adaptation and mitigation responses; and making use of indigenous knowledge. Ecosystem-based Adaptation (see Box 1) and expansion of protected areas using climate-resilient approaches offer two adaptation response options for the biodiversity sector that are appropriate for achieving increases in the climate resilience of biodiversity and maintaining and/or enhancing ecosystem service delivery. However, these two approaches should be adapted as necessary to build the resilience of ecological infrastructure to support economic sectors and livelihood activities. For example:

- Agriculture and forestry hold great potential for gaining adaptation benefits while mitigating greenhouse gas emissions through reforestation and restoration, managing soil carbon and invasive species, implementing integrated crop and livestock management, and improving management of emissions from livestock and crop production. Specific related approaches include climate smart agriculture, conservation agriculture, agro-ecology and community-based adaptation.
- Fisheries that are successfully managed to achieve resource sustainability will be better positioned in the long term to adapt to the effects of climate change. An Ecosystem Approach to Fisheries can contribute to resource recovery through protection of spawning and nursery areas and the maintenance of other essential fish habitats which are in turn dependent on water flows that are mediated by land-based ecosystems.
- Human health and ecosystem impacts that are associated with increased rainfall intensities, flash floods and regional flooding include overflowing sewers and climate change impacts on water resources (quality and quantity). These can be addressed through collaboration between the health, water and biodiversity sectors on integrated water resource management, restoration of catchment areas and effective land-use planning.
- Developing a climate-resilient network of protected areas in South Africa with greater ecological connectivity, and designed specifically with future climate conditions in mind will work towards assisting with species migration and the maintenance and/or enhancement of ecosystem service delivery to support local communities and all sectors. Implementing efficient biodiversity stewardship programmes can assist in achieving connectivity between core biodiversity and ecosystem services areas.

5. Future research needs

The potential of biodiversity adaptation strategies to provide co-benefits for other sectors could be mainstreamed and integrated across sectors if packaged and communicated appropriately. This would require both institutional and technical capacity building. Research and assessment would be important for developing products for mainstreaming, and tools and communication pathways (including decision-making and spatially referenced tools and information). Implementation of biome adaptation plans would contribute to building climate-resilience at biome level, and would provide support to adaptation in other sectors such as water, agriculture and forestry, and human health by ensuring continued supply of ecosystem services. Vulnerability assessment data should be integrated with spatial data related to ecosystem service delivery, and translated to the local level, based on user-specific vulnerabilities and needs, to inform biome adaptation plans.

Priorities for future research include the development of a predictive understanding of the rates of spread of invasive plants (including the effects of rising atmospheric CO_2) and changes to fire regimes under climate change conditions. Furthermore, there is a need to develop achievable goals for EBA and protected area expansion. This includes measurable criteria for assessing the success of restoration and protected area expansion in increasing the resilience of biodiversity, and maintaining ecosystem services under future climate conditions. A dedicated and focused monitoring programme across biomes would allow projected changes to be observed and quantified to improve modelling approaches.

6. Conclusion and linkages

There is a consistent message of significant change and loss of habitat for the grassland biome as a result of the expansion of woody savanna areas under future climate scenarios. The grassland biome is crucial for providing water for drinking and other economic and livelihood activities in South Africa, furthermore it is an area that is likely to increase in importance as a habitat for bird diversity. Thus adaptation responses in this biome will be critical for preventing reductions in bird species richness, for maintaining water supply from highland catchments, grazing services for local communities and ecosystem processes such as wildfire.

There is a need to integrate vulnerability assessment data with spatial data related to ecosystem services (in particular water-related services) as well as user-specific vulnerability data and needs. Authorities should focus on mainstreaming the potential of biodiversity and ecological infrastructure for achieving adaptation and development benefits across sectors, and for building the resilience of ecosystems and local communities to climate change through Ecosystem-based Adaptation, and climate resilient approaches in protected area expansion. It must be noted that changes likely to result by the end of this century under an unmitigated emissions scenario require careful consideration and further modelling in order to assess the risks for biodiversity and ecosystem services.

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CLIMATE CHANGE AND **BIODIVERSITY**

Climate and Impacts Factsheet Series, Factsheet 7 of 7

THE LONG-TERM ADAPTATION SCENARIOS FLAGSHIP RESEARCH PROGRAMME FOR SOUTH AFRICA

The LTAS aims to respond to the South African National Climate Change Response White Paper (NCCRP, para 8.8) by developing national and sub-national adaptation scenarios for South Africa under plausible future climate conditions and development pathways. This will inform key decisions in future development and adaptation planning.

The first phase, completed in June 2013, developed a consensus view of climate change trends and projections for South Africa. It summarised key climate change impacts and identified potential response options for primary sectors, namely water, agriculture and forestry, human health, marine fisheries, and biodiversity.

The second Phase will use an integrated assessment approach and model to develop adaptation scenarios for future climate conditions using the information, data and models from Phase 1 and a range of further stakeholder consultations and task team workshops.

The **Climate and Impacts Factsheet Series** has been developed to communicate key messages emerging from LTAS Phase 1, and to complement the LTAS Phase 1 technical reports and the summary for policy-makers.

This factsheet has been developed specifically to provide policy- and decision-makers, researchers, practitioners and civil society with up-to-date information on climate change impacts, adaptation responses and future research needs for the biodiversity sector in South Africa. The information builds on past and current research, including impact modelling for South African biomes and indicator species, as well as the National Biodiversity Framework, the National Protected Area Expansion Strategy and additional work under the Biome Adaptation Framework project, which is currently preparing to develop biome adaptation plans. For further details see the LTAS Phase 1 full technical report *Vulnerability Assessment: Climate Change Impacts on South African Biomes*.

1. Background

Biodiversity is crucial to ecosystem health, and healthy ecosystems are central to human well-being. Healthy ecosystems interlinked with working landscapes and other open spaces form the ecological infrastructure of the country and are the foundation for clean air and water, fertile soil and food. All South Africans depend on healthy ecosystems for economic and livelihood activities, including agriculture, tourism and a number of income generating and subsistence level activities (see Box 1). These natural ecosystems are under pressure from land use change and related processes causing degradation, as well as invasive alien species. Accelerated climate change (resulting in increasing temperature, rising atmospheric CO_2 and changing rainfall patterns) is exacerbating these existing pressures.

Well-functioning ecosystems provide natural solutions that build resilience and help society adapt to the adverse impacts of climate change. This includes, for example, buffering communities from extreme weather events such as floods and droughts, reducing erosion and trapping sediment, increasing natural resources for diversifying local livelihoods, providing food and fibre, and providing habitats for animals and plants which provide safety nets for communities during times of hardship. Sustainably managed and/or restored ecosystems help in adapting to climate change at local or landscape level.

Adaptation responses involving natural resources require a coherent framework that can be applied at national level, and then refined for sub-national purposes. South Africa has a good understanding – based on its vegetation biomes – of the functioning and structure of its ecological infrastructure that can provide a strong basis for such a framework. Phase 1 of the biodiversity work on the LTAS seeks to maximise the value of this background knowledge to develop a biome-based adaptation framework for the country that can serve this important purpose.

BOX 1. BIODIVERSITY AND ECOLOGICAL INFRASTRUCTURE

- **Biodiversity** describes the variety of life on earth in terms of genes, species and ecosystems, and the ecological and evolutionary processes that maintain this diversity. It is a measure of ecosystem health.
- **Ecosystems** provide ecosystem services: *provisioning*: including water, food, and timber; *regulating*: water filtration, climate regulation (carbon storage), pollination, and protection from natural disasters (e.g. mangroves and dunes against storm surges); *cultural*: recreation and relaxation, spiritual values, tourism, and education; and *supporting*: soil formation, photosynthesis (oxygen), and nutrient cycling.

The project is part of the International Climate Initiative (ICI), which is supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

environmental affairs
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On behalf of
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- **Ecological Infrastructure** (EI) is the network of natural lands, working landscapes and other open spaces that are the substructure or underlying foundation on which the continuance or growth of essential ecosystem goods and services depend (DEA, 2013[1]).
- Ecosystem-based Adaptation (EBA) approaches use biodiversity and ecosystem services in an overall adaptation strategy and includes the sustainable management, conservation and restoration of ecosystems to maintain and increase the resilience, and reduce the vulnerability, of ecosystems and people in the face of adverse effects of climate change (CBD, 2009[2]).

2. Climate change impacts on South Africa's biodiversity – a biome based perspective

South Africa consists of nine biomes[3], geographical areas comprising a number of ecosystems with related plants and animal groups and similar disturbance regimes, most importantly wildland fire (see Figure 1). The biodiversity in each biome consists of plant and animal communities specifically adapted to the existing climate and environment.

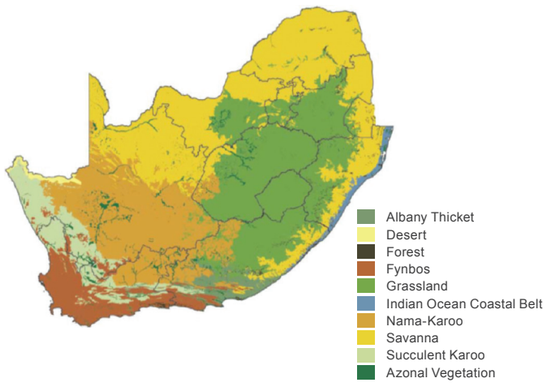

Figure 1. South Africa's biomes (geographical areas comprising a number of ecosystems with related plants and animals) (Cadman et al, 2010[4]).

One approach to assessing climate change impacts on biodiversity is to assess the spatial shift of optimum climate conditions for each of South Africa's biomes under future climate conditions. This provides a broad indication of areas that may suffer harmful impacts of climate change on biodiversity.

BIOME VULNERABILITY TO LAND-USE CHANGE

Based on a comparison of the threatened status and protection levels of each of South Africa's biomes, the following biomes are most vulnerable to land-use change:

- High priority: *Indian Ocean Coastal Belt* (critically endangered and very low protection)
- Second priority: *Grassland* (endangered and low protection)
- Third priority: *Fynbos and Forest* (endangered and moderately well protected).

BIOME VULNERABILITY TO FUTURE CLIMATE CHANGE

Based on an assessment of the spatial shift of the optimum climatic conditions for South African biomes under "low", "intermediate (median)" and "high" risk climate scenarios (see Box 2), the following biomes are most vulnerable to climate change:

- Most threatened: *Grassland* – under all climate scenarios, with large portions of the biome being replaced with savannah and potentially forest.
- Second most threatened: *Nama-Karoo* – under all climate scenarios with savannah and desert projected to cover large portions of the current biome.
- Third most threatened: *Indian Ocean Coastal Belt, Fynbos* and *Forest*:
  - Large portions of *Indian Ocean Coastal Belt* would be replaced by savanna under intermediate and high risk climate scenarios.
  - The north-eastern regions of *Fynbos* could be replaced with *Succulent Karoo* or *Albany Thicket* under all climate scenarios.
  - *Forest* will retract significantly as a result of increased fire and reduced rainfall under all climate scenarios.
- *Albany Thicket* is least threatened and will only suffer losses under the high risk climate scenario.
- *Desert* will expand at the expense of other biomes under all climate scenarios and in particular under the high risk climate scenario.
- The wettest and coolest "low" risk climate scenario would result in relatively minor impacts on almost all biomes.

BOX 2. CLIMATE IMPACT MODELLING FOR SOUTH AFRICA'S BIOMES

- To determine the effects of climate change on South Africa's biomes, global climate projections were processed to a smaller scale (referred to as downscaling) to make them more relevant to specific local conditions.
- The results from several different climate models were combined to form "low", "intermediate (median)" and "high" risk climate scenarios.
- The "low-risk" scenario represents a combination of wettest and coolest projections;
- The "high risk" scenario represents the driest and warmest projections; and
- The "intermediate/middle" scenario represents projections that fall in between the wettest/coolest and the driest/warmest projections.

OVERALL BIOME VULNERABILITY (LAND-USE AND CLIMATE CHANGE)

When combining the threats of land-use and climate change, the following biomes are most vulnerable and in need of strong protection, restoration and/or research to ensure adaptation benefits for vulnerable communities under future climate conditions (see Figure 2).

- Highest priority for action: *Grassland* and *Indian Ocean Coastal Belt.*
- High priority for action: *Fynbos* and *Forest.*
- Medium priority for action: *Nama Karoo* and *Succulent Karoo.*

For the grassland biome, significant change and loss of habitat is projected due to climate change. This is likely to be related to the high altitude location of the biome and its susceptibility to warming effects, as well as the possible increase in tree cover due to a longer growing season and CO_2 fertilisation. The savanna biome, on the other hand, is projected to expand with its geographic range partly replacing grassland. However, an increase in woody cover could shift the structure of some areas of the savanna biome towards woodland and even forest. The invasion of woody plants (alien and indigenous) into the grassland biome has major implications for the delivery of ecosystem goods and services to people, notably water delivery from highland catchments and grazing. Such shifts have extremely important implications for conservation and ecosystem service delivery, as well as ecosystem processes such as wildfire.

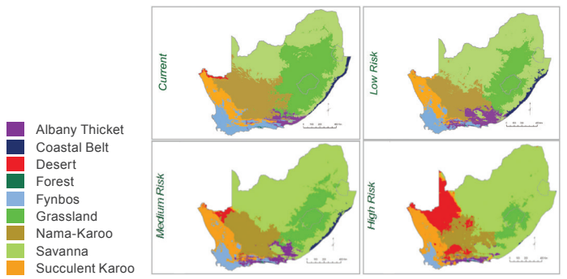

Figure 2. Projections of biome shifts under low, medium and high risk climate scenarios until approximately 2050.

3. Climate change impacts on South Africa's biodiversity – a species-based approach

Indigenous bird species are used as potential indicators of climate responses for several reasons. They are highly mobile and sensitive to changes in habitat and climate, for example, certain bird species are sensitive to changes in vegetation structure (e.g. woodland versus grassland species), and some would show behavioural responses to changes in temperature and rainfall.

The following rates of species change in response to climate changes have been determined by modelling the potential shifts in range of 623 of southern Africa's endemic bird species (See Figure 3):

- High potential rates of loss in species richness are projected in the central interior, especially the Kgalagadi Transfrontier Conservation Area, an area at risk of potential aridification and desert biome expansion.
- The north-eastern boundary of South Africa, from northern KwaZulu-Natal, along the border with Mozambique, and along the Limpopo basin is an even greater risk for loss of bird species richness.

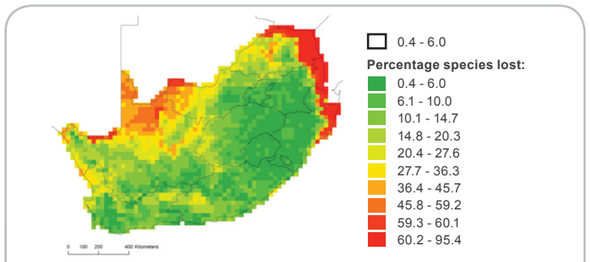

Figure 3. Projections of bird species richness loss for South Africa under future climate scenarios (ECHAM5[4] representing median change in temperature and rainfall), looking ahead to approximately 2050. Projections based on range modelling of 623 terrestrial bird species.

4. Adaptation response options

To increase the resilience of biodiversity and ecosystem service delivery under future climate conditions, synergies could be developed during adaptation planning and implementation between biodiversity, poverty reduction and development objectives. Specifically, the potential of biodiversity and ecological infrastructure to achieve sector-specific adaptation and development outcomes/benefits would need to be mainstreamed into adaptation, development and poverty reduction processes and strategies at national and local level. Coordination across sectors (including the land use planning sectors) would be essential in this mainstreaming process.

The appropriate and specific types of local action required would need to be further defined in biome specific adaptation plans. Key elements of this would be to include strong stakeholder engagement and implementation focused at local level; prioritising low-cost approaches with multiple benefits; integrating

Ref: 1. DEA. 2013. SIP 19: Ecological Infrastructure for Water Security. Initial Working Draft for discussion purposes only.
2. Secretariat of the Convention on Biological Diversity (CBD). 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Montreal, Technical Series No. 41.
3. Azonal vegetation is not discussed in this factsheet as its highly fragmented nature prevented it from being included in the vulnerability assessment conducted during the LTAS Phase 1 process.
4. Cadman M, Petersen C, Driver A, Sekhran N, Maze, K and Munzhedzi S. 2010. Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience. Pretoria: South African National Biodiversity Institute.