• Introduction to coastal vulnerability
• Climate change
• Consequences on the coast
• Vulnerability and risk on coastal zones
• Adaptation measures
• Technology solutions
The team...
Introduction

Severe weather conditions:

- Potential delays at ports
- Impacts on tow-operations
- Impact on coastal infrastructure
- Present problems may increase due to climate change (e.g. SLR, storminess)
- Need to quantify how much worse it will become due to climate change. (e.g. coastal setback lines)
Climate change
Sea level rise

Present global sea level rise (since 1993) = 3.3 mm ± 0.4 mm/y

Literature: wide range of SLR scenarios, but most “physics/process based” projections (since 2007) for 2100 ~ 0.5 m to 2 m range

Proof of global warming?
Consequences on the coast
Some important potential consequences of global warming on southern African coast:

- Potential changes in ocean winds & local wave regime - direct wave impacts
- Extreme inshore sea water levels due to SLR & storms - flooding & inundation
- Coastal erosion & under-scouring due to SLR & sea storms
- Complexities, thresholds, & non-linearities - e.g. sand transport
- Combination of extreme events (sea storms during high tides + sea level rise) will have greatest impacts - these will increasingly overwhelm existing infrastructure. Southern WIO coastal zone very vulnerable to climate change impacts:
To prevent (more of) this: High seawater levels, wave run-up, flooding, erosion
Vulnerability and risk of coastal zones
Coastal hazard/vulnerability assessment & mitigation

Primary hazards to (physical) coastal infrastructure related to sea storms

- Direct wave impacts
- Coastal flooding & inundation
- Erosion & undermining

Hazard/vulnerability modification factors

Location, underlying & local site characteristics:
- Elevation
- Distance
- Exposure to waves
- Erosion / accretion rate
- Underlying geologic erodeability
- Geomorphologic stability
- Ground cover
- Anthropogenic actions affecting stability or sediment supply
- SLR erosion
- Slope
- Dune height

Environmental factors:
- Wave regime (height, period, direction; frequency)
- Inshore sea-water levels (tides, barometrics, wind setup, wave setup & runup, SLR)

Drivers of Change

- Climate Change: Sea level rise & erosion
- Metocean climate (e.g. waves)
- Land transformation
- Demographics: population, economics
- Etc.

Resultant coastal vulnerability

Intervention measures e.g.: Setback Line

» Residual risk

Vulnerability
Example: Mossel Bay Vulnerability Mapping

Final with weighting

Legend:
- 2.4 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0

#1 Elevation
#2 Distance to infrastructure
#3 Tidal range
#4 Maximum offshore wave height
#5 Degree of protection
#6 Historic erosion/accretion rate
#7 Geology
#8 Geomorphology
#9 Groundcover
#10 Anthropogenic actions
#11 Relative height of the protective foredune buffer

Legend:
- 1
- 2
- 3
- 4
- 5

Scale: 20 km
Extreme SA “storm surge” levels (i.e. excluding wave run-up)

SA regional coastal storm surge levels for 1-in-10 year wave return period and 0 m SLR scenario

SA regional coastal storm surge levels for 1-in-50 year wave return period and 1 m SLR scenario
Quantification of risks to coastal areas and development: wave run-up, erosion, climate change.

Illustration of predicted combined effects of potential shoreline erosion with Bruun’s rule and higher wave runup for a 0.5 m rise in sea level and a 1-in-20-year sea storm on the Blaauberg coast.
Examples of coastal development setback lines determined for Richards Bay.

Mathematical modelling of shoreline evolution (1-line)
MOZ example: mapping of areas vulnerable to SLR erosion, preliminary setback line for new developments

- **Potential** erosion due to 2m SLR by 2100
- **Potential** erosion by SLR + setback
- **Detail** terrain adjustment of setback line
Adaptation measures
What can be done about the risks?

‘NO REGRET’ ADAPTATION MEASURES
Adaptation to change or hazards

- Southern African states: very little adaptive capacity + ability to halt coastal impacts on a large scale virtually non-existent.
- Adaptation would reduce impacts by factor 10 to 100 - minor cost compared to damage avoided.
  » Set & implement adaptation measures sooner rather than later!
- To mitigate detrimental impacts of climate change:
  understand adaptation options available to s. African society – considerably different from developed county approaches.
PURPOSE & APPROACH

To adaptation measures

- Conservative / precautionary principle
  - Authorities: pro-active approach to protect lives, livelihoods and infrastructure (Prevention is better than Cure)

- Sustainable solutions
  - Durable and low cost to the Municipality and / or State

‘NO REGRET’ ADAPTATION MEASURES
Coastal protection measures

Alternatives for storm damage mitigation
(storm surge, sea level rise, coastal erosion)

Today

Adaptive responses:

Accommodation

Protection

Beach nourishment

Retreat

Reference line
Adaptation measures - “Management option A1”

“Accept and retreat”: repositioning infrastructure at risk; **zoning/set-back lines, resettlement**…

**Natures Valley,** an excellent example of an appropriate development setback landward of a well-maintained natural foredune functioning as an effective buffer dune system (DEA, 2009)
B1 Sand nourishment:
Pump sand onto beach to build it up

Adaptation/protection options

C1 Seawalls

C1 Revetments

(vegetated and/or reinforced)
Adaptation and protection options

C2 Dikes

C3 Perched beach structures

C4 Shore-parallel structures artificial surf: zone reefs
Adaptation/protection options

C5 Groynes can trap sediment

C9 Closely spaced piles or wave fences to dissipate wave energy.

C11 Geotextile shore protection in low to moderate wave energy environments

C12 Gabions rock filled wire basket & mattress

» D Combined options
Mozambique example:
Site specific analysis and recommended prioritised adaptation actions
### KEY: Adaptation measures

<table>
<thead>
<tr>
<th></th>
<th>“Management options”</th>
<th></th>
<th>“Soft engineering” / Restoration</th>
<th></th>
<th>“Hard engineering” &amp; armouring</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>“Accept &amp; retreat”: zoning, etc.</td>
<td></td>
<td>Sand nourishment</td>
<td>B1</td>
<td>Managed (vegetated &amp; reinforced) dune</td>
<td>B2/C2</td>
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<tr>
<td>A2</td>
<td>“Abstention” ‘do nothing’</td>
<td></td>
<td>Managed (vegetated &amp; reinforced) dune</td>
<td>B3</td>
<td>Managed/rehabilitated mangrove/wetland areas</td>
<td></td>
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<tr>
<td>A3</td>
<td>“Alternative” developments in safe areas</td>
<td>A1/A3/B3; C5; C2</td>
<td>Dikes (sand/ earthen mound)</td>
<td>C1r</td>
<td>Revetments (sloping rock)</td>
<td>C2</td>
</tr>
<tr>
<td>A4</td>
<td>“Accommodation” e.g. raising property</td>
<td>A1/A3/B3; C5; A1/A3</td>
<td>“Hard engineering” &amp; armouring</td>
<td>C5</td>
<td>Groynes (rock/concrete)</td>
<td>C5</td>
</tr>
</tbody>
</table>

#### Low/ moderate wave energy:

| C11| “Geotextiles” sand filled | A1/A3/B3; B2/C2 |
| C12| Gabions & mattresses | A1/A3/B3; B2/C2 |

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![Google Map](image)
Technology solutions
Off-shore to near-shore wave transformation

NCEP (National Centres for Environmental Prediction)
Table Bay example

19/05/2014 - 11:30

Significant Wave Height [m]

SWAN (Simulating WAves Nearshore)
The runs of numerical wave models are completed (23 in total around the coast).

Provide medium resolution inshore wave climate data at 0.5 km resolution. Each model ~ 100 km
Off-shore wave climate obtained from historical to current record of NCEP data transformed to nearshore through look-up table (transformation coefficients).

Location area: Port Nolloth

NCEP grid-point: 30830
Approx. 40 km offshore
Quantification of risk to coastal areas and development: potential coastal flood lines

**Red line — Scenario 1:**
1-in-10yr runup + MHWS + 1-in-10yr residual + 0.35m SLR

**Blue line — Scenario 2:** (on-land)
1-in-30yr runup + MHWS + 1-in-10yr residual + 0.35m SLR

**Yellow line — Scenario 6:**
1-in-50yr runup + MHWS + 1-in-10yr residual + 1.0m SLR

(all Mather wave runup model)
There are currently 2 pilot sites; Fish Hoek & Yzerfontein.

- The Fish Hoek camera is mounted indoors while the Yzerfontein camera is mounted outdoors.
- A 3rd site, namely Port St Johns is currently being set up.

Data communication & site maintenance:

- Router
- GSM Modem
- CSIR FTP site
- http:// Domain name
- http:// Domain name
Operational forecasting

• Forecasts informing public for recreational use and safety.
• Including monitoring via COASTCAM
Operational forecasting model example
False Bay on Wave-net

http://wavenet.csir.co.za/
Thank you