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CHAPTER 7:
TERRESTRIAL ECOSYSTEMS AND BIODIVERSITY

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Changes in climate, combined with land-use change and the spread of invasive species, are likely to limit the resilience of the terrestrial ecosystems of southern Africa and contribute to biodiversity loss.

7.1. Introduction

Southern Africa has a rich diversity of plants and animals and its high levels of endemism are critical to cultural heritage and support livelihoods and economic development (e.g. ecotourism). Six of the 34 internationally identified biodiversity 'hotspots' are located in southern Africa, namely the Cape Floristic Region, Succulent Karoo, Maputaland-Pondoland-Albany, Eastern Afromontane, Madagascar and the Indian Ocean Islands, and Coastal Forests of Eastern Africa. These 'hotspots' contain high concentrations of endemic plant and animal species, but these mainly occur in areas that are most threatened by human activity.

Diverse terrestrial ecosystems in the region include tropical and sub-tropical forests, deserts, savannas, grasslands, mangroves and Mediterranean shrublands (refer to map of ecoregions and biomes in Figure 7.1). The patterns of the main vegetation types reflect the primary climate zones of the region, where the highest volume of biomass occurs in the high rainfall areas and biomes are generally defined by climate. The main ecosystems (or biomes[16]) provide crucial ecosystem services such as soil production, water flow regulation, pollination, and natural fodder for dryland livestock grazing. For example, it is estimated that forests in sub-Saharan Africa account for 25% of the total global carbon stocks, with the Democratic Republic of Congo accounting for 9.8% (Saatchi et al., 2011).

16 A 'biome' is the highest level of ecosystem classification. This chapter has considered the biome concept to include the humans and their activities within the biome area.

Protected areas have been expanded in number and extent, with the number of formally protected areas (refer to map of protected areas in Figure 7.1) over the region steadily increasing from 8.6% in 1990, 9.4% in 2006 and 14.7% in 2014 (Juffe-Bignoli et al., 2014). All of the 15 SADC member states have National Biodiversity Strategies and Action Plans (refer to Box 1 on guiding strategies and conventions relevant to terrestrial ecosystems) and have a legal responsibility to conserve land according to commitments under the Convention on Biological Diversity. Terrestrial ecosystems are however still under threat from a range of drivers including climate change, land-use change (including deforestation and urbanisation), land and soil degradation, poaching, and invasions by alien species (refer to conservation status in Figure 7.1).

Climate change is likely to lead to significant changes across the biomes and the ecosystems services they provide through the alteration of existing habitats, seasonal rainfall, species distribution, and ecosystems. Climate change will also lead to changes in species distribution through shifting habitat, changing life cycles, and development of new physical traits[17]. The vulnerability of the terrestrial ecosystems of southern Africa to climate change is assessed in this chapter as well as the adaptation priorities required to build the resilience of the ecosystems.

17 This refers to species adapting to changing conditions through 'plasticity', which is the ability of organisms to respond to climate change, such as changes in temperature, without any genetic changes.

Case study: The Maloti-Drakensberg Park

The Maloti-Drakensberg Park is a transboundary conservation area composed of the uKhahlamba Drakensberg Park in South Africa and the Sehlabathebe National Park in Lesotho, and has been awarded World Heritage status by UNESCO. In total it is 242 813 ha in extent, extending 150 km along the uKhahlamba Drakensberg mountain range. In addition to its scenic beauty, the park's diversity of habitats protects 250 endemic plants and threatened flora, including the endangered bearded vulture (*Gypaetus barbatus*), Cape vulture (*Gyps coprotheres*) and critically endangered Maloti minnow (*Pseudobarbus quathlambae*).

Given how wide the park's altitudinal gradient is, it potentially forms a critical migratory pathway for grassland species to adapt to climate change. It is by far the largest block of conserved grassland in a biome that is both poorly conserved and under extreme threat from both climate change and land transformation to agriculture, mining and settlement.

Box 7.1: International conventions and regional strategies relevant to the protection of terrestrial ecosystems and biodiversity

SADC member states have ratified a number of international conventions that aim to facilitate the conservation of biodiversity:

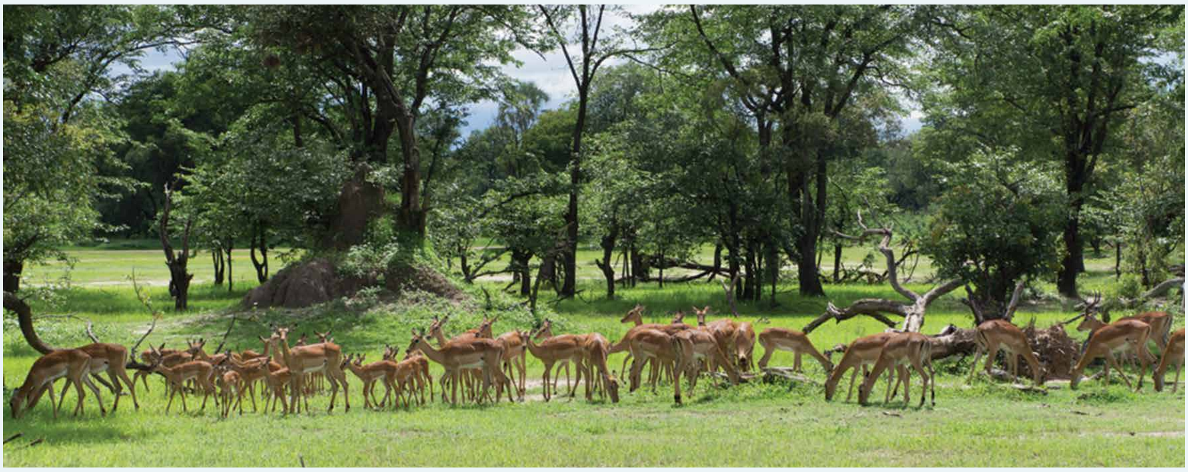
- Convention on Biological Diversity (CBD)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- Convention on Migratory Species of Wild Animals (CMS)
- Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar)
- Convention concerning the Protection of the World Cultural and Natural Heritage (WHC)
- Convention to Combat Desertification (CCD)

At the regional level, the **Regional Biodiversity Action Plan** (SADC, 2006) provides a framework to ensure a coordinated response to the management of biodiversity. The strategy provides guidelines to build capacity in implementing the provisions of the CBD and aims to act as a mechanism for the cooperation and establishment of partnerships between nations on transboundary biodiversity issues.

The establishment of **transfrontier/transboundary conservation areas** aims to connect protected areas across national boundaries and is considered more effective than local or national management because environmental problems are not limited to national boundaries. Creating connections between protected areas at the transboundary scale is seen as a vital conservation tool to increase the effectiveness of conservation areas. In addition, these areas maintain the continuity of natural disturbance regimes and ecosystem services and allow for the natural range shifts in response to long-term environmental change. In SADC, there are five Type A (Established), six Type B (Emerging) and seven Type C (Conceptual) Transfrontier Conservation Areas (SADC, 2013).

SADC Protocol on Wildlife Conservation and Law Enforcement aims to ensure that each member state facilitates community-based natural resource management (CBNRM) practices in wildlife management and wildlife law enforcement. The protocol calls for economic and social incentives for the conservation and sustainable use of wildlife (SADC, 1999).

SADC Protocol on Shared Watercourses aims to foster closer cooperation for judicious, sustainable and coordinated management, protection and utilisation of shared watercourses and regional integration and poverty alleviation (SADC, 2000).



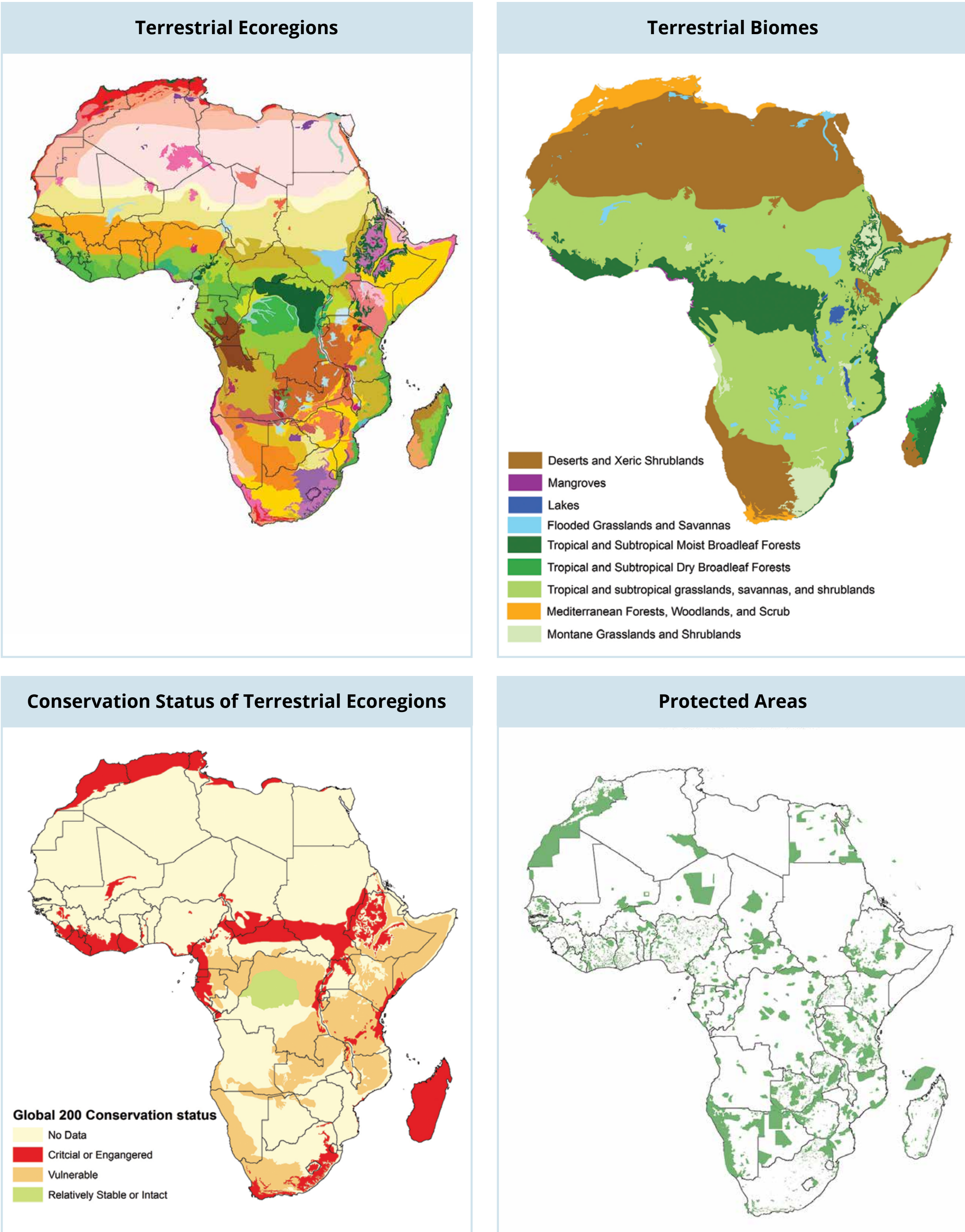


Figure 7.1: Map of the (i) terrestrial ecoregions, (ii) biomes, (iii) conservation status (Source: Olson & Dinerstein, 2002), and (iv) protected areas (IUCN and UNEP-WCMC, 2016). Ecoregions vary in their ecosystem characteristics and flora and fauna composition as well as their conservation status. The conservation status is an estimate of the current and future ability of the ecoregion to sustain ecological viability and to react to environmental change. It is based on total habitat loss, habitat fragmentation, degree of degradation, degree of protection needed, degree of urgency for conservation needs, and types of conservation practiced or required.

7.2. Non-climatic drivers of ecosystem change

7.2.1. Land-use change, habitat loss and fragmentation

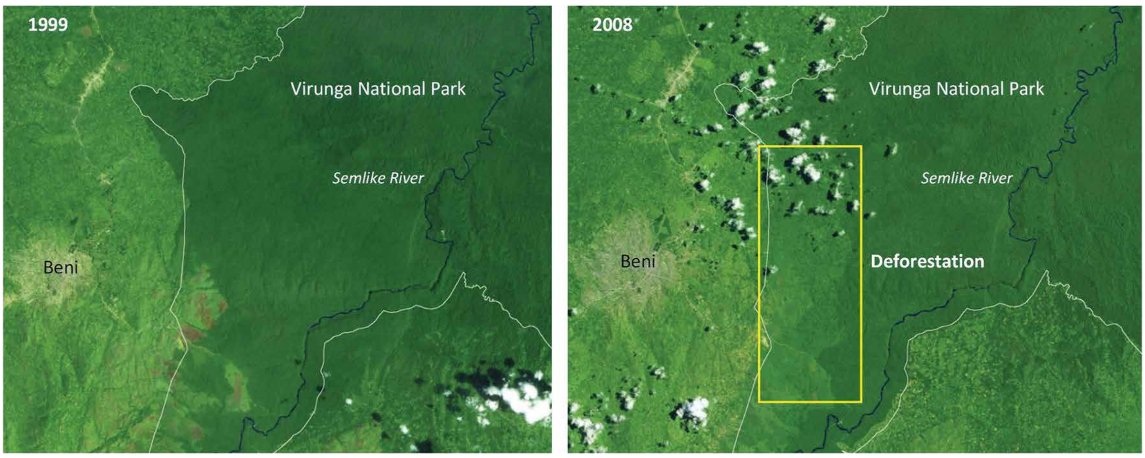
Land-use change and landscape fragmentation are important drivers of ecosystem change and the loss of biodiversity. Land-use change refers to the anthropogenic replacement of one land-use type by another, for example the conversion of natural grasslands or forests to agricultural crops, harvesting of forest resources for fuelwood, as well as shifts in the management practices of the land, for example the intensification of livestock grazing. Agriculture is seen to be the leading form of land-use change in Africa – between 1990 and 2010 African countries reported that 75 million hectares of forest land (10% of the total forest area) was converted to other land uses (FAO, 2012).

7.2.2. Invasive alien species

Invasive alien species are considered to be a major threat to the endemic biodiversity of southern Africa and affect most ecosystems. They refer to species of flora and fauna that have been introduced to an area outside of their natural origin where they are able to establish and expand their range. Declines in native species have occurred concurrently with the introduction of non-native species and it is widely accepted that invasive species are significantly altering communities and ecosystems and ultimately resulting

Case study: Forest cover loss in the Democratic Republic of Congo

The tropical humid forests of central Africa comprise the second largest continuous tropical forest in the world and about half of these are located in the Democratic Republic of Congo (DRC). Although rate and extent deforestation in the DRC is considered to be moderate compared with other countries such as Brazil and Indonesia, a study utilising Landsat Enhanced Thematic Mapper Plus (ETM+) has shown that forest cover loss is increasing (Potapov et al., 2012). Between 2000 and 2010, an estimated 2.3% of the total forest area was lost, with the greatest loss occurring between 2005 and 2010. Of particular concern is the Virunga National Park, which has the highest rate of forest loss compared with other protected areas in the DRC. The deforestation has been attributed to clearing of land for cattle grazing and agriculture and, to a lesser extent, to unregulated logging and mining. The population density in the area surrounding the national park is one of the highest in the region at 600 individuals per km².



Landsat 5 satellite images from February 13, 1999 (left) and September 1, 2008 (right) showing deforestation along the western border of the Virunga National Park (obtained from http://earthobservatory.nasa.gov/IOTD/view.php?id=79276) in the extinction of native species (Gurevitch & Padilla, 2004). Other drivers of ecosystem change, such as land-use change, act synergistically with the negative impacts of alien species on indigenous communities. To date, there is no comprehensive and coordinated regional strategy on the prevention, eradication and control of invasive species (SADC, 2006). Some countries, such as South Africa, have regulations and supporting programmes (Working for Water) that are dedicated to the prevention, control and mitigation of the spread and impact of invasive plant species.

7.3. Vulnerability to climate change

Changes in rainfall, temperature and carbon dioxide are likely to drive changes in the distribution, condition and functioning of the terrestrial ecosystems of southern Africa as well as alterations in plant phenology, increased wildfire, and exacerbated pest outbreaks (Gonzalez, 2010; Field et al., 2014). Dynamic Global Vegetation Models (DGVMs) project a variety of biome shifts (Figure 7.2), (Scheiter & Higgins, 2009; Higgins & Scheiter, 2012). An increase in woody vegetation is expected over much of southern Africa, which is supported by numerous observation studies in the region (Bond & Midgley, 2000; Wigley et al., 2009; Ward et al., 2012; Mitchard & Flintrop, 2013). Improvements in the representation of disturbance processes, such as fire and grazing, will assist in reducing the uncertainties associated with model projections.

In terms of individual species response, climate change is likely to alter the boundary of limits where species are able to survive, impacting the growth, survival and distribution of the species. There is evidence, mostly in the northern Hemisphere, that many species have already shifted their geographical ranges, seasonal activities and migrational patterns in response to changes in temperature. In a study of 329 plant and animal species, 84% had shown a poleward and altitudinal shift in their ranges (Hickling et al., 2006). In southern Africa, temperature is not the only factor limiting species range. Water availability, fire and grazing are equally important in shaping the ranges of species. As a result, a multiple stressor approach is essential for understanding the risks of climate change to terrestrial ecosystems. Taking this approach, Table 7.1 attempts to identify the most important ecosystem services and the most significant potential climate change risks for each of the nine primary biomes of southern Africa.

Table 7.1: Ecosystem services and climate risks for each of the main biomes of southern Africa

Biome	Ecosystem Services	Climate risk
Grassland	• Major area for crops, especially maize and forestry plantations • Major catchment areas for water provision • Provision of medicinal plants • Important for cattle (both beef and dairy) and sheep • Irrigated horticulture • Carbon storage – especially as soil carbon	• Increased temperature and CO_2 will result in invasion of savanna-like condition and major shrinkage of the spatial area of the biome • Increased fire intensity and likely mega fires • Increased temperature may limit livestock, and in particular dairy cattle • More intense rainfall, especially if coupled with overgrazing, will intensify erosion
Savanna	• Nature-based tourism • Livestock production, especially beef cattle farming • Carbon storage • Fuelwood, timber	• Extremely high temperatures will make domestic livestock farming challenging and may lead to a sudden switch to other nature-based ventures • Increased rainfall and rising CO_2 will lead to an increase in bush encroachment and expansion of the savanna into grasslands and other biomes • Rising CO_2 levels will lead to a high risk of alien woody plant invasion, particularly in highly degraded areas
Forests	• Nature-based tourism • Biodiversity • Fuelwood, timber, traditional medicines • Carbon storage • Water resources	• Extreme high temperatures may increase destructive fires • Drought/heat-intolerant Afrotemperate forests most at risk from increased frequency of drought and increased temperatures • All forest types vulnerable to decreasing rainfall, with swamp forest systems being vulnerable to changes in groundwater recharge
Mediterranean: Fynbos	• Water flow and water quality regulation • Soil stabilisation • Nature-based tourism, non-consumptive use • Production of wildflowers, herbal and medicinal products and for the horticultural trade • Biodiversity resources	• Increased intensity and frequency of fires and more “out-of-season” fires • Alien invasive species, especially grasses in lowland ecosystems • Habitat transformation/fragmentation, particularly on the lowlands through agriculture and urbanisation
Deserts	• Ecotourism, including a range of wildlife management operations • Commercial and emerging agriculture, large and small stock • Niche agriculture (e.g. organic, small-scale agriculture)	• Extreme high temperatures will place constraints on livestock productivity • High temperatures coupled with certain rainfall thresholds linked to increased pests and pathogens in particular areas • Higher temperatures could result in the range contraction of succulent plant species • Reduced rainfall and increased drought frequency could result in a reduction in forage quality and quantity • More intense rainfall will cause soil capping, flash flooding, erosion and poor recharge
Mangroves	• Coastal erosion protection and storm buffering • Groundwater recharge • Breeding, spawning and nursery habitat for fish species • Cultural services (e.g. recreation, aesthetic)	• Saltwater intrusion and increased sedimentation as a result of sea-level rise • Increased storm surges and coastal storms will cause erosion • Decreased rainfall and increased evaporation will increase salinity, resulting a decline in the productivity of mangroves

7.4. Response measures

The primary focus of adaptation in the biodiversity sector has been on conservation strategies, biodiversity planning, community-based natural resource management and, more recently, ecosystem-based adaptation. It has been argued that traditional conservation strategies that focus on, for example, increasing connectivity between patches of protected land, although invaluable, are likely to be insufficient to curb the impacts of climate change and more strategic approaches are required (Gillson et al., 2013). Evidence-based information at the local scale on the impacts of climate change is essential to guide land-use management and policy decisions.

The challenge is to develop adaptation options that are sensitive to the spatial heterogeneity of local social and environmental conditions and that account for major environmental and climatic feedbacks. Adaptation options should thus seek multiple benefits, which include achieving synergies between biodiversity/ecosystem conservation, sustainable livelihoods, and co-benefits for other sectors such as agriculture and health (Davis et al., 2015). Considering these guidelines, Table 7.2 provides a list of the potential adaptation responses to climate change.

7.4.1. Ecosystem-based adaptation (EbA)

Ecosystem-based adaptation (EbA) is defined by the Convention on Biological Diversity (2009) as the "use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change". EbA uses well-functioning natural systems to buffer human systems from the adverse impacts of climate change and to build resilience and adaptive capacity. EbA is implemented through the protection and restoration of ecosystem services and the sustainable management of natural resources (Field et al., 2014). EbA is considered from a range of angles, including recommendations for actions around protection of movement corridors, adjustment of burning regimes, clearing of alien vegetation and restoration of degraded areas. The best practices that must be undertaken in ecosystem-based adaptation that are critical in guiding adaptation planning are detailed in Midgley et al. (2012); and include, for example, the involvement of key stakeholders in planning and implementation, and the development of monitoring and evaluation frameworks.

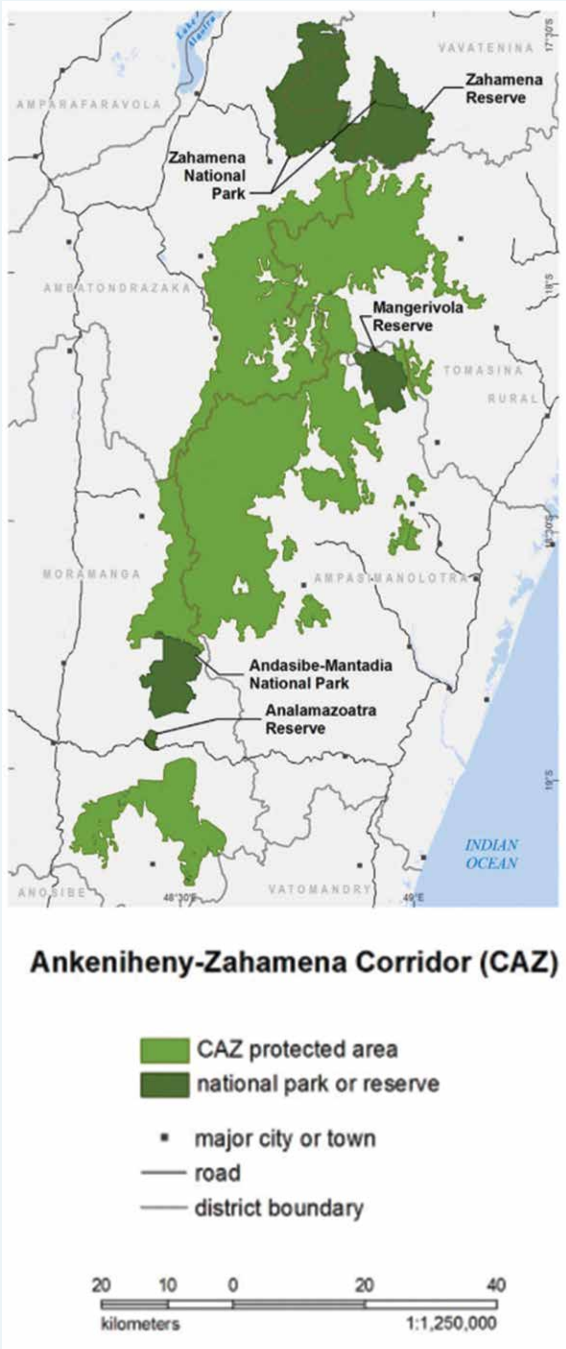
Table 7.2: Potential adaptation options (Davis et al., 2015)

Land-use planning	• Abandon unviable land • Create new, viable land uses • Adjust land-use proportions/locations • Optimise protected area network
Land management	• Adjust stocking rate • Change cultivars/species • Increase irrigation efficiency • Maintain wetlands • Water management
Ecosystem-based adaptation	• Restore degraded land (including afforestation) • Protect movement corridors • Adjust burning regime • Clear alien vegetation • Catchment rehabilitation
Community-based natural resource management	• Payment for ecosystem services • Education, outreach, extension • Incorporation of indigenous knowledge

Case study: The Ankeniheny-Mantadia-Zahamena Corridor Restoration and Conservation Carbon Project

The Ankeniheny-Mantadia-Zahamena Corridor (CAZ) is REDD+ innovative aimed at conserving and restoring the threatened forests of Madagascar as well as enhancing community well-being and reducing carbon emissions (Harvey et al., 2010). The corridor is a newly-designed protected area in the eastern region of Madagascar and covers an area between the Analamazoatra Special Reserve and Andasibe-Mantadia National Park (Lopoukhine et al., 2012). The region is home to over two thousand species of plants, many endemic to the region, as well as a large number of species of mammals, amphibians and birds. CAZ also supports nearly 350 000 people, who depend on subsistence agriculture and cash crop production for their livelihoods.

Portions are zoned into strict protection areas and other areas under the management of the community. Working with Conservation International, a partnership has been set up in the region between NGOs, government organisations (Ministry of Environment and Forests), other donor-funded projects, the private sector, and community associations. Working with multiple stakeholders ensures that the provision of incentives to local communities is driven by local development needs such as health and clean water resources.



Ankeniheny-Mantadia-Zahamena Corridor (Onofri et al., 2017)

7.4.2. Community-based natural resource management (CBNRM)

Community-based natural resource management is an incentive-based strategy for promoting both conservation and local economic development. It is an approach that offers multiple benefits; securing rural livelihoods, ensuring careful conservation and management of biodiversity and other resources, and empowering communities to manage these resources sustainably (Fabricius et al., 2013). In this model, communities are given rights of access to resources and legal entitlements to benefits that accrue from using the resources, such as eco-tourism and conservation-based agricultural programmes (SADC, 2006).

CBNRM is a vehicle for improving links between ecosystem services and poverty reduction so that these practices can serve as proactive, low-regret adaptation strategies (Niang et al., 2014). CBNRM programmes in many countries in southern Africa are driven and often initiated by a combination of government, non-governmental organisations (NGOs), community-based organisations (CBOs) and, in some cases the private sector (Fabricius et al., 2013). Operationally, CBNRM involves (SADC, 2006):

- The devolution of control and management responsibilities on natural resources from the State to the local people;
- Building the technical, organisational and institutional capacity of local communities to assume management responsibilities over natural resources.

Case study: Sustainable natural resource management in Namibia

The community-based natural resource management programme in Namibia has been ongoing since the passing of the Nature Conservation Act in 1996. By the end of 2013 a total of 79 conservancies covering 19.4% of the country had been registered (Riehl et al., 2015). The three primary goals of the CBNRM programme are natural resource management and conservation, rural development, and empowerment and capacity building. Between 1991 and 2013 the programme contributed approximately US$392 million to Namibia's net national income, generated 6 472 jobs, and contributed to increases in wildlife numbers and ranges, for example the lion populations in the northwest region of the country (Namibia Association of CBNRM Support Organizations, 2013).

Key lessons from the programme so far include the importance of (Brown & Bird, 2011):

- Linking economic incentives with environmental management;
- Establishing a legal framework that allows communities to access economic benefits directly, through better management of wildlife as well as other natural resources on the communal land.