7% to 6%. The ANC managed to achieve an absolute majority, and in fact controls all six of the wards. Of the five PR seats, two were won by the Namakwa Civic Movement, which is the largest opposition party on the Council. The DA, EFF and COPE each won one PR seat.

As in Nama Khoi Municipality, the Namakwa Civic Movement (NCM) was a big winner in its first-time election in 2021, receiving 20% of the vote and becoming the official opposition. The EFF grew from 2% to 6%, and managed to secure a PR seat. The VF+ grew from 1% to 3%, but did not qualify for a seat. Nevertheless, the VF+, with a strong base in the commercial farming community, probably wields some influence.

12.4 Kamiesberg Local Municipality

Ward	Town/ Suburb
1	Hondeklipbaai, Koiingnaas, Soebatsfontein and Spoegrivier
2	Garies
3	Lepelfontein, Kheis and Klipfontein
4	Kamassies, Rooifontein, Nourivier and Paulshoek
5	Kharkams and Tweerivier
6	Kamieskroon and Leliefontein

In Kamiesberg, the ANC won an absolute majority, with the Democratic Alliance in second place. The Namakwa Civic Movement achieved just over 7% of the vote, and won one PR seat.

27 https://en.wikipedia.org/wiki/Kh%C3%A2i-Ma_Local_Municipality
28 https://results.elections.org.za

The overall party representation is as follows: [29] ANC: 6 councillors; DA: 3 councillors; NCM: 1 councillor; NEF: 1 councillor

This is a significant shift from the municipal elections in 2016.[30] The ANC declined by 10 percentage points from 62% to 52%, although it still won an absolute majority in 2021. The DA also declined, from 28% to 24%, and the EFF shrank from 7 to 5%. COPE disappeared altogether. The FF+ doubled from 1% to 2%.

These losses were captured by National Economic Fighters (NEF), who competed for the first time, and won 8% of the vote; and the other newby, the Namakwa Civic Movement which won 75%. Again, the trend seems to be away from national parties, towards local groupings that offer local solutions.

12.5 Namakwa District Municipality

A District Municipality is not directly elected by the residents of a jurisdiction. It is made up of delegates from the constituent local municipalities. In Namakwa, this includes the four municipalities in the study region, as well as Hantam and Karoo-Hoogland LM. The political composition of Namakwa DM is as follows: 11 ANC, 4 DA, three NCM, and one Patriotic Alliance.[31]

At the district level, there are 19 Councillors, of whom 9 are elected directly by the electorate, and the remaining 10 are elected by Local Municipalities. The ANC dominates this body, but there is strong minority representation from the other parties:[32]

- **ANC: 11 members:** Executive Mayor, plus Chief Whip and Speaker, plus 1 councillor directly elected, and then delegates from Richtersveld, Kamiesberg, Nama Khoi (2) and Khai-Ma, Karoo Hoogland, Hantam
- **DA: 4 members**: Two councillors direct elected and two delegates from Nama Khoi
- **NCM: 3 members:** One member directly elected , one delegate from Nama Khoi and one from Hantam.
- **PA: 1 member** directly elected.

13: Political party profiles

13.1 The African National Congress

ANC political representation in four Local Municipalities

The African National Congress					SEATS		
	Ward votes	PR votes	Total votes	%	Ward	Total	
Richtersveld LM	2066	2116	4186	47,3%	6	0	6
Nama Khoi LM	6625	6513	13,138	42%	7	0	7
Khai Ma LM	21992	204	4403	50,5%	6	0	6
Kamiesberg LM	2695	2712	5407	52,4%	5	1	6

29 https://en.wikipedia.org/wiki/Kamiesberg_Local_Municipality
30 https://results.elections.org.za
31 https://www.namakwa-dm.gov.za/council-structure/
32 https://www.namakwa-dm.gov.za/council-structure/.

This should be compared to the outcome of the 2024 provincial election[33], in which the Northern Cape ANC secured 49.47 of the provincial vote. The Namakwa District is broadly comparable to the ANC profile in the rest of the Northern Cape Province.

13.2 The Democratic Alliance

DA Political representation in four municipalities

The Democratic Alliance					SEATS		
	Ward votes	PR votes	Total votes	%	Ward	Total	
Richtersveld LM	1129	1379	2508	28,4	0	3	3
Nama Khoi LM	4665	4739	9404	30,1%	1	4	5
Khai Ma LM	512	507	1019	11,7%	0	1	
Kamie+sberg LM	1208	1238	2446	23,7&	1	2	3

This should be compared to the outcome of the 2024 provincial election,[34] in which the DA secured 20.94% of the provincial vote. This performance is broadly comparable with that of our study area.

13.3 The Namakwa Civic Movement

NCM political representation in four municipalities

Namakwa Civic Movement					SEATS		
	Ward votes	List votes	Total votes	% of municipal votes	Ward	List	Total
Richtersveld LM	147	193	340	3,8%	0	0	0
Nama Khoi LM	3229	3290	6519	20,8%	1	3	4
Khai Ma LM	820	889	1709	19,6%	0	2	2
Kamiesberg LM	375	397	772	7,5%	0	1	1

33 https://results.elections.org.za/dashboards/npe/
34 https://results.elections.org.za/dashboards/npe/

13.4 The National Economic Fighters

Table: NEF political representation in four municipalities

National Economic Fighters					SEATS		
	Ward votes	List votes	Total votes	% of municipal votes	Ward	List	Total
Richtersveld LM	143	293	436	4,9%	0	1	1
Nama Khoi LM	132	0	193	0,4%	0	0	0
Khai Ma LM	52	61	113	1,3%	0	0	0
Kamiesberg LM	427	430	857	8,3%	0	1	1

13.5 The Economic Freedom Fighters (EFF)

Political representation of the EFF in four municipalities

The EFF					SEATS		
	Ward votes	PR votes	Total votes	%	Ward	Total	
Richtersveld LM	324	329	653	7,4%	0	1	1
Nama Khoi LM	115	1202	35	0,8%	0	0	0
Khai Ma LM	272	275	547	6,3%	0	1	1
Kamiesberg LM	271	259	530	5,1%	0	0	0

13.6 The KhoiSan Revolution

Table: KRP representation in four municipalities

The Khoisan Revolution Party (KRP)					SEATS		
	Ward votes	PR votes	Total votes	%			
Richtersveld LM	-						
Nama Khoi LM	213	225	438	1,4%	0	0	0
Khai Ma LM	-						
Kamiesberg LM	-						

13.7 The Northern Cape Communities Movement (NCCM)

In the 2024 national and provincial elections, a range of small political organisations in the Northern Cape came together as the NCCM. Led by Ronald February, the NCCM serves as an elections vehicle for constituent organisations. The local organisations remain autonomous, and their relationship with the NCCM is governed by constitutional and policy guidelines. There are six organisations currently

participating in a provincial umbrella organisation, which includes organisations in Kathu, Prieska, Barkly West, and Douglas.[35]

In the 2024 provincial election, the NCCM won a total of 7 016 votes, which amounted to 1.77% of the provincial vote.[36] It did not qualify for a seat in the provincial legislature. However, even though it is small, it will be important to assess its trajectory in future, as a new model of grassroots mobilisation and regional collaboration.

13.8 The Freedom Front Plus

Political representation of the FF+ in four municipalities

The Freedom Front Plus					SEATS		
	Ward votes	PR votes	Total votes	%	Ward	Total	
Richtersveld LM	108	94	202	2,3%	0	0	0
Nama Khoi LM	2232	34	457	1,5%	0	1	1
Khai Ma LM	147	143	290	3,3%	0	0	0
Kamiesberg LM	126	122	248	2,4%	0	0	0

13.9 Congress of the People (COPE)

Political representation of COPE in four municipalities

COPE					SEATS		
	Ward votes	PR votes	Total votes	%	Ward	Total	
Richtersveld LM	-						
Nama Khoi LM	131	143	274	0,9%	0	0	0
Khai Ma LM	255	247	502	5.8%	0	1	1
Kamiesberg LM	-						

35 https://nccm.org.za
36 https://results.elections.org.za/dashboards/npe/

14: Financial challenges in Nama Khoi LM

Nama-Khoi Local Municipality financial overview [37]

Indicator	Details
Audit reports	Qualified audit reports, and "audit outstanding" opinion
Creditor Payment Period	Average of 892 days (should be <30 days)
Unrecoverable Municipal Debt	88% of municipal debt is uncollectible
Debt Collection Period	Average of 68 days to collect debts owed
Total Liability Position	No total liability position at year-end
Bank Balance at Year-End	Positive cash balance (no overdraft)
Deficit for the Year	Spent R71.8 million more than income
Budget Spending	Over 50% of following year's budget already spent (i.e. overspending)
Financial Sustainability Concerns	Indications of poor resource management and long-term viability risks

The municipality's total expenditure, which includes salaries, finance charges, and other operational costs, has regularly outpaced revenue, reflecting poor fiscal discipline and inefficient resource allocation. Finance charges have increased from R3 million in 2018/19 to R6,7 million in 2022/23. (However, the political transition to a coalition council in 2021 may start to turn this situation around).

Cash flow from operating activities remains problematic, reaching a deficit of R1,4 million in 2022/23. It received capital transfers of R3,5 million in 2022/23, but the lack of internal funds to support capital expenditure illustrates a dependence on external financial aid. The municipality's poor performance in managing unauthorised, irregular, and fruitless expenditure — which amounted to R34 million in 2021/22 — further compounds concerns about its financial oversight and creditworthiness.

The negative cash balances at year-end and the increasing liabilities, with current liabilities surpassing current assets, signal a critical liquidity position that could undermine its ability to manage future financial obligations. Strengthening financial management and improving revenue generation strategies, alongside better expenditure control and accountability, are essential for improving the municipality's financial position and securing its long-term fiscal health.

According to the municipality's annual report, the municipality achieved a 93% compliance rate with the National Treasury as of June 2024.[38]

[37] AGSA, 2022. *Consolidated report on local government audit outcomes*, 2021-2023. Typical factors are material misstatements in areas such as taxes, receivables, and inventory, alongside insufficient audit evidence for several financial transactions, including maintenance expenses and contracted services. Non-compliance with supply chain management regulations also contributed to understated irregular expenditure in the financial statements.

[38] Nama Khoi LM, 2024. *Annual Report,* p. 22.

15: Service delivery and financial difficulties in Khai-Ma Local Municipality

Service Delivery and Infrastructure Challenges in Khai-Ma Local Municipality[39]

Area	Challenges	Required Resources/Actions
Solid Waste Removal	Lack of regular waste removal, especially in Witbank. More households require expansion of services. Illegal dumpsites removed periodically with contractor support. Limited service in towns like Onseepkans, Blyvooruitsig. No officer for waste management or environmental by-law enforcement. Insufficient machinery for waste clearing.	Financial aid for vehicles, machinery, and regular waste removal. Integrated Waste Management Plan needs updating. Additional refuse trucks and timely provision of refuse bags. Appointment of an enforcement officer. Procurement of TLBs and tipper trucks.
Recycling and Transport	Green Dream project started in Pella. Lack of transport for recyclables, especially large loads.	Dedicated recycling vehicles, need suitable site for Pofadder project.
Waste Disposal Sites	Licensed sites in some areas; Pofadder site exhausted.Lack of landfill in Witbank, fencing issues, illegal dumping.	New landfill sites, rehabilitation of Pofadder, fencing, funding.
Energy & Electricity	No comprehensive energy plan. Consultant has not delivered a draft.	Expedite energy master plan development.
Human Resources & Skills	Limited trained staff for infrastructure maintenance. Temporary cleanup by Dept. of Environmental Affairs.	Training programs and permanent staff for waste management.
Road Backlogs	Gravel roads need upgrading to paved surfaces. Limited paved sections. Lack of machinery for road leveling and repairs. Existing grader needs repair. No formal maintenance plan. Ad hoc repairs made through external support.	Restart paving projects and address rocky areas. Develop a comprehensive road maintenance plan.
Stormwater Management	Basic stormwater channels, need for upgrades. Open channels, some requiring more robust lining.	Upgrade stormwater systems.
Vehicles	Insufficient funds for fleet maintenance. Rising costs of maintenance of four sewer trucks. Financial losses	The current fleet will not be sufficient to handle wastewater removal in the next five years, considering the projected increase in conservancy tanks

The municipality's total expenditure, which includes employee costs, finance charges, and other operational costs, has regularly outpaced revenue. Rising finance charges, from R3 million in 2018/19 to R6,7 million in 2022/23, could exacerbate the municipality's financial problem.

The deficit from operating activities, reached R1,4 million in 2022/23. It received capital transfers of R3,5 million in 2022/23, the lack of internal funds to support capital expenditure further illustrates a dependency on external financial aid. The municipality's poor performance in managing unauthorised, irregular, and fruitless expenditure — which amounted to R34,8 million in 2021/22 — further compounds concerns about its financial oversight and creditworthiness. Strengthening financial management and improving revenue generation strategies, alongside better expenditure control and accountability, are essential.

The Khai-Ma Local Municipality has consistently received a qualified audit opinion between 2018 to 2022.[40] Key challenges identified include inadequate internal controls, incomplete or unsupported

39 Khai-Ma Local Municipality, 2023, *Integrated Development Plan,* pp 7, 32. 38.

40 Source: Municipal Monies: Khai-Ma Local Municipality https://municipalmoney.gov.za/profiles/municipality-NC067-khai-ma/

financial records, and non-compliance with regulations governing financial management and procurement processes (AGSA, 2021)[41].

Khai-Ma Local Municipality financial overview (AGSA, 2021)

Indicator	Details
Audit reports	Qualified reports, 2018-2022
Creditor Payment Period	Average of 829 days (should be <30 days)
Unrecoverable Municipal Debt	94% of municipal debt cannot be recovered
Debt Collection Period	Average of 31 days to collect debts owed
Total Liability Position	No total liability position at year-end
Bank Balance at Year-End	Positive cash balance (no overdraft)
Deficit for the Year	Spent R6.8 million more than income (i.e. overspending)
Budget Spending	Over 50% of next year's budget already spent

These issues reflect weaknesses in the municipality's ability to effectively manage public funds and adhere to necessary financial standards.

16: Municipal infrastructure and financial challenges in Kamiesberg LM

Service Delivery Challenges in the Kamiesberg Local Municipality[42]

Service Delivery Challenges	Details
Budget Constraints and ongoing economic difficulties	Limited funds for maintaining existing infrastructure. Reduced revenue and limited ability to meet service delivery expectations.
Personnel Capacity	Insufficient training and availability of skilled personnel.
Ageing infrastructure (water, sewerage, roads, electricity)	Increased costs for maintenance and upgrades, affecting service quality and reliability.
Water Supply Issues	Inadequate surface and underground water supplies due to drought. Urgent need for an underground water survey to develop a long-term water security strategy. No Water Asset Management Plan.
Rising bulk electricity costs (Eskom tariff increases)	Increased service tariffs for residents, making services less affordable.
Water Scarcity	General low water consumption, with the first 2 kl provided free to households; reliance on drought relief funding.
Ageing fleet	Higher repair and maintenance costs due to an outdated fleet.
Housing Demand	Growing housing needs exceed the available funding resources.
Unlicensed Dumping Site	Hondeklipbaai dumping site remains unlicensed despite submitted applications.
Poor Road Conditions	Most access roads are gravel and in poor condition, except the road between Garies and Klipfontein.

41 AGSA. 2021. *Consolidated general report on the local government audit outcomes 2020-2021*. Auditor-General South Africa. Available: https://mfma-2021.agsareports.co.za/

42 Kamiesberg LM, Annual Report 2022/2023; Kamiesberg Medium Term Revenue and Expenditure Forecasts 2022/23 to 2024/25; Kamiesberg LM, 2024. 2023/24 Final Annual Budget and MTREF; Kamiesberg LM, 2024, *Integrated Development Plan*, p. 71.

Planning and Building Control	Limited capacity for effective planning and building oversight.
Vandalism of Municipal Assets	Significant increase in vandalism, leading to budget strain for repairs and replacements.
Communication Infrastructure	Some towns lack communication facilities.
Drought conditions	Strain on water resources and infrastructure, exacerbating service delivery challenges.

A deficit of R26m in 2022/23 signals ongoing financial difficulties. The municipality depends on government transfers, particularly for operational revenue, which makes up a large portion of its income, amounting to R35,6m in 2022/2023. Government transfers amounted to R35,6 million in 2022/23, The municipality's expenditure continues to exceed revenue, with total expenditure of R109,9 million in 2022/23, contributing to the sustained deficit. Rising employee costs, depreciation, and finance charges have added to the strain on the budget. Finance charges have escalated from R3,5m in 2018/19 to R10m in 2022/23.

In terms of capital expenditure, the municipality has managed to secure some funds through internally generated funds, but the overall lack of new borrowing options and declining capital expenditure will limit its ability to invest in infrastructure and service delivery. Cash flow remains a persistent challenge, with a negative cash flow of R2,4m by the end of 2022/2023. This lack of liquidity can severely affect the municipality's ability to meet its obligations and fund its operations. Compounding these issues, the municipality has faced significant unauthorised, irregular, and fruitless expenditure, with unauthorised expenditure amounting to R62,6m in 2022/23.

The Kamiesberg Local Municipality's audit outcomes have highlighted significant governance challenges, particularly regarding financial management and performance reporting. One of the key issues is the municipality's lack of reliable performance information, which makes it difficult to track the progress of development priorities and performance targets. The audit reports reveal that a substantial portion of the municipality's reported targets did not align with the planning documents, reflecting weaknesses in internal policies and monitoring systems.

The audits also revealed substantial concerns with unauthorised, irregular, and fruitless expenditure, which raises alarms about governance and compliance with financial regulations.

Between 2018 and 2024, the Kamiesberg Local Municipality faced significant challenges in its financial management, with numerous issues highlighted in audit reports. In the 2018-2019 financial year, the municipality was unable to account accurately for various revenue streams, such as grants and non-exchange revenue, due to inadequate accounting systems and record-keeping practices. [43] This resulted in misstatements in financial records and a lack of sufficient audit evidence for key transactions, such as overstated employee-related costs exceeding R1 million. In the 2018-2019 financial year, the municipality received a Disclaimer of Opinion, with the Auditor-General unable to form a judgment due to insufficient documentation.

Moreover, the municipality's operational and financial processes revealed serious inefficiencies, such as the incorrect accounting for irregular expenditure. These issues were compounded by underspending in critical areas like water and electricity operations, which exacerbated resource shortages.[44] The municipality also struggled with managing its electricity distribution system, where material losses were not adequately substantiated.

[43] AGSA, 2019. *Annual audit outcomes for local municipalities*. Available at: https://mfma-2019.agsareports.co.za/municipality/8-kamiesberg

[44] AGSA, 2022. *Consolidated report on local government audit outcomes*.

Kamiesberg Local Municipality financial overview[45]

Indicator	Details
Audit reports	2018-2019: Disclaimer of Opinion; 2019-2020: Qualified; 2020-2021: Outstanding (presumably not submitted at all); 2021-2022: Qualified; and 2022-2023: Qualified
Going Concern Uncertainty	Municipality's continuing operation has been in doubt for more than 5 years
Creditor Payment Period	Average of 1,287 days (should be <30 days)
Unrecoverable Municipal Debt	77% of municipal debt cannot be recovered
Debt Collection Period	Average of 320 days to collect debts owed
Total Liability Position	No total liability position at year-end
Bank Balance at Year-End	Positive cash balance (no overdraft)
Budget Spending	Over 50% of next year's budget already spent (i.e. overspending)

Kamiesberg Local Municipality's reliance on external grant funding and its financial instability underscore the urgent need for enhanced governance and stricter financial controls. Failure to effectively address these systemic issues could jeopardise the municipality's capacity to manage large-scale infrastructure projects, ultimately exacerbating its financial difficulties and impairing its ability to deliver services. A sustained lack of financial oversight may hinder long-term sustainability and further erode the municipality's credibility in managing development initiatives

45 Municipal Monies: Kamiesberg Local Municipality https://municipalmoney.gov.za/profiles/municipality-NC064-kamiesberg/

APPENDIX 7-B

Economic data

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1: Sectoral economic shifts, 1968, 1978, 2022[1]

Percentage of economic sectors in the economy of Namakwa DM

Sector	1968	1978	Current (2022)[2]	Northern Cape 2022	Namakwa 1968-2022
Mining[3]	82 %	86 %	40 %	22 %	Dramatic decline as percentage, but greater than Provincial average
Agriculture	4	3	12	8	Dramatic increase as percentage, higher than Provincial average
Trade, Catering and accommodation (incl tourism)	4	3	10	11	Significant increase as percentage, almost equal to provincial average
General government / community services	3	3	18	28	Dramatic increase as percentage, still lower than provincial average
Construction	2	1	2	2	Static as share of provincial economy; equivalent to provincial average
Finance	2	1	10	14	Dramatic increase as percentage, still lower than provincial average
Manufacturing	1	0	2	4	Significant increase as percentage, still lower than provincial average
Transport and communications	1	1	6	8	Dramatic increase as percentage, still lower than provincial average
Electricity	?	?	2	3	Cannot be determined longitudinally
General	3	3	0	0	
TOTAL	**100**	**100**	**100**	**100**	

1 Dunne (1986), J, *Regional Development Strategy for Namaqualand*, p. 119.
2 South Africa Regional Explorer, in Northern Cape Profile, 2024, p. 17.
3 Currently, there is a likely and significant expansion of mining in the Khai Ma Local Municipality, in terms of the Vedanta Zinc Mine and the Special Economic Zone. However, these impacts have not percolated into the statistical profile.

2: Employment by sector in Namakwa and Northern Cape

Employment by sector, Namakwa (1980-2023) and Northern Cape (2023) [4]

Purple indicates decline, Green indicates growth

Industry	Namakwa Percentage 1980	Namakwa Percentage 2023	Northern Cape Percentage 2023	Comments
Mining	45 %	13	10	Drastic decline as district share; still larger than provincial average
Government Services	15	28	26	Almost doubling as district share, on par with provincial average
Construction	12	7	8	Decline as district share, on par with provincial average
Agriculture	9	13	18	Significant increase as district share, less than provincial average
Trade, catering and accommodation	8	17	12	Doubling as provincial share, greater than provincial average
Unclassified	5	0	0	
Transport and communication	3	3	4	Static, same level as provincial average
Manufacturing	1	4	4	Significant increase as district share, on par with provincial average
Electricity	1	0.6	0,4	Declining district share, on par with provincial average
Finance and Real Estate	1	8	10	Massive increase as district share, less than provincial average
Households	0	7	7	On par with provincial average
TOTAL	**100%**			

People with work experience in sectors related to the Port and GH projects:

MSP reports: The data below shows figures from 2018 (number of jobs per sector, and percentage share), as well as the average employment growth in the three years 2016-2019): [5]

In **Richtersveld LM**, the largest employment sectors are:

- Community, social and personal services: 948 people (21%), which increased by 40 people between 2016 and 2019
- General government: 824 people (18%)
- Trade, catering, accommodation: 819 people (18%), but this sector showed the strongest growth (72 people)
- Mining and quarrying: 464 people (10%), which declined by 64 people between 2016 and 2019

4 Dunne, J, *Regional Development Strategy for Namaqualand,* (1986), p. 99 and Northern Cape Profile, 2024, p. 25.

5 *Municipal Socio-economic Profiles* (MESP), reports compiled by National Treasury and GTAC. See https://lg.treasury.gov.za/ibi_apps/portal/Municipal_Socio_Economic_Profiles. Calculations based on Quantec and Urban-econ calculations, 2020.

- Agriculture: 385 people (9%), slightly declining
- *Construction: 294 people* (6.5%)
- *Small numbers of people work in the Electricity, Water, and Transport sectors*.

The Construction/Utilities/Transport group of employed people will likely number about 300-400.

In **Nama Khoi LM,** the largest employment sectors in 2018 were, listed by size and trend:

- Trade, catering and accommodation: 3746 people (24% of the workforce), increasing trend
- General Government: 2713 people (17% of the workforce), increasing trend
- Mining and quarrying: 2553 people (16%), but it declined by 89 people between 2016 and 2019)
- Community, social and personal services: 1824 people (12%), increasing trend
- Finance and business services: 1 496 people (10%), increasing
- Agriculture and fishing: 1082 people (7%), declining trend
- *Small numbers of people employed in Construction (913 people, declining trend), manufacturing (711 people, increasing trend), Transport (651 people, increasing trend), and* Electricity *and Water (115 people).*

This means that about 2 500 people in Nama Khoi LM have had exposure to the kinds of sectors required for the Port and GH Complex.

In **Khai-Ma LM**, the profile is very different, with intensive agriculture being the most prominent.

- Agriculture: 2248 people (48%), by far the largest, but showing a declining trend
- Government: 583 people (13%), growing trend
- Trade, catering and accommodation: 443 people (12%), growing trend
- Mining and quarrying: 237 people (5%), declining
- *Construction: 133 people (0,1%), declining*
- *Transport: 73 people*
- Small numbers of people in the other sectors.

Only about 200 people would have had exposure to likely sectors in the Port and GH complex.

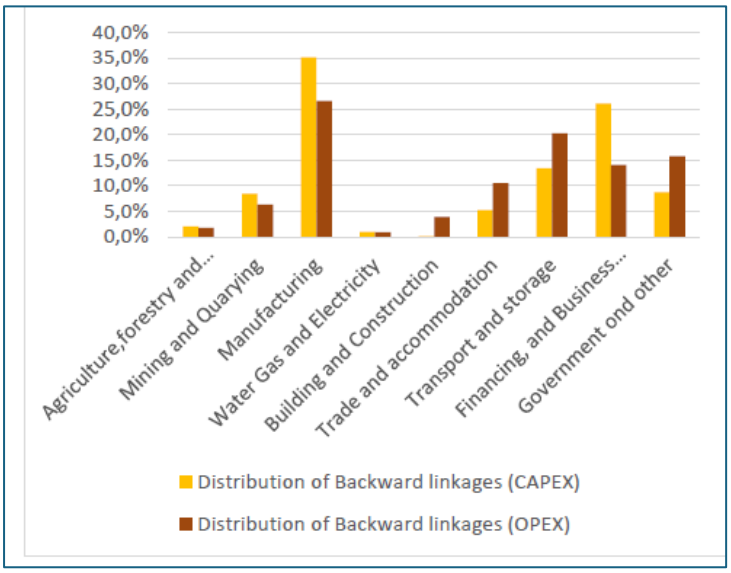
In **Kamiesberg LM,** in 2018:

- The largest employment sector was agriculture: 591 people (24%, and declining)
- Government: 492 people (20%, and declining)
- Trade, catering and accommodation: 380 people (15%), and growing
- Construction*: 244 people (10%).*
- Transport*: 45 people (2%)*
- Small numbers in other sectors.

Like Khai-Ma, only about 300 people would have had exposure to construction, transport and artisan-type trades.

3: Backward economic linkages of the Boegoebaai Port[6]

Likely backward linkages due to the development of the Port



The Transnet study highlighted the direct, indirect and total impacts of the Port, as follows:

Economic impacts during the Construction Period of the Port

Impact Variable	Boegoebaai Port - CAPEX (2024) Impact			
	Direct	Indirect	Induced	Total
New business development (Rm)	12 592.6	3 429.3	11 833.7	27 855.6
Gross geographic product (Rm)	3 220.7	1 324.7	4 628.4	9 173.8
Employment	7 190	4 400	16 200	27 790
Total worker income (Rm)	1 723.4	706.2	1 974.9	4 404.5
Taxes(Rm)	731.9	240.7	750.1	1 722.7
Multiplying effect				
New business development (R'm)	1.0000	0.2723	0.9397	2.2121
Gross geographic product (R'm)	0.2558	0.1052	0.3675	0.7285
Employment	0.5710	0.3494	1.2865	2.2068
Total worker income (R'm)	0.1369	0.0561	0.1568	0.3498
Taxes (Rm)	0.0581	0.0191	0.0596	0.1368

Source: SRR Socio-economic Impact Model, 2024.

6 Transnet 2024, *Boegoebaai Port Development SEB Report*, p. 19.

Economic impacts of the Port during the operational phase

Impact Variable	Boegoebaai Port Opex Impact			
	Direct	Indirect	Induced	Total
New business development (R'm)	2 000.0	459.6	1 734.6	4 194.2
Gross geographic product (R'm)	735.7	177.0	684.4	1 597.2
Employment	420	586	2 350	3 356
Total worker income (R'm)	152.0	94.0	295.4	541.4
Taxes	97.4	33.0	113.9	244.2
Multiplying effect per R1,000,000				
New business development	1.0000	0.2298	0.8673	2.0971
GGP	0.3679	0.0885	0.3422	0.7986
Employment	0.2102	0.2928	1.1748	1.6779
Tot. worker Income	0.0760	0.0470	0.1477	0.2707
Taxes	0.0487	0.0718	0.0657	0.0582

4: Tourism subsectors in Namaqualand

4.1 Agri-tourism

Some farmers are turning to agri-tourism and eco-tourism options for another income stream. One of the most iconic "tourism" linked farms is Sarrisam is in the Groenriver area. Other tourism attractions on farms include the Donkey railway track, Schaap River Canyon near Bulletrap, the Spoegriver Caves, the Namakwa 4x4 route, Klein Pella, rock pilings at Helskloof near Kotzeshoop, Kinderlê monument near Steinkopf, ship wreck route, and Noup (known for its diamond diver huts and waves for the surfer community). Spending a day in the countryside with herders could be a marketable option.

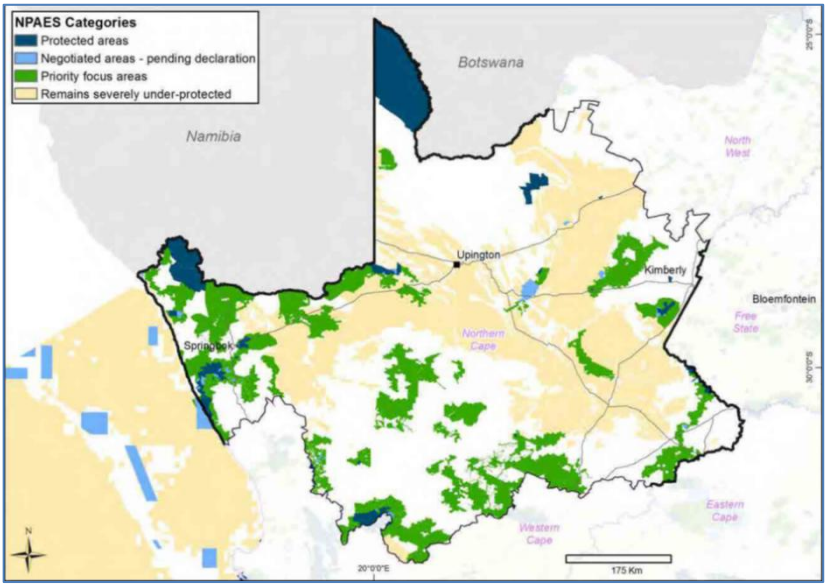
Given the growth of tourism described in the previous chapter, the scope for further agri-tourism, on commercial and communal farmland, is immense.

4.2 Biodiversity

The importance in terms of biodiversity and conservation value is underscored by the National Protected Area Expansion Strategy for South Africa (2016), which is based on the National Environmental Management: Protected Areas Act, 2003 (act no. 57 of 2003). This Act aims to create a representative network of protected areas on state land, private land and communal land, and to provide guiding principles for norms and standards to protect ecologically viable areas representative of South Africa's biological diversity and its natural landscapes. The Act also promotes nature-based tourism. With a new appreciation of the importance of biodiversity for tourism purposes, a momentous economic shift is taking place: "Taken as a whole, the demographic, socio-economic and land-use changes that signal the onset of the post-agrarian ecological revolution are becoming evident in the landscapes and ecosystems of Namaqualand as they begin to recover from two centuries of intensive colonial exploitation."[7]

[7] Hoffman, M.T. and Rohde, R.F. 2007. 'From pastoralism to tourism: The historical impact of changing land use practices in Namaqualand', p. 656.

The Northern Cape SDF points to the importance of preserving areas of natural beauty.[8] " Protected areas" are "aesthetically prominent natural features ... to promote natural scenic beauty or biodiversity".



Priority areas for protected area expansion in the Northern Cape.

Protected areas can include productive farms, but under certain prescribed conditions relating to sustainable stocking practices. For example, 26 farmers that are allowed to farm with a maximum of 950 Large Stock Units in the Richtersveld National Park. In addition, the Orange River Mouth Corridor Tourism Master Plan (2013) can guide tourism development in the area.

Typically, the biodiversity sector relies on public sector finance, but this sector has received substantial investment through various donors, such as the Global Environment Facility (GEF), the Critical Ecosystem Partnership Fund (CEPF), the Norwegian Agency for Development Cooperation (NORAD) and World-Wide Fund for Nature (WWF) and Wilderness Foundation. A concerted approach between farmers, government departments (Agriculture and Nature Conservation) and tourism bodies in the region can maximise tourism on these protected lands.

4.3 Indigenous history of Namaqualand

The archaeological richness of pre-colonial people, as well as stone age civilisations, in the entire Namakwa region can be utilised for local displays; (see Appendix B).[9]

The San were the original inhabitants, and lived as hunter-gatherers. Their cultural practices and knowledge, such as tracking, hunting and ethno-botany, are ideal for cultural displays.[10] The Nama culture is also suitable for tourist information sites.

4.4 Christian missions

In Namaqualand, these include the German Mission at Kommas (Pella) and Steinkopf in 1812; Barnabas Shaw, a Wesleyan (Methodist) missionary who settled at Leliefontein in 1824; the Rhenish Missionary Society which established the Komaggas mission, and later at Kookfontein mission (now Steinkopf). After 1870, Concordia became a separate mission station and reserve. The mission stations became the core settlements of the coloured reserve land. Each mission

station has its own colourful history, which can be celebrated in tourist displays. In the Richtersveld Park, for example, Rev W Richter, a Dutch missionary at Kuboes, can be celebrated.

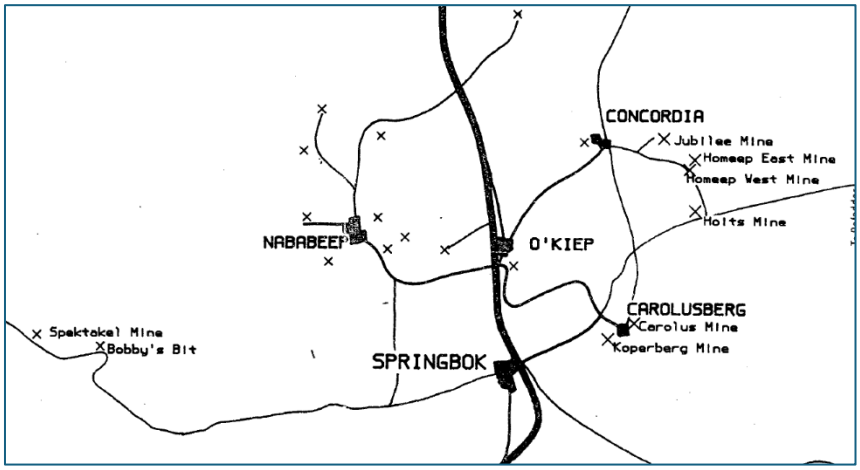
8 Northern Cape, 2022, *Spatial Development Framework,* p. 201.
9 Webley. L,2007,Archaeological evidence for pastoralist land-use and settlement in Namaqualand.
10 Tourism routes in this section were conceptualised by the Namakwa District Municipality: https://www.namakwa-dm.gov.za/wp-content/uploads/2017/07/Experience-Namibia-Map.pdf

4.5 Copper mining

The O'kiep copper district covers an area of 15 000 km2, and includes Springbok, Nababeep, O'kiep and Carolusberg. A speculation boom took place in 1853 and 1854, with overblown expectations of copper ore and profitability. Only three companies survived by 1857. Ore was taken by mule to the Orange River, sent in barges to Alexander Bay, and shipped to England. By 1870, smelting was done at Springbok and O'kiep. In the 1860s, Government built its first road, from Springbok to Hondeklip Bay; but the Cape Copper Company got permission to build a rail line to Port Nolloth in 1876. For 68 years, the little railway was the main outlet to the sea. In 1886, mule traction was replaced by steam engines, but mules were retained for passenger traffic until 1896 (see Appendix B).

Okiep is the hub of this route, where there is already a beautiful museum.[11]

Key copper mining sites[12]



4.6 Diamond mining

Diamonds were first discovered in Namaqualand in 1926 by Captain Jack Carstens, the son of a Port Nolloth shopkeeper. He found them in a coastal tract of land stretching from the Orange River to the southern boundary of Port Nolloth. Soon prospectors, option buyers and diamond buyers flocked to the coast, creating a "diamond rush", with claims pegged mainly around Alexander Bay. This area became the world's richest diamond area, yielding 2762 diamonds on only one month.[13] Fearing another chaotic event like the Lichtenburg diamond rush, the Government prohibited all diamond mining on the Namaqualand coast in 1927. At that point, Ernest Oppenheimer bought the entire output of the Namaqualand fields, and placed the stones on the world market in an orderly manner. The Government then proclaimed the coast a State diggings, except for six discoverers' rights on distinct geological deposits. Merensky and Oppenheimer bought up the other discoverers' rights, and became sole controllers of Alexander Bay, being obliged to sell their stones to the Government.

The "Namaqualand Rebellion" took place in December 1928, because of the prohibitions on private diggings and illicit diamond dealers. The State responded by increased policing, employment on roadworks and railways, and the establishment of a poverty relief fund. The Kleinzee Museum offers the history of diamond mining. A mine tour shows the workings of a modern alluvial diamond mine.[14]

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11 https://onsknk.co.za/Businesses/SeeDo/okiep-museum/3370
12 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* p. 141.
13 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* p. 50.
14 Namakwa Info. 2025. *Northern Cape. Kleinzee.* https://www.namakwa-info.co.za/region/town/523/kleinzee ; https://www.namakwa-info.co.za/region/town/523/kleinzee

4.7 Geology

Namaqualand started forming some 2,600 million years ago with volcanic eruptions.[15] The area contains some of the world's most unique geological formations, long pre-dating the Gondwana split, and holds great mineral wealth. The heart of Namaqualand comprises an almost circular intrusion of igneous (volcanic) rocks, with the centre comprising the high granite massifs of the Kamiesberg themselves, surrounded by a landscape of rolling dome-shaped hills. These unique geological features offer breathtaking views. The region's rugged terrain is ideal for thrilling 4x4 routes. Along the coast is a sandy plain known as the Sandveld, with active dune fields,

The Richtersveld, a mountain desert with arid plains, has been described as “one of the most interesting and visually stunning geological areas of Southern Africa”, with coastal plains and mountain ranges (Ploegberg, Stinkfonteinberge, Vandersterrberg). The far north-east corner of Namaqualand is marked by the very hot and arid Gariep River valley, flanked by very broken mountainous terrain. This remarkable geological diversity underpins the mining history of copper and diamonds. In fact, the whole area amounts to an “open-air museum”. A large geological literature is available to use for tourism displays.

4.8 Fishing, marine life and shipwrecks

The west coast of Namaqualand hosts four Marine Protected Areas (MPAs), as gazetted in 2019. They are the Orange Shelf Edge (off-shore from Port Nolloth, an example of a healthy sea bed); the Namaqua Fossil Forest (Off-shore from Kleinzee, a fossilised forest of yellowwood trees, dating from 1 million years ago); the Namaqua National Marine Park, which includes giant kelp forests and deep mussel beds; and “Child’s Bank” (pristine corals, supporting very diverse sea life).[16] Displays at coastal towns can educate visitors (and local communities) about the marine treasures that lie close off-shore. The MPA also supports the recovery of West Coast lobster from over-fishing in the past, and helps to protect a distinctive West Coast cuisine. Interventions should include education programmes, skills development, and infrastructure development, to support tourism.[17]

The shipwreck trail connects three major shipwrecks, namely, the Piratiny, the Border and the Arosa. The tours include travelling along the coast and visiting the beaches, archaeological sites, and landmarks. These are managed by a private company.

[15] Cornell, DH et al, 2006, The Namaqua-Natal Province; Cornell, FC, 1920. The glamour of prospecting.
[16] https://www.marineprotectedareas.org.za/namaqua-national-park-mpa
[17] Namakwa DM, *Spatial Development Framework*, 2023.

5: Potential tourism routes in Namaqualand

5. The Clara Steam Locomotive Route

Clara is the name given to the steam locomotive which transported the copper ore from the inland copper mining towns to the harbour at Port Nolloth from where it was shipped to foreign markets. Tourists can go on a 4x4 or hiking trail along Clara's former railway line that starts in Nababeep at the mine museum, where Clara is parked, and ends at Okiep where the locomotive was parked for many years after her last journey.

Town	Tourist Attractions
Okiep	This historic copper mining town is the oldest mining town in the Southern Hemisphere. The current Anglican Rectory was the location of the original Okiep railway station.
Stuierkraal	A Cornish structure along the N7 between Okiep and Steinkopf where Clara, the steam locomotive, used to stop for water.
Steinkopf	Here tourists can visit the site of the old hotel that housed Clara's passengers.
Port Nolloth	This is where Clara's journey ended and from where her cargo was shipped off to foreign markets.

4. The Pilgrimage Route

On this route tourists can visit several churches and missionary stations in the Namakwa area that were established by the Rhenish Mission Society, the London Mission Society, the Church of England, the Roman Catholic Church, the Methodist Church, the Jewish Society and many other church organisations. These church organisations established both churches and schools in the area and contributed greatly to education and religion in the area. The pastors in charge of these churches also assisted in the negotiations for land and other rights for the local communities.

We trust that you will be inspired by the relics and remains of the past decades which strived to preserve and develop religion in our communities.

Town	Historical Background	Tourist Attractions
Springbok	Springbok is rich in religious, historical and cultural heritage with English, Dutch Reformed and Jewish influences that are visible in the architecture of the town.	» Synagogue (Namakwaland Museum) » Dutch Reformed Church/Die Klipkerk » All Saints Anglican Church » Saint Peter and Paul Roman Catholic Church in Maatjieskloof » Saint Ann's School for Girls under the management of the mission's nuns
Concordia	Founded in 1852 by Reverend Brecher from the Rhenish Missionary Society.	» Rhenish Missionary Church with its Cornish architectural building style
Kuboes	The town of Kuboes was founded in 1844 by Reverend Johan Hein of the Rhenish Missionary Society.	» The Johan Frederick Hein United Reformed Church
Pella	A mission station was opened here in 1878. The Roman Catholic Church took over an already existing mission station from the London Missionary Society after it was closed down. It was reopened by the Roman Catholic Church.	» Roman Catholic Cathedral » Museum » Mission/Convent School
Kamieskroon	Roman Catholic Mission Station	» Kamieskroon Roman Catholic Church and Mission
Leliefontein	Methodist Mission Station	» Leliefontein Methodist Church (a national monument)
Nourivier	Methodist Mission Station	» Nourivier Methodist Church and Primary School
Soebatsfontein	United Reformed Community	» United Reformed Church and Primary School
Steinkopf	The town was founded as a Rhenish Mission Station for the Nama people in the area.	» Dutch Reformed Church
Calvinia	The historic town of Calvinia was influenced by various religions. There's the story of the demolishing of the Anglican Church in the Apartheid era, the Dutch Reformed Church and even the Star of David.	» The Anglican Church » The Dutch Reformed Church » The Sinagogue that later became the Calvinia Museum

1. The Historic Copper Mine Route

This is a self-drive tour through the region's historic copper mining towns. The copper mining history dates back to 1685 when Simon van der Stel's search for gold led him to discover copper at Carolusberg. Commercial copper mining commenced in 1852 and drew to a close in 2004. The Okiep Copper Company (OCC), or "Jan Komponie" as the locals referred to it, was once a well-known industry leader in the copper mining sector. This route will take you on a journey through Carolusberg, Springbok, Concordia, Okiep, Alexander Bay, Hondeklip Bay and Nababeep.

We trust that your copper mining town experience will be one to remember.

Town	Historical Background	Tourist Attractions
Alexander Bay	Copper ore was conveyed in bags from Kodas in the Richtersveld down the Orange River to the shores of Alexander Bay for shipping purposes by Sir James Alexander in 1836.	» Alexander Bay Museum
Hondeklip Bay	After copper deposits were discovered by Governer Simon van der Stel's expedition party, a search began for a suitable harbour from where copper could be exported. In 1846 a small harbour was built at Hondeklip Bay. Copper was transported by ox wagons from the inland copper mines to Hondeklip Bay via Messelpad Pass between 1850 to 1852.	» Messelpad Pass » Hondeklip Bay Harbour
Carolusberg	In 1865 a mine shaft was sunk at Carolusberg, by order of Governor Simon van der Stel, in search of gold, but instead copper was discovered. Carolusberg was also recorded as one of the richest copper mining plants in the operating era of the Okiep Copper Company (OCC).	» Simon van der Stel Mine » Diep Oor Mine » Copper Rock Tourism @ 078 518 5495
Springbok	Springbok is the South-African town where the first commercial mining operations originated. Springbok's copper mining history dates back to 1852.	» The Blue Mine » Smelting Furnace » Old Cemetery » All Saints Anglican Church » Namakwaland Museum @ 027 718 8100
Concordia	Concordia's copper mining history also dates back to the 1800's. Ore was transported since 1876 from the Okiep station (today the Anglican Church, Saint Augustans Rectory) to Port Nolloth with "Clara", the old steam locomotive.	» Tweefontein Mine » Granite Ore Bins » Cornish architecture
Okiep	Copper was discovered here in 1855, which makes Okiep the second oldest mining town in South-Africa after Springbok.	» Cornish Pumphouse » The View Point at the Okiep Big Hole » Smoke Stack » Ship Engine (electricity generator for mining operations in Okiep) » Photo collection at the Okiep Country Hotel @ 027 744 1000
Nababeep	Nababeep is historically the last copper mining town of the OCC which closed down in 2004.	» Nababeep Mine Museum » Morning Glory Viewpoint

3. The Nama Culture Route

Culture enthusiasts can experience the Nama culture by eating dinner cooked in a traditional fashion on an open fire in an iron pot, sleep in a Nama hut and listen to the stories told by Nama elders. Tourists can also sit around the fire at night and experience Nama dancing and singing.

Town	Historical Background	Tourist Attractions
Steinkopf	This is where a Rhenish Mission Station was opened for the Nama people in the area.	» Kinderlê » Kookfontein Rondawels (Experience Nama cuisine and dancing)
Eksteenfontein	Here the Nama culture can be traced back to its nomadic status.	» Museum » Nama cuisine » Nama story-telling, dancing and singing
Kuboes	The Nama capital of the Richtersveld.	» Nama being taught at the primary school » Nama cuisine » Nama huts » Nama dance groups
Pella	The Nama people's tracks can also be followed to Pella.	» Museum

2. The Historic Diamond Mine Route

Tourists can explore the Diamond Mine Route of the Namakwa region that stretches from Hondeklip Bay along the coast up to the Richtersveld along the mighty Orange River. Diamond mining industry leaders such as De Beers and Trans Hex have been practicing commercial mining for decades in this area. Small-scale diamond mining and deep-sea diamond diving are still the course of business in the area. The diamond mining history of the region has been captured in photos, and tourists are welcome to visit the exhibitions of the diamond mining history in the museums in Kleinzee and Alexander Bay.

Town	Historical Background	Tourist Attractions
Hondeklip Bay	Trans Hex conducted diamond mining operations in the area from 1974 to 2003.	» Site of the Trans Hex mine workers' hostel on the beachfront near the Aristia shipwreck
Kleinzee/ Koingnaas	Commercial diamond mining dates back to 1927 on the farm Kleyleyn Zee after Jack Carstens discovered diamonds on the farm the previous year. Alluvial diamonds were commercially mined by De Beers in Kleinzee and Koingnaas. The village of Kleinzee was established in 1942 and Koingnaas during the 1970s.	» Kleinzee Museum » Diamond Coast Hiking Trail » Boulder Heritage Route (historic walk through the village of Kleinzee)
Port Nolloth	Small-scale diamond recovery and deep-sea diamond diving.	» Port Nolloth Museum
Alexander Bay	Alexander Bay's diamond history dates back to 1925, and commercial diamond and deep-sea diamond diving are still in operation.	» Alexander Bay Museum » Alexkor Mine is a South-African government owned diamond mine
Sandrift	Diamond in the Sandrift area dates back to the 1970s.	» Active commercial diamond mining is practiced in Sandrift/Barken

6: Agriculture

Number of farming units and area covered per district

District	Farm units	Area (ha)	Average farm unit size	Most prevalent farming types
Richtersveld	60	1 560 808	26 013 ha	Large communal farming units
Nama Khoi	236	1 496 301	6340 ha	Combination of commercial and private farming units
Kamiesberg	222	1 170 624	5273 ha	Combination of commercial and private farming units
Khai-Ma	97	825 657	8 511 ha	Large private farming units in Bushmanland
Total	**615**	**5 053 391**		

7: Coloured Reserve Areas (TRANCRAA communal land) in Namaqualand

Under the tutelage of the mission stations, coloured residents could not be coerced to enter the service of farmers; there were no provisions for preventing subdivision and joint ownership; and taxation was not strictly enforced.

By the beginning of the 19th century, the Nama were largely a landless proletariat and mission stations became their only places of refuge. The Namaqualand communal areas were based on "tickets of occupation" granted to the mission stations and the resident populations trying to protect themselves against dispossession and exploitation. The state took administrative control of the areas through the Mission Stations and Communal Reserves Act 29 of 1909. Later known as "Coloured Rural Areas" (administrated in terms of Act 9 of 1987), these "Reserves" are held in trust by the Minister of Agriculture and Land Affairs, but are managed by the local authorities. The 1909 Act imposed a head tax on adult males, which was aimed at decreasing pressure on the land and making labour available to the nearby white-owned farms. Local Boards were elected in the CRAs, which were now a form of civil administration, separate from the missionaries. The entire Act was deeply unpopular, and resulted in open defiance in some areas.

Substantial areas of land were expropriated from inhabitants and granted to the mining companies. The loss of the means of subsistence made inhabitants vulnerable to merchants who advanced commodities on credit, and "usurer capital", who purchased grain on credit. Consequently, the inhabitants became increasingly indebted, and had to repay debts in the form of labour (e.g. at harvesting time) or sell produce at prices fixed by traders.[18]

The successive apartheid governments' attempts to reform communal lands, including the forced individualisation of communal lands in the economic unit's programme, have had significant and lasting impacts on the social and economic fabric of communities. These policies disrupted traditional land tenure systems and communal living arrangements, causing a loss of communal identity and social cohesion. The forced individualisation often resulted in land fragmentation, making it difficult for small-scale farmers to achieve economies of scale and sustain their livelihoods.

For the next fifty years, few changes were made, and the communal land tenure system remained largely unchanged. There were several factors which "induced an official inertia to the Namaqualand region as a whole".[19]

- As the mines and their labour requirements declined, so the Reserves became insignificant;
- With few employment opportunities, the Reserve population was reduced to a general level of impoverishment accompanied by a lower level of internal protest
- The Okiep Copper Company was content with the communal system as the cost of maintaining its labour force was reduced; it did not have to provide housing and infrastructure for workers recruited from the reserves
- The Government was unclear about the status and future dispensation of coloured people.

In 1944, the Reserves were removed from the control of the Department of Native Affairs and transferred to the Department of Social Welfare. The Coloured Persons Settlement Act (Act no 7 of 1946) provided the legal basis for the reservation of new Coloured areas. Furthermore, the Rural Coloured Areas Act (Act 24 of 1963) provided for the incorporation of land already occupied by coloured communities. In future, the Government regarded CRAs as Rural Group Areas, where coloured people could get title to farmland and practice commercial agriculture. This differentiated residential from agricultural zones, and stipulated that previous commonage be made to "*bona fide* farmers" – a term which seemed to refer to full-time farmers.[20]

There have long been indications of growing class distinctions within the CRAs. The 1909 Act legally sanctioned the "kulak" (wealthier peasant) class, as access to "sub-economic" units on a permanent basis was undermined.[21] The missionaries also encouraged a progressive and productive peasant class. This led to an increase in the size of land-holdings by certain individuals and impoverishment for others.[22] Residents with capital, skills or secure employment also had an advantage; they were relatively mobile and could survive recessions by migrating for work. People without such assets suffered increasing impoverishment.[23] Since the 1960s, Government has focused on creating a class of independent commercial farmers – an endeavour which caused confusion and conflict, and which has always been in conflict with the dominant trend of utilising farming as a survivalist strategy in times of economic need.[24]

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18 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* 70, citing Luyt.

19 Sharp, JS (1984), "Rural Development Schemes and the Struggle against Impoverishment in the Namaqualand Reserves" (1984).

20 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* p. 39.

21 Dunne, JM, 1986, *Towards a Regional Development Strategy for Namaqualand* , p. 71, citing D Luyt, "The Transition to Capitalism in the Namaqualand Reserves", unpublished paper, UCT, 1982.

22 In the Richtersveld, particularly, there was a distinct difference between the land tenure reforms in the south of the "Reserve" (where the land was divided by Government into "economic units", available to larger or full-time farmers), and the north of the "Reserve" (where the communal land use system was retained) (Jurgens, N, 2001, Remarkable Differences in Desertification Processes)

23 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* p. 73.

24 Berzborn, S and Schnegg, M, 2007, Vulnerability, social networks, and resilience.

The insecure and non-permanent employment on the farms and mines meant that inhabitants in the communal areas were reluctant to sever their connections with the soil, which acted as the only form of security in their livelihoods. On these" Reserves", a large "surplus population" developed, who had no means of subsistence and no recourse to permanent wage labour. In fact, several interests wanted these people off the land – the elite peasants, the mines and the famers.

The communal areas continued to create a sense of community, because each dweller possesses a formal, communal title to the land. Furthermore, urban areas in Namaqualand have remained limited in terms of investment, and this slowed down out-migration and the formation of wider identities. The communal areas continued to offer security in the face of retrenchment, unemployment or retirement.[25]

By the 1980s, the Department of Local Government, Housing and Agriculture of the House of Representatives administered Namaqualand and other CRAs, under the provisions of the Rural Coloured Areas Law (1979). There are six "CRAs" (Coloured Rural Areas) in Namaqualand.

In practice, it has been very difficult to finalise governance institutions on communal land, due to complex dynamics within the communities and the lack of agricultural management capacity of the municipalities who should oversee the process. [26] It requires a delicate process of facilitation to grapple with these dynamics, and government institutions do not have the level of staffing and skills which would be required. This has blocked the "TRANCRAA process" and created a stalemate in some communities. The funding and institutional support required to carry out tenure reform was under-estimated by government. Reformed tenure rights are often ineffective and vulnerable if isolated from other entitlements such as training, finance and integrated development initiatives. Some of the communal management institutions remain weak, with inadequate institutional rules to ensure sustainable and profitable land use. This legal uncertainty has been described by some authors as a "tragedy of the commons" phenomenon, where ineffective institutions cause land users to over-exploit land resources (such as grazing).[27] Other authors dispute this depiction of the negative impacts of communal management. There may be some regional variation in the impacts of communal management on the environment.

The TRANCRAA Trust Land is still held by the Minister in terms of the Act of 1998. It is awaiting transfer to communities, pending the establishment of legal entities as communities have opted. In addition to the TRANCRAA and CPA legislation, the Spatial Planning and Land Use Management Act (2013) requires a proper land rights inquiry to be done to align the transfer of the land with the Spatial Development Framework of the relevant Municipality.[28] Thus far, different Act 9 communal areas have chosen somewhat different types of legal entity for future land management. Concordia, Pella, Steinkopf and Richtersveld have chosen CPAs. Leliefontein has chosen to remain under the Kamiesberg Local Municipality. Komaggas has not yet settled on a choice. [29] The first transfer has been made to the Concordia community in 2024, and the CPA therefore now has ownership and a title deed.

Since 1997, all municipal commonages received additional land (more than 300 000 ha) by means of farms bought by the then Department of Land Affairs (now Department of Rural Development and Land Reform) in terms of the Land Redistribution Act. Through this, grazing areas were expanded, and commonages could keep higher numbers of livestock. These newly bought farms are managed by commonage committees that consist of representatives of the users, municipalities, and the Northern Cape Department of Agriculture, Environmental Affairs, Land Reform and Rural Development (DAELR).

However, under the ineffective tutelage of the municipalities, there appears to be a process of "elite capture" of these newly acquired commonage farms, with wealthier farmers dominating local institutions and promoting their own land-use interests as larger-scale, full-time farmers.[30] These newly acquired commonage farms are often located far from people's place of residence in the towns, and require a "shuttle" mode of farming, where livestock owners and herders need to "commute" to the farms. This means that farmers need vehicles to access their livestock, and that again favours the wealthier farmers.

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25 Dunne, J, 1986, *Regional Development Strategy for Namaqualand,* 75, citing Klinghardt.
26 For example, in Komaggas. See Bregman, J, 2010, *Land and Society in the Komaggas region.*
27 Wisborg, P, 2003, TRANCRAA and communal land rights: Lessons from Namaqualand.
28 DALRRD, *Namakwa Spatial Framework*, 2023, p. 62.
29 DALRRD, *Namakwa Spatial Framework,* 2023, p. 62.
30 Lebert, T and Rohde, R, 2007. Land reform and the new elite.

In addition, these commonage farms create a financial burden for municipalities: To allow poor people access to commonage implies that the municipality must subsidize those users by either leasing the land at low rates (i.e. below the real cost of maintenance), or skimp on their maintenance responsibilities. The lack of administrative and financial capacity within municipalities makes it difficult for them to manage the commonage land effectively — both in terms of regulating access and maintaining physical infrastructure such as fences and water-points — and to ensure that the poor (those who are least able to pay user fees) are the primary beneficiaries of this land.[31]

[31] May, H and Lahiff, E, 2007, Land reform in Namaqualand, 1994–2005: A review.