FULL TECHNICAL REPORT

CONSERVATION SOUTH AFRICA
Member of the CI Network

climate change Vulnerability Assessment

for the Namakwa District Municipality

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& Professor Guy Midgley

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PREFACE

Climate change is among the most pervasive threats to people and biodiversity today. Without action it will cause the extinction of countless species, destroy some of the world's most precious ecosystems, and devastate human livelihoods. Regardless of mitigation actions put in place today, a certain level of climate change is now inevitable. We will have to adapt in order to conserve our natural resources, achieve continued economic growth, and ensure social equity and poverty alleviation in the face of climatic uncertainty. Protecting the world's most vulnerable people and the environments they depend on from the adverse effects of climate change is a moral imperative in line with the constitution and all other major legislation of South Africa.

Climate change will place additional stress on Succulent Karoo ecosystems in the Namakwa District with all climate models indicating the Municipality will become hotter and drier, with more intense storms, floods, and droughts. These changes are already apparent, with coastal storms and droughts over the last 10 years costing the local economy millions of Rands in damage to infrastructure alone. Since our lifestyles are inextricably linked to the natural world, defending the resilience of ecosystems and the services they provide is essential to withstanding future climatic changes.

This report is a milestone consolidation of information on the vulnerability of the ecosystems, social-economic condition, and institutional structures of the Namakwa District. It is based on the most up-to date ecological and social data available for the District and is informed by the extensive local consultation carried out by the Districts Disaster Risk Strategy development process in 2011. This information was integrated to identify the most vulnerable areas where an Ecosystem-based Adaptation (EbA) approach—defined by the Convention on Biological Diversity 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 —can have the greatest impact in building a local buffer against the negative impacts of short term climatic variation and long term climate change.

Directing government efforts towards building resilience in vulnerable areas is essential. We cannot wait until long-term climate impacts exacerbate degradation and re-enforce poverty traps. Early measures need to be put in place to dampen the severity of climate change impacts in the Namakwa District Municipality. As partners in the production of this report, we hereby pledge to utilize the information in this report to prioritise, implement climate resilient programmes, and measure our impact at reducing vulnerability of the people of NDM and their unique environment. We also encourage any other government entity, business, NGO, or donor to use this information similarly to rapidly build a climate resilient society in the Namakwa District.

Sarah Frazee

CEO, Conservation SA

ACKNOWLEDGEMENTS

This document is the result of a collective effort and would not have been possible without the contributions of many people and organisations. In particular, Conservation South Africa would like to acknowledge the work of Professor Guy Midgley, Doctor Stephen Holness, Doctor Belinda Reyers, Doctor Camila Donatti, and Doctor Anton Du Plessis.

In response to the climate change challenge, Conservation South Africa has formed a partnership with five of South Africa's largest conservation NGOs, two government conservation agencies and the South African National Biodiversity Institute to adapt South Africa to climate change by increasing the resilience of the country's biodiversity and communities to change. Working through the partnership, CSA aims to promote sustainable land management practices among farmers and other land users, promoting healthy ecosystems at a landscape level that ensure biodiversity conservation and the sustained provision of ecosystem services essential to surviving unpredictable climatic conditions, such as water flow, fertile soil, wildlife stocks and flooding buffers. We would like to recognise this crucial partnership here.

Critically, this document would not have been possible without the kind support and contribution of the Northern Cape Provincial Government, particularly the Departments of Environment and Nature Conservation, Social Development, and Science and Technology, the Namakwa District Municipality, and all of the Namakwa District's local municipal governments. CSA would particularly like to thank the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and their International Climate Initiative Programme for their generous support.

Finally, we express our tremendous gratitude to each of the Namakwa District Climate Change Conference participants and their home institutions, and to the numerous colleagues in Conservation South Africa and Conservation International who provided feedback and input at several stages of the development of this project.

EXECUTIVE SUMMARY

This report assesses vulnerability to climate change in the Namakwa District Municipality (NDM). It a) addresses climate change risks and impacts in the NDM, b) profiles the structural conditions that contribute to socio economic vulnerability in the NDM, c) assesses institutional vulnerability and local government capacity, d) identifies priority areas for Ecosystem-based Adaptation (EbA) and conservation actions, and e) makes recommendations for EbA actions.

A vulnerability index complements the map, informing priority setting for resource allocation to EbA and for use as the metrics for measuring reduced vulnerability over time as a result of government effort and the efforts of other stakeholders.

A statistical approach was developed to generate climate change scenarios based on a wide range of global climate change model (GCM) data on temperature and rainfall. Highest projected temperature increases and largest projected rainfall decreases were combined to generate a 'high-risk' or 'worst case' scenario, and vice-versa for a 'low-risk' or 'best case' scenario. Median projected changes were combined to create an intermediate scenario. The scenarios define the range of possibility rather suggesting the most likely future climate change events.

In all three scenarios, average annual temperatures are predicted to increase by 2050, when compared to the current conditions. There is greater uncertainty around changes in rainfall patterns. The best case scenario indicates small increases in rainfall in certain areas. The intermediate and worst case scenarios predict a reduction in rainfall across the NDM. The most dramatic reductions occur in present-day higher rainfall areas.

The study also looked at storm surges, rising sea levels, changes in coastal fog, and rising levels of atmospheric carbon dioxide as possible impacts of climate change in the region. These are projected to be low risk impacts relative to changes in rainfall and temperature intensity and frequency of storms

Ecological vulnerability: Climate change is likely to have an impact on biome stability in the region, but the species rich Succulent Karoo holds relatively stable to 2050, providing an opportunity for EbA and ecosystem conservation. Climate impacts interact with existing pressures in the landscape, such as over-grazing, over-abstraction of groundwater, and unsustainable mining practices. These will also be superimposed on an already challenging natural environment fraught with natural hazards and climate and water related challenges.

Socio economic vulnerability: The NDM is large and sparsely populated. This limits the effective delivery of basic services, such as health care. The District has a challenging natural environment and limited economic opportunities for the majority of the population. The local economy is natural resource based and dependent on livestock farming and a declining mining sector. Given the agricultural basis of the economy, climate change is likely to impact negatively on productivity and livelihoods, exacerbated by the high levels of poverty and low levels of education.

Institutional vulnerability: South Africa has strong institutions and powerful environmental legislation. The NDM too has well-developed biodiversity management plans. There are many implementation challenges at the local level, however. There is extremely limited staff capacity and no funds at the local level for environmental work of any kind. Likewise, while climate change and adaptation are on the agenda for many local politicians and officials, there are no official bodies dedicated to adapting to climate change.

A central recommendation of this report is to focus on reducing socio-economic and institutional vulnerabilities as the primary method for building local resilience to climate change. As local livelihoods are inextricably linked to and reliant on functioning natural systems, we recommend an ecosystem services and ecosystem-based adaptation approach in addressing core socio-economic vulnerabilities. Effort must be made to build local institutional capacity to respond effectively to climate change. Critically, this institutional capacity must be supported with appropriate resources allocations to achieve climate adaptation goals and implement EbA activities at the necessary scale.

Although we are advocating adaptation in this report, it is essential to be familiar with the worst case scenario for climate change for the region and to lobby strongly, now, for extensive mitigation towards a safe global temperature goal.

Action to reduce ecological vulnerability could include biodiversity stewardship, expanded protected areas, or expanded public works programmes such as Working for Wetlands or Working for Water.

Effectively reducing socio-economic vulnerability to climate change relies on recognising the vital ties between people's livelihoods and security and their natural environment, and acting to ensure that this is as sustainable as possible. It also rests on reducing those indicators which cause vulnerability more generally – poverty, unemployment, lack of sufficient quality education, or a lack of sustainable economic opportunities.

Strong, organised, well-informed, well-prepared, and well-funded local institutions will ensure the most effective possible adaptation response. The context of climate change vulnerability is critical, including multiple local non-climate stressors. Strong community-based institutions and local advocates can ensure that relevant local knowledge is incorporated into EbA practices. Strong institutions refer as much to conditions in the enabling environment as to local leadership and implementers on the ground.

CHAPTER 1: INTRODUCTION

By Amanda Bourne[1]

Vulnerability to climate change can be defined in part as a function of the level of available resources with which it is possible to adapt to or cope with a changing climate. South Africa's resources, including wealth, knowledge, and access to services, infrastructure, and education, are unequally distributed across the country and across different social groups. This results in large numbers of people lacking the resources necessary to effectively adapt to the impacts of climate change. In this document, we have taken OneWorld's (2010) approach of assessing the distribution and quality of the relevant available socio-economic, ecosystem, and institutional resources in the Namakwa District Municipality (NDM) to assess where greatest vulnerability (for example the lack of access to adequate resources to facilitate climate change adaptation) exists. Through this approach the vulnerability of people, as well as the biophysical impacts of climate change, are addressed in parallel. After these studies were completed, both sets of information were brought together and integrated at a conference with scientists and representatives of government and local communities. The purpose of the conference was to discuss and to agree on priority areas for Ecosystem-based Adaptation in the NDM.

Ecosystem Based Adaptation (EbA) has been defined by the Convention on Biological Diversity (CBD) as ***"the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change"****.*

[1] Climate Adaptation Coordinator, Namakwa Green Economy Demonstration, Conservation South Africa

Such an approach requires a good idea of conditions on the ground in a variety of sectors including water, agriculture, ecosystems and biodiversity, and human health and wellbeing. Insights into these conditions were collected through desktop study and personal engagement with relevant experts in each sector. It also requires good climate data, supplied by leading international expert on global change, Prof. Guy Midgley, and South African expert on mapping the impacts of climate change on biome stability, Dr Stephen Holness. This vulnerability assessment documents ecological and socio-economic vulnerability to climate change in the Namakwa District Municipality (NDM) and presents a map that identifies the priority areas for EbA and conservation actions.

An index of vulnerability was generated alongside the mapping processes to inform priority setting for and budget allocation to EbA and for application as metrics for measuring the reduction of vulnerability over time as a result of government effort and the efforts of our partners.

OVERVIEW OF THE NAMAKWA DISTRICT MUNICIPALITY

The NDM is situated in the far northwest of South Africa's Northern Cape Province, bordering Namibia. The Northern Cape is the largest province in the country and has a very low population density[2] and low natural

[2] The total Northern Cape population is 1,103,900 people, according to 2010 mid-year population estimates. This amounts to about 2.4% of the total South African population. The Northern Cape also

resources in terms of water and land suitable for agriculture relative to other areas in the country. Within it, the NDM is the largest and least populous District. The NDM is further broken down into 6 governance units, the local municipalities, that incorporate several towns, settlements, and natural or agricultural areas. Spanning approximately 12.686M ha, the NDM stretches from the Lower Orange River in the North to the border of the Western Cape Province in the South. The District is home to only 126, 700 people at a population density of 1 person per km². Given that government funding for human development is allocated primarily according to population density and population numbers, the Northern Cape, and NDM within it, is a low priority area in terms of government spending. Perceptions of a relatively healthy economy in the province are the result of a large, though rapidly declining, extractive mining sector.

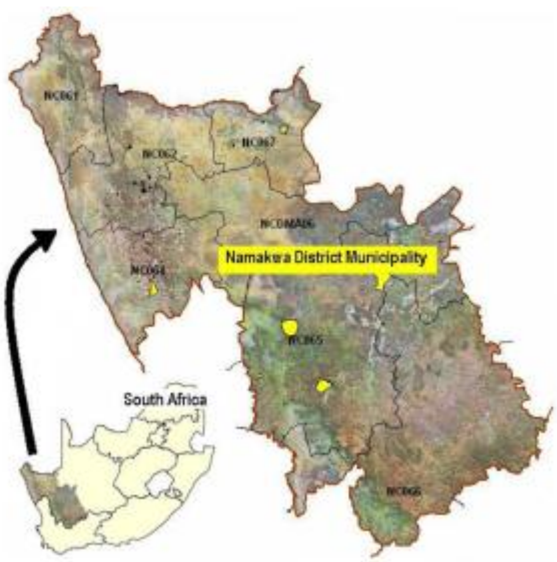

FIGURE 1: LOCATION OF THE NAMAKWA DISTRICT MUNICIPALITY IN SOUTH AFRICA, (NDM APPROVED INTEGRATED DEVELOPMENT PLAN 2010-2011).

The NDM contains large areas of Succulent Karoo - one of only two semi-arid biodiversity hotspots in the world, and exhibiting by far the highest plant diversity of any arid ecosystem. The Succulent Karoo falls primarily in the District's winter rainfall region, along the coast. There is also a large area of summer rainfall Nama Karoo as well as small patches of the Mediterranean-climate Fynbos, concentrated in the extreme SW of the District, and Desert Biome along the Orange River in the North. Having both summer and winter rainfall arid zones in the NDM contributes extensively to the exceptional variety of biodiversity the region contains.

FIGURE 2: THE MAIN TOWNS AT LOCAL MUNICIPALITIES IN THE NDM (DU PLESSIS, 2010)

There are six local municipalities, each with their particular characteristics. The *Kamiesberg* municipality is composed of impressive and ecologically significant high lying regions, and valuable coastal areas – both of which are key biodiversity rich regions. Rainfall totals averaging 400mm a year in the mountainous areas make the Kamiesberg uplands 'a critical water catchment area in the region.' (NDBSP,

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covers the largest land area of any province in the country.

2008:110). 20 of the 105 vegetation types that occur in the NDM are found here, and 10 of these are found nowhere else in the world[3].

The *Nama Khoi* local municipality is home to 37 of the NDM's vegetation types. Of these, 23 are endemic to the NDM, a remarkably high number demonstrating the high levels of diversity in the area[4]. Endemism rates for invertebrates are high, and many unique and remarkable adaptive insects can be found in this region, 22 of which are known to be endemic to the NDM. The area surrounding Springbok 'contains the most endemics per quarter degree square in the Succulent Karoo' (NDBSP, 2008:130) and much of the lower Orange River system falls within the boundaries of this municipality.

The *Richtersveld* local municipality contains 41 vegetation types. A staggering 34 of these types occur only here[5]. It is home to a large variety and the highest number of endemic plants, as well as some very charismatic plant species (*Aloe dichotoma* Quiver Tree, *Aloe pillansii* – Giant Quiver Tree, *Pachypodium namaquanum* - Halfmens). *Khai Ma* local municipality contains virtually the entire extent of the Bushmanland Inselbergs and the eastern part of the Gariep Centre of Plant Endemism, including the Koa river valley, and a stretch of the lower Orange River. In contrast with the rest of the District, Khai Ma has summer rainfall and is an undulating plains habitat characterised by desert grassland and ancient rocky outcrops. The municipality contains many special plant species including rare dwarf succulents. Riparian habitats along the Orange River are threatened by irrigated agriculture.

Karoo Hoogland local municipality is a largely flat undulating summer rainfall region supporting a variety of endemic bulbs, invertebrates, and fauna (*Bunolagus monticularis* – Riverine Rabbit, *Chrysochloris visagiei* – Visagie's Golden Mole). The Roggeveld Mountains are a critical water catchment for the southern NDM. Finally, the *Hantam* local municipality is recognised as a worldwide centre of bulb endemism and is home to a huge variety of plants and vegetation types. It is also the only place in the world where plant and bee endemism overlap (NDBSP, 2008:97). The area contains 28 vegetation types, 10 of which are endemic[6].

The seventh local municipality is a *District Management Area* with an extremely low population density and little in the way of critical biodiversity. It is not considered as one of the local municipalities in this report.

This exceptional biodiversity underpins the most widespread economic activity in the NDM, livestock production using extensive grazing of natural fodder. The scenic landscapes, isolation, unusual vegetation, and mass seasonal flower displays are a major tourist attraction. According to the SKEP Ecosystem Services Report (Le Maitre et al, 2009:3) 'the annual value of flower viewing tourism was calculated to be R18 million and

[3] Restricted vegetation types include vulnerable Namaqualand Granite Renosterveld and Kamiesberg Granite Fynbos. 1232 plant species are known to occur in the Kamiesberg, of which 48 are known endemics. 19 of these are found in the Kamiesberg Granite Fynbos.

[4] Endemic vegetation types include Anenous Plateau Shrubland and Namaqualand Shale Shrubland (in the Steinkopf area). The number of endemic plant species is also high and concentrated around the Springbok/Steinkopf/Concordia area.

[5] Endemic vegetation types include Richtersveld Coastal Duneveld and the Namib Coastal Vegetation, both classified as vulnerable; endangered Lower Gariep Alluvial Vegetation; and the critically endangered and entirely endemic Namib Lichen Fields and Alexander Bay Coastal Duneveld.

[6] Endemic vegetation types include Vanrhynsdorp Gannabosveld and Bokkeveld Sandstone Fynbos, as well as the endangered Nieuwoudtville Shale Renosterveld.

scenic tourism has a value of R156 million.' Tourism is a growth industry. Other biodiversity related services, including medicinal plants, plants for restoration, horticultural species, and other natural products, also provide opportunities for economic development and growth.

Finally, the landscape provides a critical freshwater service, which is crucial for supporting all the economic activities listed above. There are numerous threats to these services. Biodiversity hotspots are known for facing significant threats from human activities. A changing climate will overlay and interact with non-climate stresses in ways that are difficult to predict given uncertainties around the potential trajectory of climate change at the local level, and a lack of precise scientific understanding of the range of potential biological responses (Lovejoy and Hannah, 2004). Rising temperatures and changes in rainfall patterns are likely to increase water scarcity across the District, negatively affect biomass production and therefore livestock productivity, and curtail the growing tourism and natural products industries. Additional non-climate stressors also affect the landscape. Worsening poverty places increasing pressure on resources and land transformation, species extermination, and illegal and excessive plant collection will all affect resource viability in the future.

A VULNERABILITY ASSESSMENT FOR THE NAMAKWA DISTRICT MUNICIPALITY

The vulnerability assessment for the NDM requires considering the components of potential impacts and adaptive capacity of ecosystems and the people that rely on the services provided by those ecosystems. The potential impact of climate change on an ecosystem includes the degree to which it is exposed to climate change hazards and its inherent sensitivity to a changing environment. Adaptive capacity, on the other hand, must consider congenital capacity and survival of historical exposures to similar hazards. Likewise, the adaptive capacity of a social system depends on its internal characteristics and ability to withstand past and future exposures.

The approach taken for this vulnerability assessment was to make use of existing socio-economic and biodiversity information, representing current and historical conditions, and contextualise it within the latest available climate science for the region. Vulnerability is taken as a starting point, under the core assumption that vulnerabilities already exist and will be exacerbated by climate change. The same level of change will affect more and less vulnerable people and systems differently. A focus on known current socio-economic and ecosystem vulnerability is less sensitive to the uncertainties in climate projections and aligns more easily and closely with South Africa policy priorities around poverty alleviation, economic growth, and job creation. The aim of this vulnerability assessment report is specifically to integrate biophysical, socio-economic and institutional conditions with climate vulnerability and make this useful for policy makers. Vulnerability to climate change is understood as determined by the internal properties of a system as it interacts with its context.

Exposure: the extent to which a given system will be subjected to a particular hazard. In this report, exposure is measured in terms of the extent to which a social or ecological system will be exposed to or come into contact with increasing atmospheric temperatures over land, and changes in rainfall patterns.

Sensitivity: the extent to which a given system will be affected by a particular hazard. Sensitivity speaks to an analysis of the inherent qualities and characteristics of the entity or system. Sensitivity is measured in terms of the system's internal resilience and existing vulnerabilities.

Adaptive Capacity: the extent to which a system is able to exploit opportunities and resist or adjust to change. Adaptive capacity is measured in terms of historical response to stress or estimated according to a set of proxies such as income and education.

Once vulnerability profiles for each of institutions, socio-economic , and ecological systems had been compiled and the climate data had been analysed and mapped, these were presented, evaluated, verified, and revised at a conference in Springbok attended by local and provincial government, climate change experts, researchers in ecology and social science, and other local stakeholders.

This report documents key ecological, socio-economic and institutional vulnerabilities in the NDM, a site identified for its high biodiversity value and the fact that it is home to a large proportion of the Succulent Karoo Biodiversity Hotspot. Chapter 1 documents vulnerabilities. Chapter 2 looks at the specific climate change risks and impacts that the NDM faces, specifically in terms of expected climate change impacts on biomes, key ecosystem services and local communities that depend on these. The chapter focuses on the vulnerability of biodiversity and ecosystems and includes an analysis of biome stability in the NDM under various climate change scenarios. Chapter 3 examines socio economic vulnerability in the NDM, profiling the structural conditions that contribute to and detract from the District's capacity to effectively prepare for and adapt to climate change impacts and the specific socio-economic challenges and vulnerabilities that characterise the region. The impacts of climate change are examined in detail for the particular threats they pose to various economic land-uses. Chapter 4 focuses on institutional vulnerability and local government capacity to respond to a climate change crisis effectively. Chapter 5 summarises climate change vulnerability across the NDM and makes recommendations for adapting to climate change using an ecosystems-based adaptation approach. This report concludes that the overall vulnerability rating for the NDM is medium. This is encouraging as it suggests that EbA actions have the potential to be effective.

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CHAPTER 2: BIODIVERSITY AND ECOSYSTEM VULNERABILITY TO CLIMATE CHANGE IN THE NAMAKWA DISTRICT

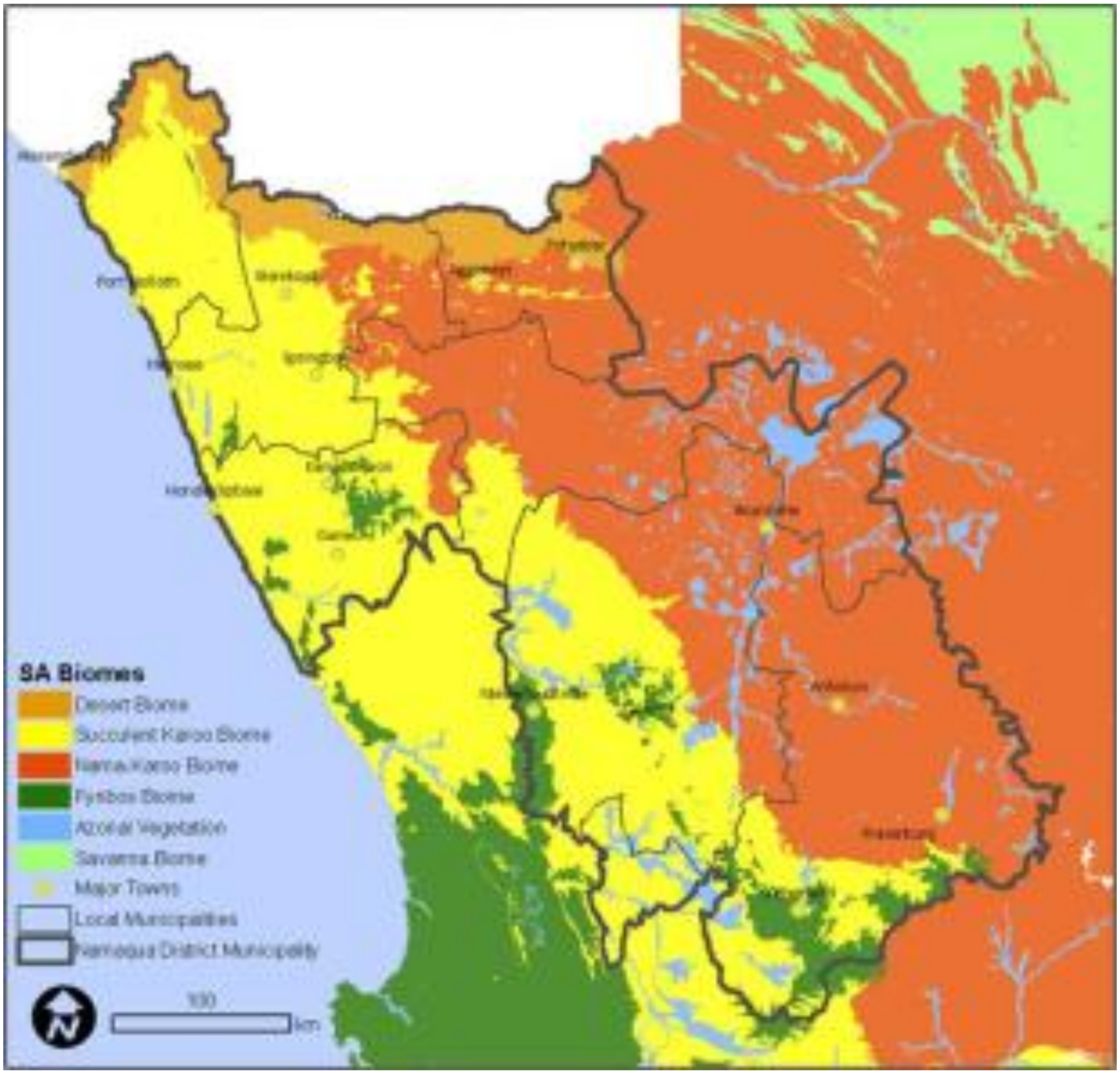
NAMAKWA DISTRICT ECOSYSTEM PROFILE

South Africa is one of 17 mega-diverse countries in the world. South Africa's terrestrial ecosystems are characterised by high levels of species diversity and endemism, particularly in plants – with the third highest number of vascular plant species in the world. With a land surface area of 1,2 million km^2 – representing just 1,2% of the earth's total land surface – South Africa is home to almost 10% of the world's total known bird, fish and plant species, and over 6% of the world's mammal and reptile species. The country's marine and coastal ecosystems, straddling the Atlantic and Indian Oceans, include an exceptional range of habitats, with almost 15% of known coastal marine species.

South Africa also contains within its borders three globally recognised biodiversity hotspots: the Cape Floristic Region (one of the world's six Floral Kingdoms), the Succulent Karoo Hotspot (shared with Namibia) and the Maputaland-Pondoland-Albany Hotspot (shared with Mozambique and Swaziland). According to Mucina and Rutherford (2006), South Africa has 9 biomes: Albany Thicket, Desert, Forest, Fynbos, Grassland, Indian Ocean Coastal Belt, Nama Karoo, Savanna, and Succulent Karoo.

The Succulent Karoo biodiversity hotspot is home to more than 6000 plant species, 250 bird species, 78 different mammals, 132 species of reptile and amphibian, and an unknown number of insect species. There are also high levels of endemism, with more than 40% of these species, particularly the unique and various indigenous succulents, found nowhere else on earth. The world's largest quiver tree forests (*Aloe dichotoma*, a charismatic plant known locally as the kokerboom) grow near Loeriesfontein, Kenhardt, and Onseepkans, and the region's many geophytes and daisies make for unparalleled spring flower displays. The NDM contains 105 distinct vegetation types.

Figure 3 below shows the South African Biomes found nationally and within in the Namakwa District. There are also small patches of azonal vegetation found, for example, along river systems. These occur throughout the country, in suitable habitats across biomes. Figure 4 shows the vegetation types found in the District.



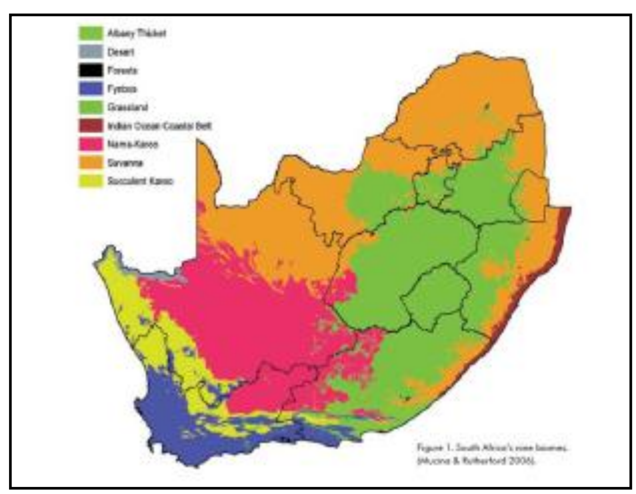


FIGURE 3: THE FOUR BIOMES OF THE NAMAKWA DISTRICT MUNICIPALITY. MAP BY DR PHIL DESMET

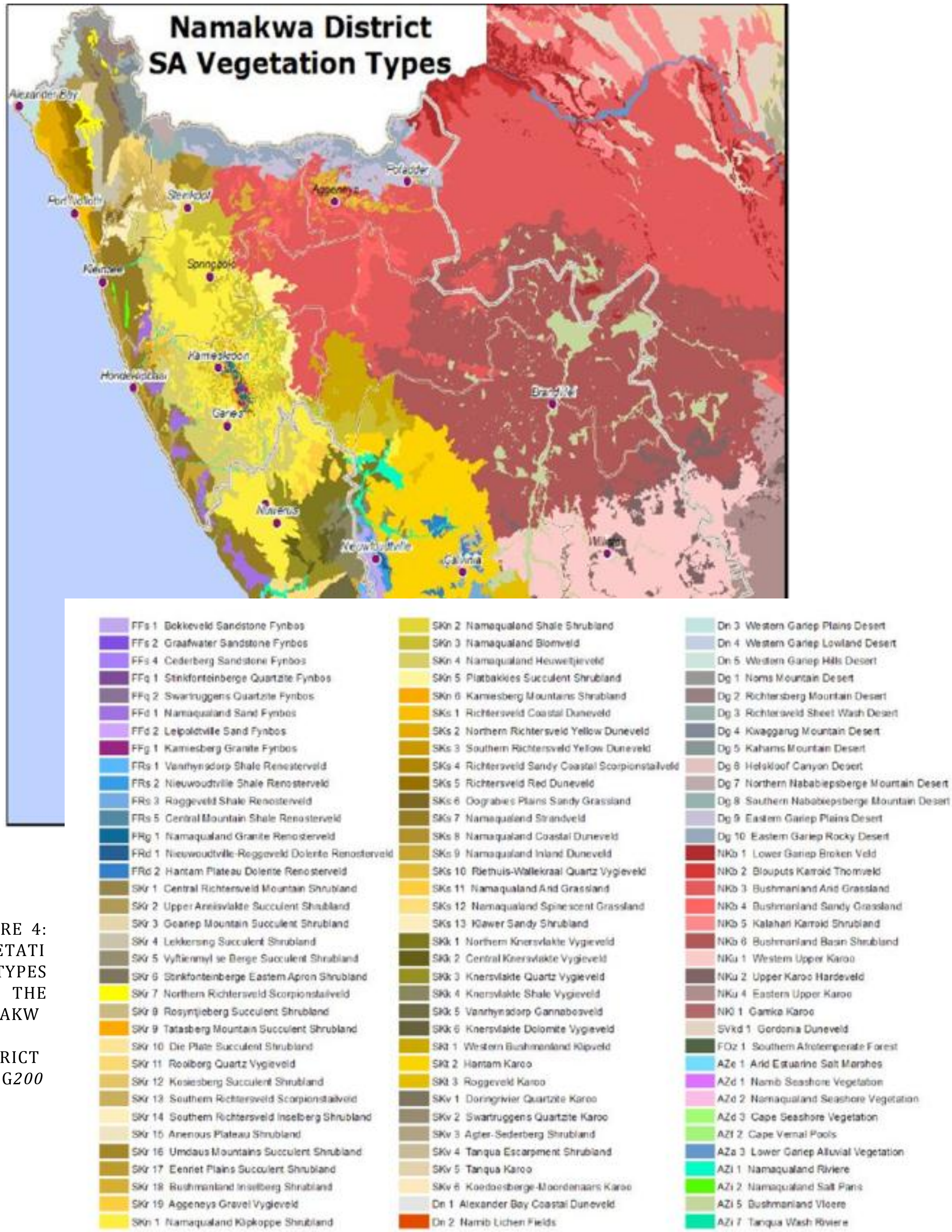


FIGURE 4: VEGETATION TYPES OF THE NAMAKWA DISTRICT (NCPG*2008)*

Most of the NDM's vegetation types fall into a 'Least Threatened' category. This is primarily because most current land cover indicators do not take into account degradation due to, for example, the spread of alien plant, the secondary impacts of mining, or overgrazing by livestock. Even with these methodological limitations, several ecosystems in the NDM are listed as Critically Endangered, Endangered or Vulnerable according to the sets of targets for intact ecosystems set by the Biodiversity Act. The Biodiversity Act targets are set at between 13-26% intact, mostly based on species area curves. Critically endangered types have less area in an intact state than the ideal set in the target. Endangered types have a total natural/intact extent that is less than the target plus 15%, i.e. it is a red flag category which indicates that we are nearing the position where we cannot meet target, a critically endangered position. Vulnerable systems are less than 60% intact, while least threatened types are the rest.

In the NDM, the Orange River mouth at Alexander Bay is a critically endangered site. Much of the length of the Orange River is listed as Endangered. Large areas along the coast and in the upland areas in the Kamiesberg and around Nieuwoudtville are listed as Vulnerable.

The Kamiesberg, Bushmanland, Augrabies area (15 on the map in Figure 5 below) is the largest remaining natural area in the country. This area is home to 22 Desert and Succulent Karoo vegetation types as well as several river types, important ecological gradients and centres of endemism – all reasonably intact at the moment, although threatened by mining and agricultural pressures and almost completely unprotected. Overall, as demonstrated in Figure 6, the NDM exhibits high biodiversity value.

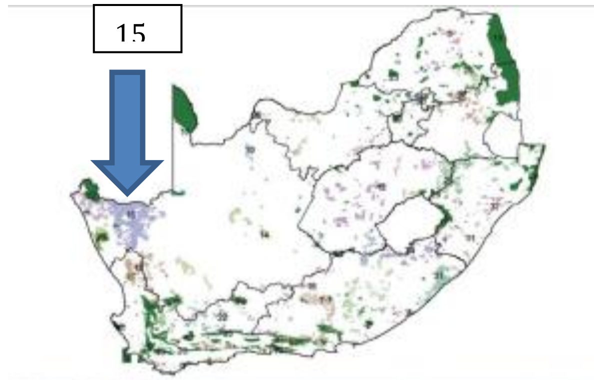


FIGURE 5: REMAINING NATURAL AREAS PRIORITIES FOR PROTECTED AREA EXPANSION (GOVERNMENT OF SOUTH AFRICA, 2012)

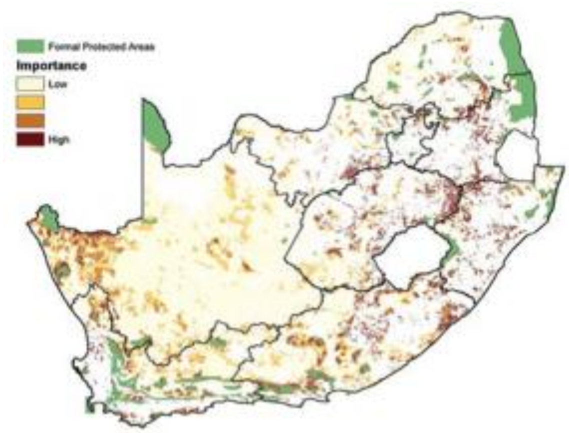


FIGURE 6: BIODIVERSITY VALUE OF SOUTH AFRICA'S LANDSCAPES (GOVERNMENT OF SOUTH AFRICA, 2010)

Besides its spectacular biodiversity, the region is characterised by its aridity. The climate of the Succulent Karoo is relatively consistent with low annual rainfall of 50-400mm falling mainly in the winter months between May and September. Some inland areas are characterised by summer thunderstorms. The presence of the cold Atlantic Ocean moderates temperatures to a mean summer temperature of 30°C inland, cooler along the coast itself, and provides an additional source of moisture in the form of coastal fog and heavy dew. Overall, however, the Namakwa District is extremely water scarce, with large areas in the north regularly receiving less than 100mm of rainfall annually. Water scarcity is likely to be exacerbated by climate change due to the increasing atmospheric temperatures over land and sea, and changes in rainfall patterns that are expected to happen in the next few decades.

There is evidence to suggest a long history of aridity in this region, dating back to the Cretaceous (Goudie and Eckhart, 1999), and a historically stable climate, both of which contributed to species diversification. According to Midgley and Thuiller (2007:3), 'regions with high endemic species richness, such as Namaqualand, especially of species with low dispersal ability and vagility, are likely not to have experienced substantial Pleistocene climate change.' Reconstructions have been carried out to test how glacial and interglacial climate changes may have impacted on bioclimatic suitability for Succulent Karoo as we know it today (Midgley et al, 2001). What limited evidence is available suggests that, 'even under peak glacial conditions of the Last Glacial Maximum, the Succulent Karoo Biome retained an appreciable core range within Namaqualand, namely in the ''Knersvlakte'', and further north in the arid mountains of the northern Cape (Richtersveld)' (Midgley and Thuiller, 2007:4).

Considering the long stable period in which the plants characteristic of the Succulent Karoo evolved, the Succulent Karoo may be particularly sensitive to sudden and dramatic climatic changes. Others believe that the short duration cycles of climatic variation and exposure to extremes that occur in natural annual cycles make the system inherently more resilient. Nevertheless, it is agreed by both sides that a precautionary principle should be applied to all land-use to maximize resilience in the NDM environment for the people who depend on it.

BIO-PHYSICAL IMPACTS OF CLIMATE CHANGE FOR THE NAMAKWA DISTRICT: EXPERT REPORT

By Prof. Guy Midgley[7] and Dr Stephen Holness[8]

INTRODUCTION

Considerable concern was raised in the late 1990's about the long term viability of endemic species, ecosystem function and by implication the livelihoods of people after the publication of South Africa's Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). The application of simplistic models of climate change impacts on biome distributions indicated that considerable reductions in climatically suitable areas for winter-rainfall biomes (Succulent Karoo and Fynbos) could be expected. Such reductions were projected to be most significant in the absence of effective mitigation action. This report prompted numerous follow-up studies that also identified the semi-arid winter rainfall zones of south-west South Africa as highly vulnerable to the potential impacts of climate change. Furthermore, monitoring and observation of the near-endemic *Aloe dichotoma* (a charismatic tree-succulent of the winter-rainfall semi-arid region) suggested that long term climate change may be causing die-back in some populations closest to the climatic limits of the species.

However, it was stressed by this early work that the projections were preliminary, and

[7] Chief Director, Climate Change and Bio-Adaptation Division, South African National Biodiversity Institute

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that many uncertainties were attached to them, both because of climate scenario uncertainty and because of uncertainty in the impacts projection methods themselves. Several advances have been made in this area of applied science, and both new climate scenarios have become available, and new impacts methods have been developed. In addition, there have been advances in considering the inherent resilience in landscapes through the application of geographic information systems approaches (GIS) and, recently, considerations of how ecosystem services might be employed in helping human societies to adapt to the adverse impacts of climate change.

This section updates the early work developed for the semi-arid winter rainfall region of South Africa in a way that allows climate scenario uncertainty to be better addressed, employs statistically-based impacts models, and current GIS methods of incorporating landscape and other features in assessing priority conservation areas in the Namakwa Region of this semi-arid winter-rainfall climatic zone. It also considers the value and credibility of these modelling approaches given two key climatic and non-climatic drivers that are not yet well incorporated into climate impacts models, namely atmospheric CO_2 and fog inputs.

RE-ASSESSING CLIMATE CHANGE RISK AT BIOME SCALE

The primary focus of this section is to reassess vulnerability to climate change for the biomes of the Namakwa District in South Africa according to the latest available science. This can give us insight into how those changes may affect local communities reliant on ecosystem services. In addition, a series of maps that indicate areas of biome stability according to the current projections were developed for this report. These clearly demonstrate prioritisation for conservation-related and ecosystem-based adaptation action.

South Africa has nine biomes, four of which are found within the Namakwa District, namely Succulent Karoo, Nama-Karoo, Fynbos and Desert. Each biome has a characteristic 'climate envelope' or a range and pattern of temperature and rainfall values within which it occurs. Our understanding of climate control of vegetation types dictates that, as the climate changes, an area that is currently climatically suited to one biome might become climatically suited to another, inducing climate-related stress in components of the biome. If such changes were to occur over a long period of time (many thousands of years), and if natural habitat were predominantly intact, the ecosystems and species that make up the biome would likely be able to undergo adaptation and spatial

Definitions used for habitat description:

Throughout this document, we are using the habitat units as defined and identified for South Africa in Mucina & Rutherford (2006), The Vegetation of South Africa, Lesotho and Swaziland.

Biome - a broad ecological spatial unit representing major life zones of large natural areas, and defined mainly by vegetation structure, climate as well as major large-scale disturbance factors (such as fire). Each biome may consist of a number of bioregions and each of these bioregions will contain many vegetation types.

Bioregion - these are a group of similar vegetation types sharing similar biotic and physical-geographical features, connected by ecological processes operating at a regional scale.

Vegetation types or units - these are a complex of plant communities ecologically and historically (both in spatial and temporal terms) occupying habitat complexes at the landscape scale. A more user friendly definition is that these are the smallest unique units of similar vegetation in terms of composition or structure which have been mapped across the whole country.

shifts in response. However, with changes in climate projected to occur over relatively short periods (decades) and the current state of significant natural habitat loss, degradation, and fragmentation, it is more likely that disruptive change (such as population declines and even extinctions) would occur, especially in areas of future climatic unsuitability.

The first research on how the distribution of South Africa's biomes might be impacted by climate change was done in the mid-1990s and reported in 2000, among the first such work worldwide (Rutherford et al, 2000). Rutherford et al's report was part of the South African Country Study on Climate Change which contributed to South Africa's Initial National Communication to the UNFCCC. This work examined how the distribution of different biomes was likely to be influenced by climate change. The study was conceptually very similar to that used in our current report and the work presented here builds on this concept, using more recent climate data and analysis methods.

Rutherford et al's (2000) analysis was based on climate data which, although relevant at the time of analysis, is now is extremely dated given advancements in climate science over the last decade. Key differences between the outcomes of the previous study and the current study include that Rutherford et al (2000) indicate an almost complete loss of the Succulent Karoo climate envelope as a result of dramatic predicted reductions in winter rainfall while this report suggests that winter rainfall patterns will change slower than originally predicted and, therefore, contractions in the Succulent Karoo biome will be less pronounced in the short to medium term.

Over the last decade, the science of climate change has evolved rapidly. Nevertheless, there is considerable uncertainty about the evolution of climate over 50 or 100 year time-scales, and while confidence in global circulation models is growing there is greater appreciation of the uncertainties involved, especially in 'downscaling' the global models to produce climate projections at the regional and local scales.

Acknowledging this unavoidable uncertainty, we have developed a statistical approach to incorporate a wide range of possible climate scenarios in impacts models that uses median and 90th and 10th percentile changes in temperature and rainfall from a number of general circulation models, from which future scenarios are developed. Highest temperature increases and largest rainfall decreases were combined to generate a 'high-risk' or 'worst case' scenario, and vice-versa for a 'low-risk' or 'best case' scenario. Likewise the median projected changes in rainfall and temperature were combined to generate an intermediate scenario.

Based on outputs from 15 global circulation models that were spatially interpolated, we developed three climate scenarios for the Namakwa District for approximately 2050 as follows:[9]

- Best case scenario: smallest predicted increases in temperature and changes in rainfall,
- Intermediate scenario: middle of the range (median) predicted increases in temperature increases and changes in rainfall,
- Worst case scenario: greatest predicted increases in temperature and changes in rainfall.

[9] For more detail on the analysis and methods summarised here see Holness et al. In prep. Where can protected areas contribute most to supporting resilience of biodiversity to climate change at the landscape scale in South Africa?

Detail on the climate scenarios:

The present values are based on the agro-hydrology data for rain and temperature. Temperature and precipitation data for seasons DJF (Dec,Jan,Feb), MAM (Mar,Apr,May), JJA (Jun,July,Aug) and SON (Sept,Oct,Nov) were used as the base climate variables. The current climate data are a 1' grid (approximately 1.8km x 1.8km).

The climate scenario data used were based on the difference between future and current values for each of the 15 GCMs (i.e. future predicted value - control values produced by the model for present conditions), with present being 1960-1999, and future being 2040-2059. The future climate data are approximately a 50km x 50km grid.

The scenarios are calculated as [present agro-hydrology data values for rain and temp] + [anomaly]. The anomaly chosen varied for each scenario:

- Best case scenario: temperatures at the lowest end of those predicted by the 15 downscaled GCMs (10th percentile for temperature values) and rainfall values at the highest end of the range predicted (90th percentile of rainfall values).

- Intermediate scenario: median temperature and rainfall changes from the 15 models.

- Worst case scenario: temperatures at the highest end of those predicted by the 15 downscaled GCMs (90th percentile for temperature values) and rainfall values at the lowest end of the range predicted (10th percentile of rainfall values).

Note1. This does not imply that these particular combinations are predicted to occur in combination by a specific model or are more or less likely. They are specifically chosen to represent the full range of potential values, in order to ensure that actual futures are likely to be within the range of these scenarios.

Note2. All GCM outputs are used in each of the scenarios.

dependent on any particular global circulation model but hold under a very wide range of possible climate futures, enhancing the robustness of conclusions as climate changes and as climate science revises outputs and projections.

Note that the study was based on medium term data (for 2050) as this represented a compromise between the uncertainty associated with the very long time horizon data (2100) and the very small changes predicted by the shorter duration data (e.g. 2020). This 50 year time horizon also represents a reasonable long term planning horizon as it is within the lifetimes of most people currently living. When this study is updated based on new climate data, if possible, we will include both the medium term and long term predictions. In the interim, as climate change occurs gradually over time, it is useful to conceptualize the worst case scenarios for 2050 as being likely to represent the intermediate case scenarios in 2100. The worst case scenario for 2100 is likely to look similar to the Rutherford et al (2000) report as winter rainfall shifts increasingly come into play over time.

CLIMATE CHANGE SUMMARY MAPS

The following pages include summary maps of annual average temperature and precipitation based on the available historical data for 1960-1999 and for each of the three future scenarios.

We have selected here, deliberately, not to map the anomaly data from either the individual global models or from the composite scenarios as it is far coarser than the spatially downscaled climate outputs given below. Should we receive the new climate data currently being explored, we will update this report to include maps of the anomalies from this finer scale regional downscaling data.

Our modelling shows that, under all scenarios, greatest warming is projected for the south-central interior and along the Orange River in the north. The coastline is also projected to warm substantially, particularly towards the south. The most stable areas in terms of projected temperature change are around Sutherland in the south east and in the Kamiesberg, where higher altitudes limit temperature increases. In all three scenarios, average annual temperatures are predicted to increase by 2050. As a result of the methodology applied, temperature increases reflect as more subtle in the best case and more drastic in the worst case scenarios.

The rainfall maps demonstrate greater uncertainty around projected changes in rainfall. The best case scenario predicts an increase in rainfall around the Kamiesberg and into south central and south east NDM. The intermediate and worst case scenarios predict a reduction in rainfall across the NDM. In the intermediate scenario, projected decreases in rainfall are small, while in the worst case scenario, rainfall is projected to decrease significantly. The north remains dry across all scenarios. Most drastic projected rainfall reductions occur in the worst case scenario in the regions currently receiving the highest average annual rainfall in the district, as well as in the north east of the District.

Note that the maps illustrate an extreme of the range of potential rainfall scenarios for the district, and should not be interpreted as suggesting that any one particular scenario is more or less likely to occur.

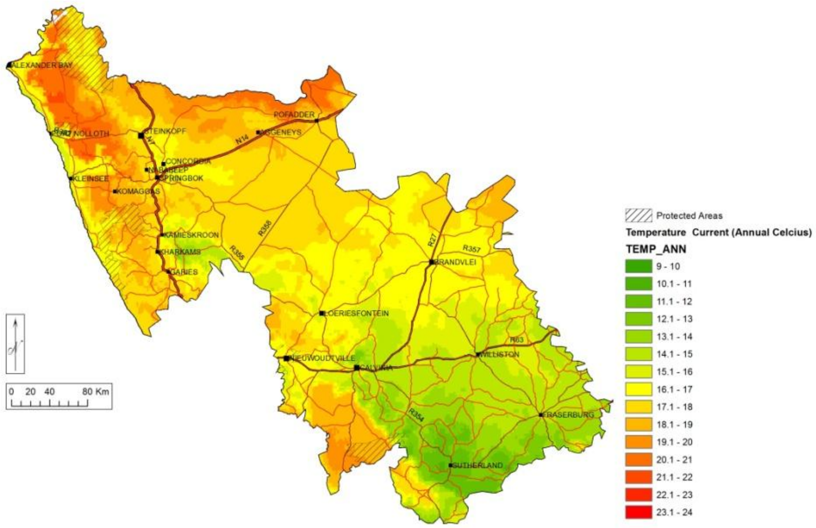

FIGURE 7: CURRENT ANNUAL AVERAGE TEMPERATURE FOR THE NAMAKWA DISTRICT

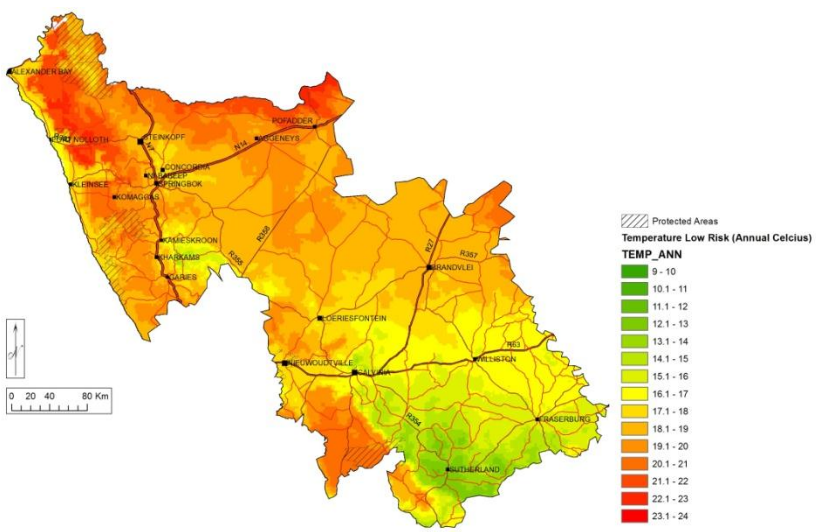

FIGURE 8: ANNUAL AVERAGE TEMPERATURE FOR THE NAMAKWA DISTRICT FOR 2050 UNDER A BEST CASE SCENARIO, WITH SMALLEST PREDICTED INCREASES IN TEMPERATURE

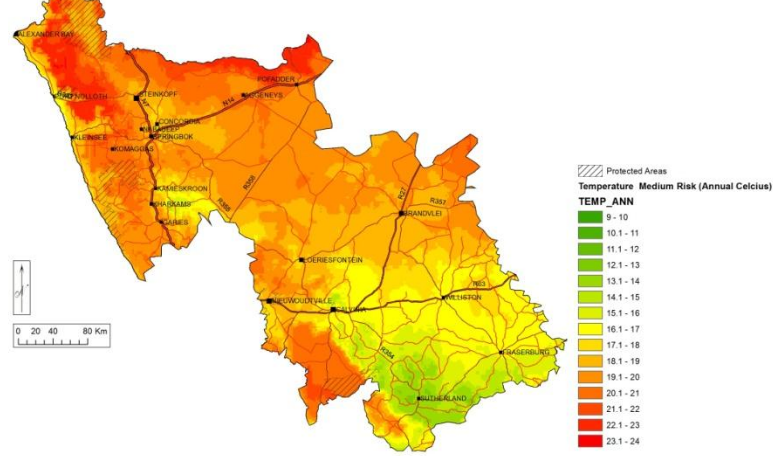

FIGURE 9: ANNUAL AVERAGE TEMPERATURE FOR THE NAMAKWA DISTRICT FOR 2050 UNDER AN INTERMEDIATE SCENARIO: MIDDLE OF THE RANGE (MEDIAN) PREDICTED INCREASES IN TEMPERATURE

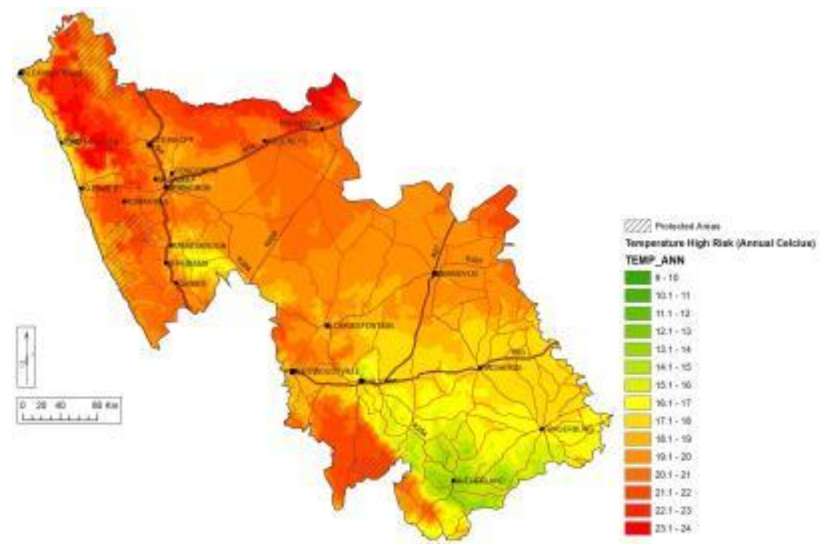

FIGURE 10: ANNUAL AVERAGE TEMPERATURE FOR THE NAMAKWA DISTRICT FOR 2050 UNDER A WORST CASE SCENARIO: GREATEST PREDICTED INCREASES IN TEMPERATURE

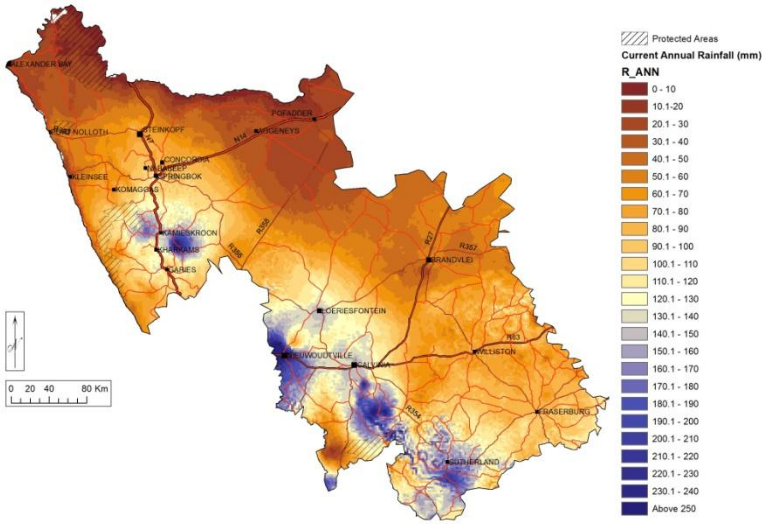

FIGURE 11: CURRENT ANNUAL AVERAGE RAINFALL FOR THE NAMAKWA DISTRICT

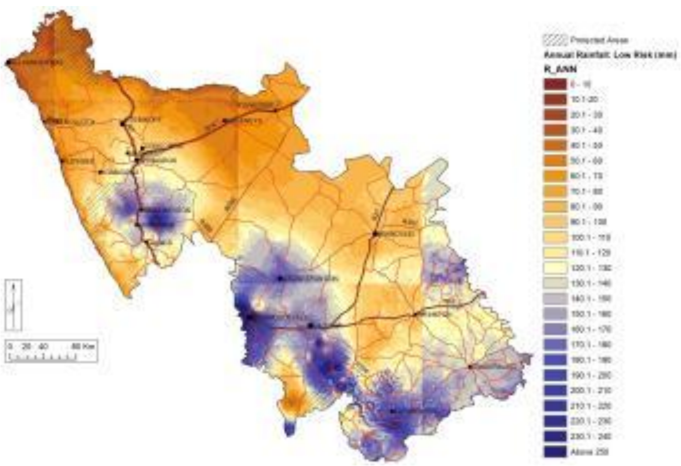

FIGURE 12: ANNUAL AVERAGE PRECIPITATION FOR THE NAMAKWA DISTRICT FOR 2050 UNDER A "BEST CASE" SCENARIO, WITH SMALLEST PREDICTED INCREASES IN TEMPERATURE, AND RAINFALL VALUES FROM THE 90TH PERCENTILE OF VALUES PREDICTED BY MODELS.

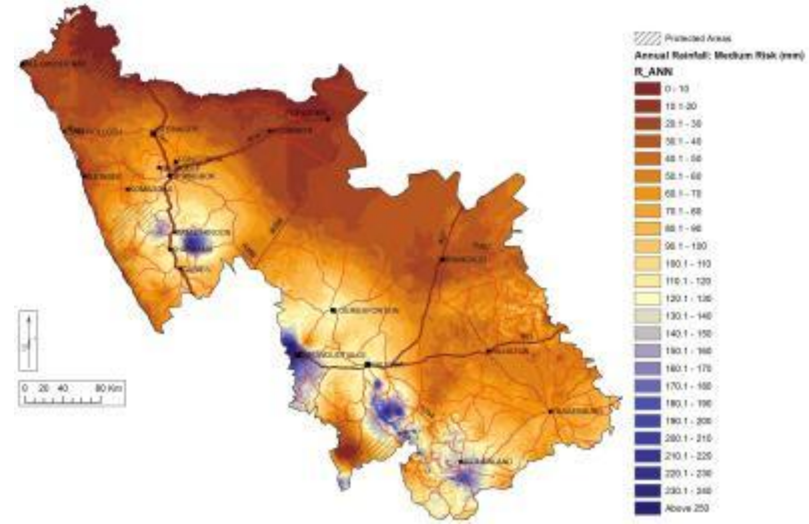

FIGURE 13: ANNUAL AVERAGE PRECIPITATION FOR THE NAMAKWA DISTRICT FOR 2050 UNDER AN INTERMEDIATE SCENARIO: MIDDLE OF THE RANGE (MEDIAN) PREDICTED INCREASES IN TEMPERATURE AND CHANGES IN RAINFALL.

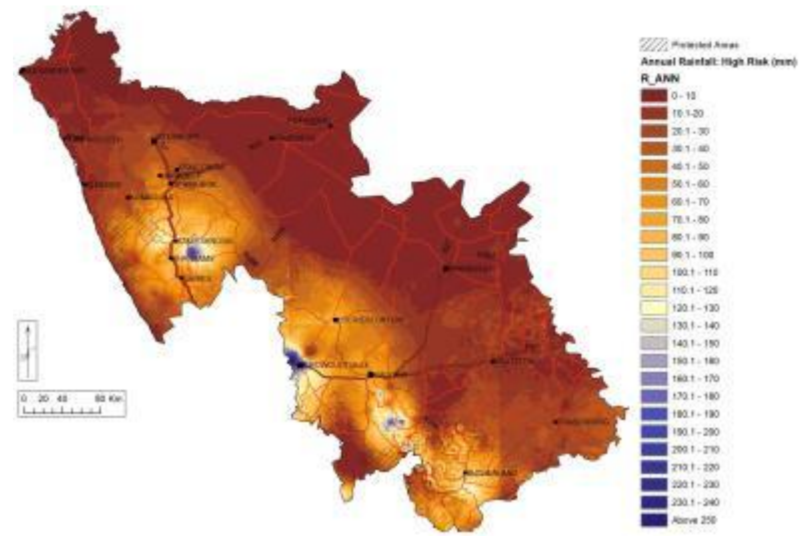

FIGURE 14: ANNUAL AVERAGE PRECIPITATION FOR THE NAMAKWA DISTRICT FOR 2050 UNDER A WORST CASE SCENARIO: GREATEST PREDICTED INCREASES IN TEMPERATURE AND CHANGES IN RAINFALL

BIOME ENVELOPE MODELLING

The approach taken here is to model the climate envelopes responsible for biome suitability. In this way, we were able to identify biomes, and specific areas within biomes, that are likely to be more stable under climate change and could therefore provide appropriate sites for the implementation of EbA. While we are able to draw some conclusions about water availability from the climate models, this was not possible for the palatable species, geophytes, and flowering annuals that underpin livestock grazing and tourism respectively.

A maximum entropy model (using the industry standard software MaxEnt) was used to develop a biome distribution model which predicts the distribution of biomes based on a set of climate variables. The ability of the model to predict future distributions of biomes was tested by using it to 'predict' the current distribution of biomes. The model was very accurate at 'predicting' the current distribution of biomes, producing a map that matched the actual distribution of biomes very closely.

This biome distribution model was then used to show how the distribution of climate envelopes associated with different biomes is likely to change under each of the three climate scenarios. The results are shown over the following pages. The maps show which biome's climate envelope the future climate in an area is likely to resemble most closely; this is often different from the current biome in that area.

Importantly, because a biome (e.g. the Succulent Karoo) encompasses a broad range of climatic conditions, a specific site could experience fairly large changes in precipitation and temperature and still remain within the envelope of conditions currently associated with that biome. An area which is currently in the coolest and moistest portions of the biome may end up with a climate similar to the hottest and driest areas of that same current biome. Although, for a particular species, this may result in local extinction, broadly as the site is still within the envelope of conditions associated with Succulent Karoo, it is likely to remain structurally similar to Succulent Karoo and retain a suite of Succulent Karoo species.

This does not imply that the change will not be extremely serious for a very large number of species. Some species level information is available, however. Midgley and Thuiller (2010), for example, modeled climate change response in 20 Karoo succulent endemic species, showing that most species would experience a range reduction under climate change.

However, this also does not necessarily mean that an area demonstrating a significant shift in the climate envelope will change into a different biome. We do not yet know how biomes, and the ecosystems and species that make them up, are likely to respond to these new climatic conditions in practice. The maps provide a picture of where biomes are most at risk as a result of climate change to mid-century. This analysis is based on statistically downscaled climate data only. Some key outcomes are:

- The climate envelope found in the Nama-Karoo area of the NDM is likely to remain stable under the best case and intermediate scenarios, but changes to a Desert climate envelope in the north under the worst case scenario (see Figures 15-18).
- Areas with a climate envelope characteristic of Succulent Karoo largely persist under all the scenarios. This contrasts substantially with previous predictions from the mid-1990s as newer climate models with statistical downscaling indicate far smaller impacts on winter rainfall than previous generation models predicted in the chosen timeframe. The approach taken here does not preclude more significant impacts towards the end of the century. It is, therefore, useful to conceptualize the worst case scenario for 2050 as being likely to represent the intermediate case scenarios in 2100.
- Under the best case scenario, the core portions of the Fynbos, typically located in the mountainous areas, remain within the current biome envelope, but probably with significant up-slope movement of suitable climate envelopes for particular species and habit types. The islands of Fynbos found in the NDM are likely come under increasing stress in higher risk scenarios, with the climate envelopes in these areas becoming more like Succulent Karoo.
- Areas with a climate similar to the current Desert biome are likely to expand in the future into areas which are now Nama-Karoo.

In addition to highlighting areas where biomes are at risk of structural change, the analysis shown can also be used to highlight areas where biome climate envelopes are likely to be most stable under a range of statistically downscaled scenarios. A similar analysis was completed for the National Spatial Biodiversity Assessment in 2004 (Driver et al), based on the previous predictions of changes in biome climate envelopes published in 2000 using older climate models. Figure 19 shows areas where the climate envelope for the current biome is expected to persist, shown as the darkest areas on the map. These are areas which are most likely to have a stable ecological composition and structure in the face of climate change as simulated using statistically downscaled scenarios. More sophisticated modelling of South African climate is currently underway that could potentially alter this view to some degree. It will be a priority to test if simulations using this greater national capacity in climate change modelling support the projections made here, and if these hold to the end of this century. It is also important to note that changes due to rising CO_2 effects on plant growth and productivity are not simulated by this modelling approach, and must also be considered urgently to provide a more comprehensive picture of change.

In areas where biomes are most at risk of ecological composition and structural change, it is particularly important to retain natural features in the landscape that will allow ecosystems and species to adapt as naturally as possible. These could include, for example, corridors of natural habitat that enable species to move along an altitudinal gradient. These landscape features are discussed further below. Areas where biomes are most likely to be stable in the face of climate change present good opportunities for the location of new or expanded protected areas aimed at improving the representation of the biome concerned in the protected area network in the longer term. This is because they are more likely to retain their current composition and structure and thus to effectively represent the ecosystems concerned. Those areas are, therefore, potential candidates for EbA actions aimed at maintaining current biodiversity from a representation perspective.

EbA will also have great value for adapting to change in areas projected to experience biome shifts under climate change, from an ecosystem services perspective.

The maps show that the future climate envelope in an area is likely to resemble most closely the climate of a particular biome, often different from the current biome in that area. This does not necessarily mean the area will change to a different biome.

Details on biome envelop modelling:

Current (control) climate data as described above were entered into MaxEnt. Temperature and precipitation data for seasons DJF (Dec, Jan, Feb), MAM (Mar, Apr, May), JJA (Jun, July, Aug) and SON (Sept, Oct, Nov) were used as the base climate variables. The climate data are a 1' grid.

The National Vegetation level map (Mucina et al. 2006) was dissolved on the biome field, to produce an accurate biome boundaries map. Centroids of the climate data grid pixels were used as sample sites to generate training points for MaxEnt. These training points were fed into MaxEnt to produce models for each of the biomes under current conditions.

We produced a 'Current Modeled' Biome map by taking the outputs from the above MaxEnt models. We then assigned a modeled biome based on the MaxEnt score (for each biome) with the final modeled biome being assigned according to the highest MaxEnt predicted value.

To test the 'Current Modeled' Biome map we compared it to an 'Actual Current' generalized biome map created by assigning the area dominant biome in each grid square.

We compared the modeled biome map with the actual biome map. Just over 86% of the areas were correctly predicted. Areas that were misidentified were mostly on the boundaries of biomes, or had a mixture of biomes present in the square (e.g. the square may have been 55% Fynbos - 45% Succulent Karoo, and the MaxEnt model may have a slightly stronger Succulent Karoo signal).

We then used the models created for the biomes and applied these to the future climate modeled data.

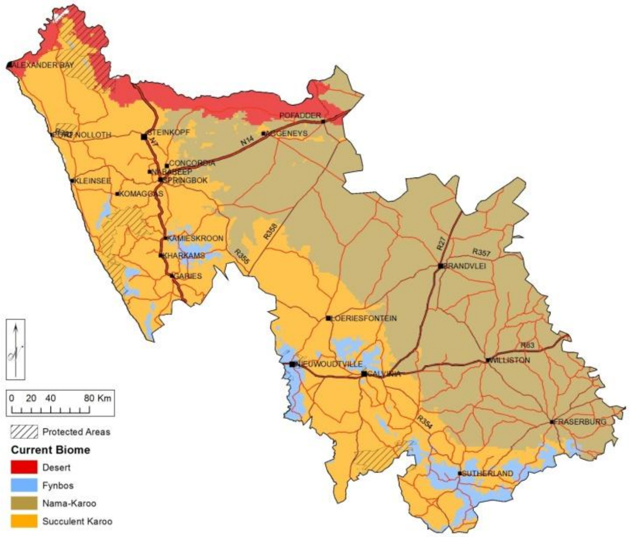

FIGURE 15: CURRENT DISTRIBUTION OF BIOMES IN THE NAMAKWA DISTRICT.

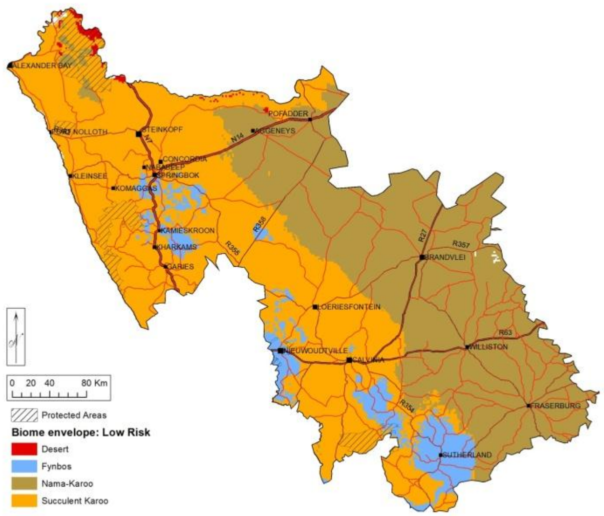

FIGURE 16: PREDICTIONS OF BIOME CLIMATE ENVELOPES UNDER A BEST CASE SCENARIO, LOOKING AHEAD TO APPROXIMATELY 2050.

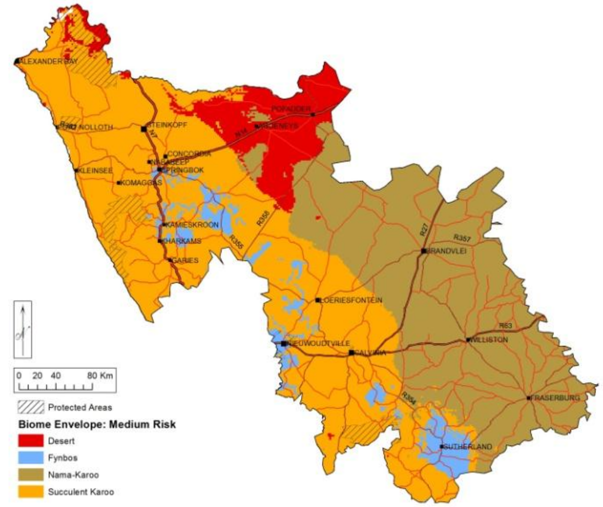

FIGURE 17: PREDICTIONS OF BIOME CLIMATE ENVELOPES UNDER AN INTERMEDIATE CASE SCENARIO, LOOKING AHEAD TO APPROXIMATELY 2050.

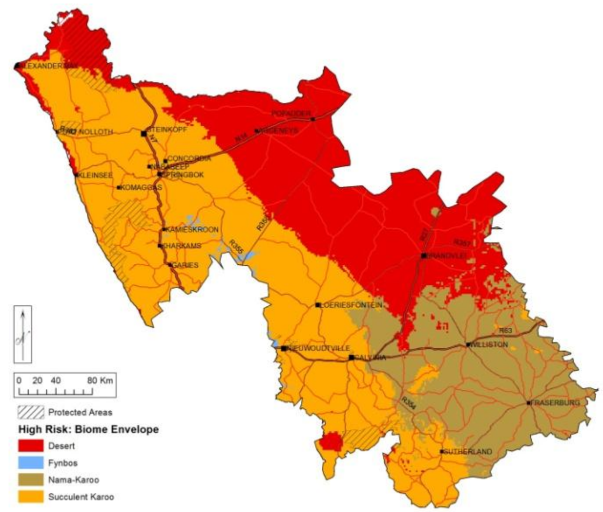

FIGURE 18: PREDICTIONS OF BIOME CLIMATE ENVELOPES UNDER A WORST CASE SCENARIO, LOOKING AHEAD TO APPROXIMATELY 2050.

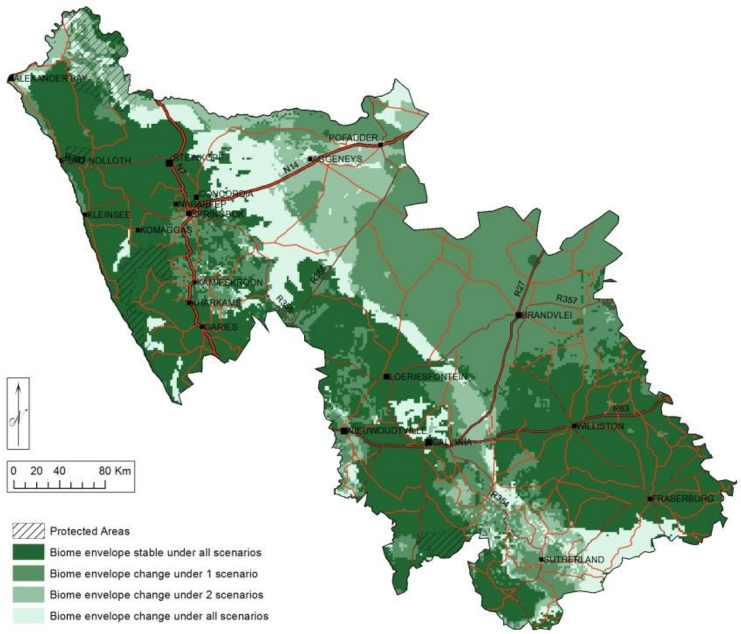

FIGURE 19: AREAS OF BIOME STABILITY IN THE FACE OF CLIMATE CHANGE

Under a range of climate scenarios, according to niche modelling results using statistically downscaled future climate scenarios only: The darkest areas are predicted to stay within their current climate envelopes under all three climate scenarios, and hence are most likely to maintain a stable ecological composition and structure. The white areas are areas where biomes are most at risk of ecological composition and structural change in the face of climate change.

AREAS IMPORTANT FOR SUPPORTING CLIMATE CHANGE RESILIENCE:

Within areas of biome stability as well as areas where biomes are most likely to be at risk, some current and intrinsic features in the landscape are more likely to support the resilience of biodiversity to climate change than others and may therefore be good candidates for conservation and climate change adaptation. Such features include: riparian corridors and buffers; coastal corridors; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs (areas with steep slopes and close proximity to rivers); and priority large unfragmented landscapes. All of these features were mapped, and then combined to provide a single map of areas important for supporting the resilience of biodiversity to climate change at the landscape scale. Keeping these areas in a natural or near-natural state will allow ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services. They should be considered vital elements of South Africa's ecological infrastructure in the face of climate change, underpinning local ecosystems-based adaptation to climate change.

IDENTIFYING AREAS IMPORTANT FOR SUPPORTING CLIMATE CHANGE RESILIENCE:

The logic for, and derivation of, the input layers required for identifying areas important for climate change resilience are summarised in the following paragraphs.

Coastal Corridor: A coastal process or corridor layer was developed. It includes areas that comply with the legal definitions in the National Environmental Management: Integrated Coastal Management Act: a minimum of a one kilometer buffer inland of coastal features, landtypes associated with coastal geomorphological processes (especially sand dunes) and also coastal vegetation units as defined in the South African vegetation map (Mucina and Rutherford, 2006). If left undisturbed, the natural ecosystem is expected to have good adaptive capacity in many instances. The best policy for long-term adaptation in coastal zones appeasrs to be to allow coastal processes to progress naturally. Some of these areas may be affected by sea level rise. For example, the west coast is rising by 1.87 mm per year (Midgley et al, 2010). A conservation outcome from this report suggests that a 1km buffer should be protected to maintain key coastal processes in this area.

Riparian corridors and buffers: Corridors provide critical ecological linkages between large core patches of intact habitat through hostile matrix areas of transformed habitat. Corridors are seen to be critical for the movement of a variety of animal species in the short term (pollinators, predators) from source to sink areas, to provide for genetic interchange between spatially separate populations of animals in the medium term, and in the long term are hoped to be important for the migration of plant and other species under conditions of global climate change. We recognise that the range and distribution of particular species may shift with climate change and, therefore, that current corridors may not enable certain species to move across the landscape.

We have, however, mapped one of the most clearly defined corridors, especially in heavily transformed arable agriculture landscapes, those associated with rivers. Importantly, the river associated movement corridors also provide upland-lowland linkages on the macro-scale. A corridor layer was created based on the 2nd order and larger rivers[10] and a cost surface[11] derived from a transformation and fragmentation layer[12]. A total corridor width of approximately 1km was aimed for in completely transformed landscapes, and 10km in completely natural areas, with the corridors varying in width in response to the level and pattern of transformation.

Areas with important temperature, rainfall and altitudinal gradients: Maintaining these areas is important in order to allow species and ecosystems to rapidly adapt to changing climate, as they represent the shortest routes for the species which make up ecosystems to move along upland-lowland and climatic gradients in order to remain within acceptable climate envelopes. These areas are particularly important for species which are not able to move rapidly in response to climate change. These areas also have high levels of climate and landscape heterogeneity, and hence are likely to contain a range of important micro-climates which may act as local refugia for those species that otherwise may not be able to adapt to rapid environmental change. A series of topographic and climatic indices were combined in the preparation of this layer:

Altitudinal heterogeneity: A 90m resolution digital elevation model was examined at a 0.01 degree or just over 1 km squared resolution. Altitudinal differences were calculated based on the maximum and minimum altitudes found within a roving 7x7 grid (i.e. approximately 49km^2 area). The output was divided into 8 quantiles with the top category considered to be the areas best representing high altitude gradient areas. This quantile corresponded to areas with greater than 340m of altitude variation within the 49km^2 area.

Precipitation gradients: Precipitation data from the Agricultural Research Council was examined at a 0.01 degree or just over 1 km squared resolution. Precipitation gradients were calculated based on the maximum and minimum values found within a roving 7x7 grid (i.e. approximately 49km^2 area). The output was divided into 8 quantiles with the top category considered to be the areas best representing high precipitation gradient areas. This quantile corresponded to areas with greater than 235mm of precipitation variation within the 49km^2 area. We assume that these gradients will be maintained under future climate change.

Temperature gradients: Temperature data from Agricultural Research Council was examined at a 0.01 degree or just over 1 km squared resolution. Temperature gradients were calculated based on the maximum and minimum values found within a roving 7x7 grid (i.e. approximately 49km^2 area). Areas with over 4°C difference in average temperature within a 49km^2 area, were classified as areas with high temperature gradients. We assume that these gradients will be maintained under future climate change. In fact, the future scenario maps suggest that these temperature gradients will be maintained, for example in the southeast around Sutherland.

These three layers were combined to provide a summary layer of all areas with high climate and landscape heterogeneity and gradients.

Areas with high biotic diversity: These are areas where relatively high numbers of biomes, vegetation groups or vegetation types occur in close proximity. Importantly, these represent areas of high biotic diversity under current conditions. Although there is no guarantee that these patterns will persist in their current form under future climate change, we believe these areas are likely to be of higher importance than other areas, as they represent a large portion of current biodiversity, contain diverse conditions (e.g.

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[10] Department of Water Affairs 1 in 500 000 river layer developed by Resource Quality Services.

[11] This is a GIS layer used in the subsequent analysis which in this case describes how difficult it is for biodiversity elements to cross that area, e.g. it is far easier for a species to migrate through an intact natural area compared to area of arable agriculture (e.g. a mosaic of ploughed fields, roads and fences), and both of these would be far easier than through a built-up urban area.

[12] Transformation and fragmentation layer developed by Stephen Holness for the National Protected Areas Expansion Strategy Conservation Assessment 2008. The layer was used in a cost surface based analysis which calculated the total cost of moving away from the river centre line. Transformed areas had a cost friction of 10x that of natural habitat, while degraded and fragmented areas had a cost 2x that of natural areas. The result of this process is a variable width corridor which takes into account the pattern of land transformation, e.g. one could have a 5km wide buffer on one side of a river in natural habitat, with a 500m buffer in agricultural fields on the other side of the river.

soil and micro-climate) which are likely to continue to support a range of communities, and contain important ecotones which are associated with numerous ecological processes.

They contain an extremely diverse set of habitats, landscapes and microclimates, and represent areas that are likely to be very important for supporting biodiversity adaptation capacity. These areas have high levels of floristic diversity and are likely to represent areas of high levels of speciation. Areas with high levels of biodiversity heterogeneity were identified using the South African Vegetation Map (Mucina and Rutherford, 2006) at three scales: biome, vegetation group and vegetation type. The number of biomes, groups or types was calculated for each 49km^2 area. Areas were considered to have high habitat heterogeneity if they contained three or more biomes, three or more vegetation groups, or four or more vegetation types.

Biome heterogeneity: The South African Vegetation Map was converted to a 0.01 degree or just over 1 km^2 resolution raster layer in Idrisi. The number of biomes found within a roving 7x7 grid (i.e. approximately 49km^2 area) was calculated. Various other methods (such as other relative richness indices, and varying in pixel size and search radius) were also explored, but this simple method gave a robust clearly understandable answer. Areas were considered to have high diversity at the biome level if 3 or more biomes were found within the 49km^2 area.

Vegetation group heterogeneity: Similar to the biome heterogeneity calculation, the vegetation map was converted to a 0.01 degree raster layer, and the number of vegetation groups found within a roving 7x7 grid (i.e. approximately 49km^2 area) was calculated. Areas were considered to have high diversity at the bioregion level if 3 or more bioregions were found within the 49km^2 area. Note that this will inevitably include the areas identified in the biome heterogeneity assessment, in addition to extra areas.

Vegetation type heterogeneity: As for the above calculations, the vegetation map was converted to a raster, and the number of vegetation types found within a roving 7x7 grid (i.e. approximately 49km^{2}area) was calculated. Areas were considered to have high diversity at the bioregion level if 4 or more vegetation types were found within the 49km^2 area.

These three layers were combined to provide a summary layer of all areas with high habitat heterogeneity.

Centres of floral endemism: Southern Africa has extremely high levels of floristic diversity and endemism, with more than 10% of vascular plant species (over 30 000 species) found in 2.5% of the world's surface area. 60% of these species are endemic to the region (van Wyk and Smith, 2001). This is particularly the case in the Namakwa District which contains a very high number of endemic species. Most of these endemic species are concentrated in a few relatively small and clearly defined centres of endemism. At a national scale these centres represent i) an area of concentrated unique biodiversity pattern (i.e. there are concentrations of endemic plant species here which are not found elsewhere), ii) areas with a particular combination of ecological processes that have resulted in high levels of biodiversity and endemism developing, and iii) the characteristics which allow these high levels of diversity to persist, as these are areas where species have survived previous climate variability, and hence are likely to be very important for supporting the adaptive capacity of the region's biodiversity. The floristic centres of endemism summarised in Regions of Floristic Endemism in Southern Africa were clipped to remaining extent of natural habitat (transformed, degraded and fragmented areas were excluded from the dataset according to Holness's [2008] Transformation and Fragmentation layer.

Local refugia- south-facing slopes and kloofs: Refuge sites include south-facing slopes and kloofs. These sites tend to be wetter and cooler that the surrounding landscape, and represent key shorter term refugia which allow species to persist in landscapes.

South facing slopes: A 90m digital elevation model was used as the basis for identifying south facing slopes. Standard Idrisi modules were used to identify all areas with a southerly aspect, which was defined as having an aspect of between 135° and 235°. Slope angles were then calculated to identify all steeper slopes (i.e. those area where aspect is likely to play an important role in solar inputs), which were defined as all slopes steeper than 10°. These layers were combined to get a subset of steep south facing slopes; this layer was converted to a vector layer and all areas under 25ha were removed; and the layer was reconverted to a raster layer.

Kloofs: The identification of kloofs/gorges at a landscape scale requires some assumptions to be made about what a kloof is. For the purposes of this analysis, kloofs are seen as areas with steep slopes in close proximity to rivers. The 90m digital elevation model used in previous analyses was again used as the basis for identifying steep slopes, which for this analysis were defined as being steeper than 15° (this value is deliberately higher than that used for the south facing slope calculation), using standard modules of Idrisi. River lines[13] were converted to a raster layer with the same resolution as the 90m DEM, on the basis that any pixel that overlapped with a river line was classified as river and given a numerical value. A maximum filter was then run in Idrisi using a 7x7 roving window to identify all pixels which were within a maximum of 7 pixels (x or y distance) away from a river pixel. These areas were defined as being river proximity pixels, and were intersected with the steep slopes raster layer to give the subset of areas with steep slopes in close proximity to rivers. This was converted to a vector layer and all areas under 25ha were removed; and the layer was reconverted to a raster layer.

The local refugia layer was derived by spatially combining the south-facing slopes and kloofs layers.

Priority large unfragmented landscapes: These include existing protected areas as well as large areas identified in the National Protected Area Expansion Strategy (Jackelman et al, 2008) as priorities for protected area expansion to meet biodiversity targets for terrestrial and freshwater ecosystems. The ecological processes which support climate change adaptation are more likely to remain functional in unfragmented landscapes than in fragmented ones.

[13] Department of Water Affairs 1 in 500 000 river layer developed by the Resource Quality Services. This layer is of the larger rivers which one would expect on a 1 in 500 000 map, but with the actual river alignments being as accurate as those found on 1:50 000 maps. For this analysis rivers of all orders were used.

Protected areas: Formal protected areas[14] which include National Parks, provincial Nature Reserves, proclaimed Mountain Catchment Areas and local authority Nature Reserves were included. Representation of species, ecosystems and ecological processes in an ecologically robust protected area network is widely recognized as one of the most effective adaptation strategies for responding to climate change. Intact natural habitats found in protected areas are likely to play an important role in supporting landscape scale resilience to climate change through acting as refuge areas for ecosystems and species which are likely to be under more pressure in production landscapes, in supporting the ecological processes required for long term adaptation to climate change, and in the provision of key ecosystem services. Since these areas are protected by law it is expected that they will persist into the future. Although not all protected areas will have the same importance, even small reserves will be important for supporting local scale adaptation. In addition, the layer of priority large unfragmented landscapes (see below) is incomplete if considered without the existing protected areas.

Priority large unfragmented landscapes: The spatial assessment of the National Protected Area Expansion Strategy used a systematic consevation planning process to identify focus areas for land-based protected area expansion which are large, intact and unfragmented areas of high importance for biodiversity representation and ecological persistence, suitable for the creation or expansion of large protected areas. They present the best opportunities for meeting the ecosystem-specific protected area targets set in the NPAES, and were designed with strong emphasis on climate change resilience, supporting ecological processes and the requirements for freshwater ecosystems. Although these areas were identified from a large formal protected areas expansion perspective, and therefore do not sufficiently address all conservation priorities, they nevertheless represent the best exampes of intact landscapes with functioning ecological processes which are likely to play a significant role in long term climate change adaptation.

[14] Available from http://planet.uwc.ac.za/BGISdownloads/protectedareasNPAES_Formal.zip

The priority unfragmented areas layer was derived by spatially combining the existing protected areas with the priority large unfragmented landscapes layer. The identified unfragmented areas are likely to persist across most of the District due to a low population density and the nature of economic activities.

COMBINATION AND REFINEMENT PROCESS:

Figure 33 summarizes the combination and refinement process for the climate change resilience layer.

A base raster file was constructed with a 90m grid. Where neccessary (and this was avoided for many layers by utilizing an indentical base raster layer in the underlying analyses) input layers were reclassified and resampled to the extent of the base layer, so that the extent and resolution of all input layers were identical. A cumulative total area approach was used to summarize each resilience theme (e.g. areas with important temperature, rainfall and altitudinal gradients were summarized by combining all the areas identified as important in the underlying analyses, and all areas identified would have the same value whether they include only a steep temperture gradient or whether they had steep gradients for more than one variable). Areas important for each resilience theme were then given an equal numerical value. An unmodified value representing the value of a particular area for supporting climate change resilience was then calculated by adding the individual resilience theme scores. Crucially, these areas can support resilience to climate change only if they remain in a natural or near-natural state. For this reason areas where natural habitat has already been irreversibly lost were removed from the analysis, and degraded and fragmented areas were reduced in value by half. The result was the final 'Areas important for supporting climate change resilience layer'.

Areas important for climate change resilience need to be managed and conserved through a range of mechanisms including land-use planning, environmental impact assessments, protected area expansion, and working with industry sectors to minimise their spatial footprint and other impacts.

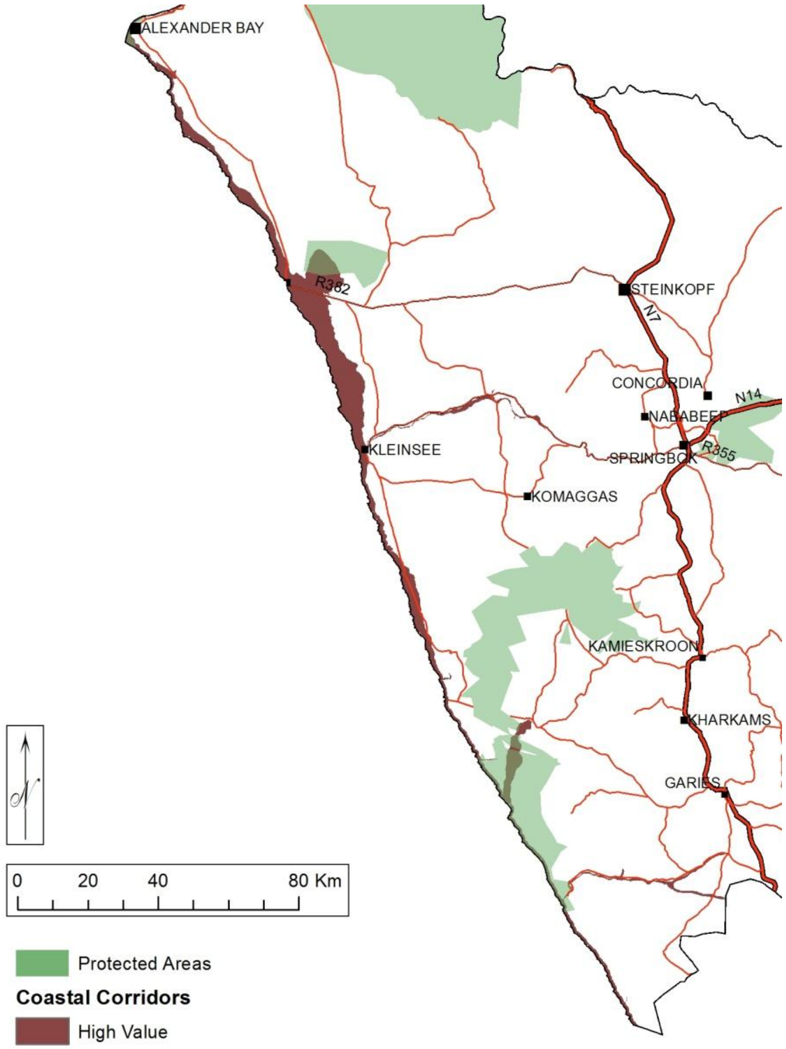

FIGURE 20: COASTAL PROCESS AND CORRIDOR LAYER FOR NAMAKWA DISTRICT

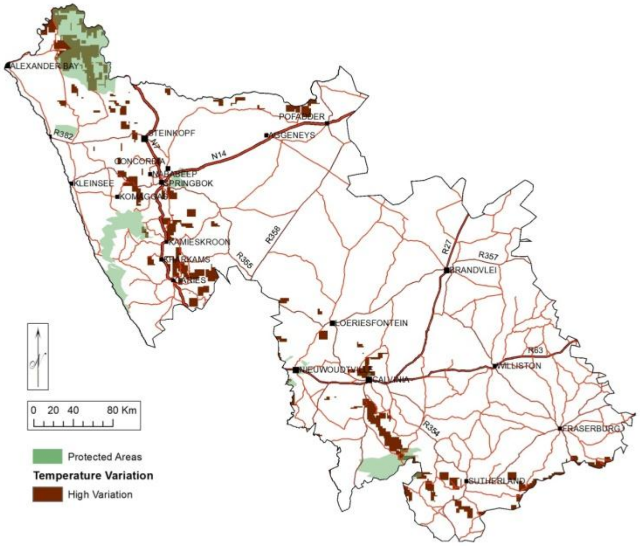

FIGURE 21: AREAS WITH STEEP TEMPERATURE GRADIENTS IN NAMAKWA DISTRICT

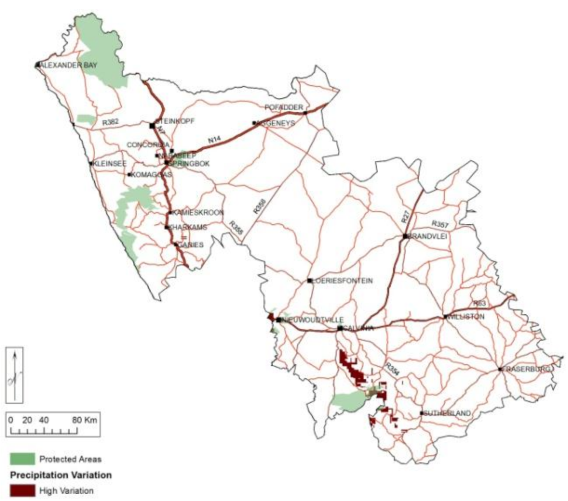

FIGURE 22: AREAS WITH STEEP PRECIPITATION GRADIENTS IN NAMAKWA DISTRICT

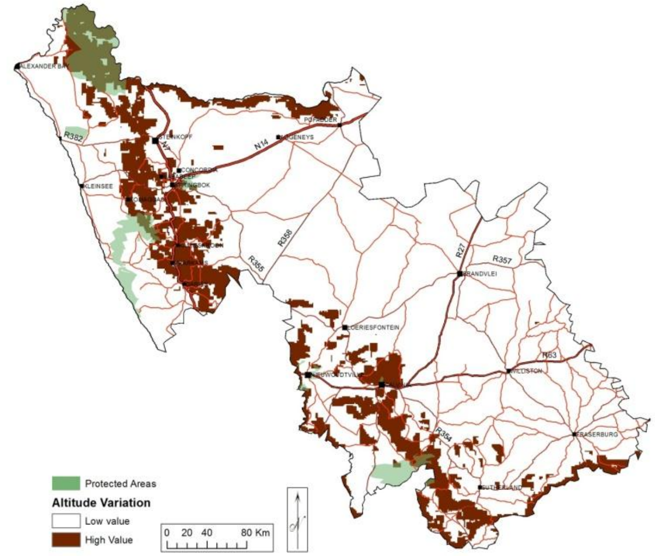

FIGURE 23: AREAS WITH STEEP ALTITUDE GRADIENTS IN NAMAKWA DISTRICT

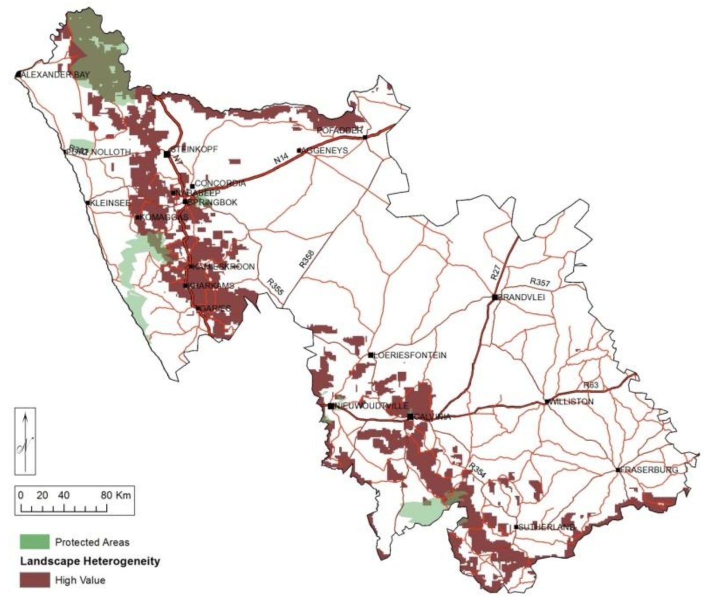

FIGURE 24: COMBINED AREAS OF STEEP ALTITUDE, TEMPERATURE AND PRECIPITATION GRADIENTS IN THE NAMAKWA DISTRICT.

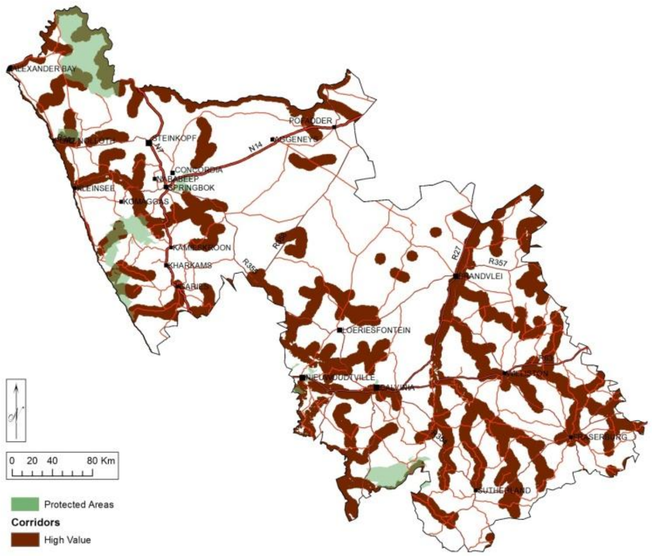

FIGURE 25: RIPARIAN CORRIDORS AND BUFFERS LAYER FOR NAMAKWA DISTRICT

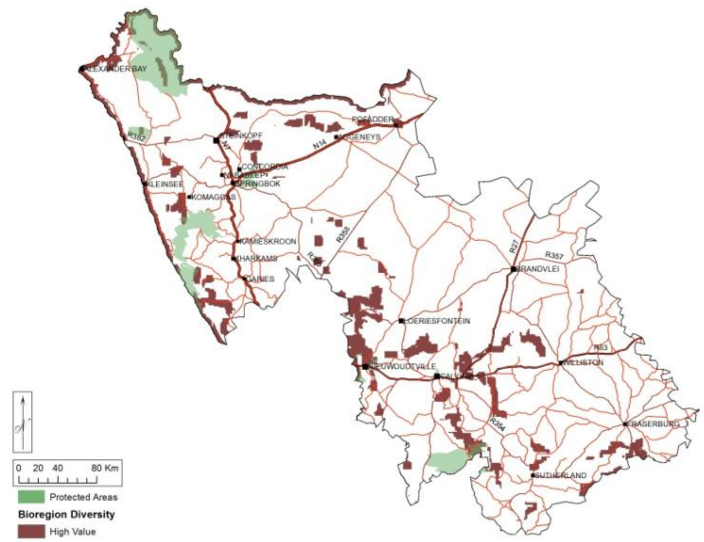

FIGURE 27: AREAS OF HIGH BIOREGION DIVERSITY IN NAMAKWA DISTRICT.

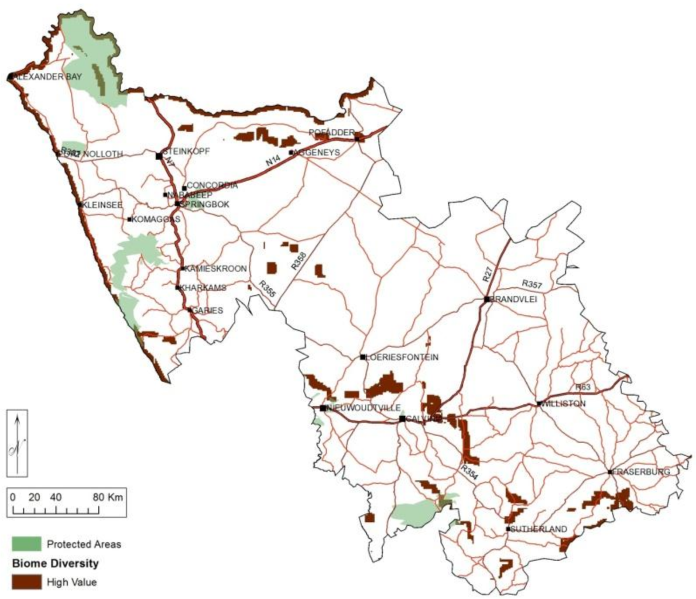

FIGURE 26: AREAS OF HIGH BIOME DIVERSITY IN THE NAMAKWA DISTRICT

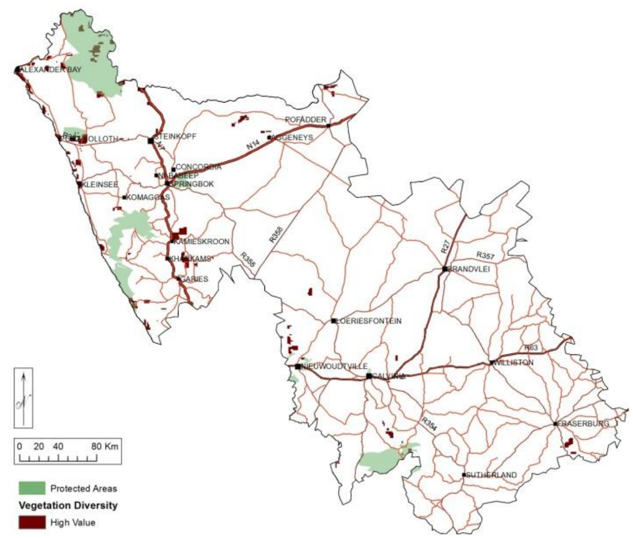

FIGURE 28: AREAS OF HIGH VEGETATION TYPE DIVERSITY IN THE NAMAKWA DISTRICT

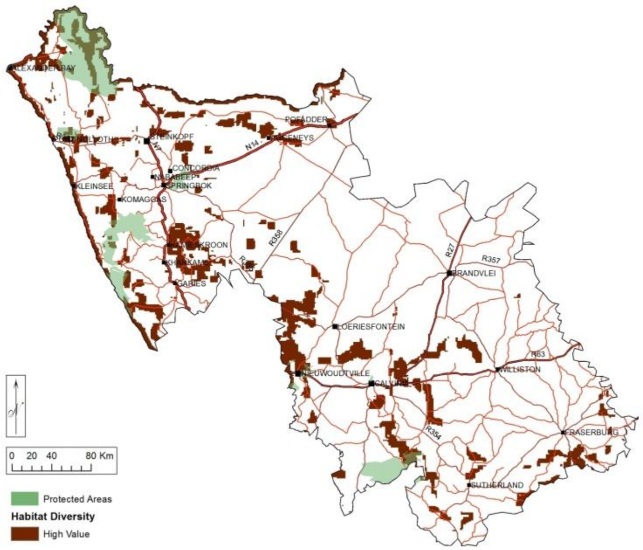

FIGURE 29: COMBINED AREAS OF HIGH HABITAT DIVERSITY IN THE NAMAKWA DISTRICT

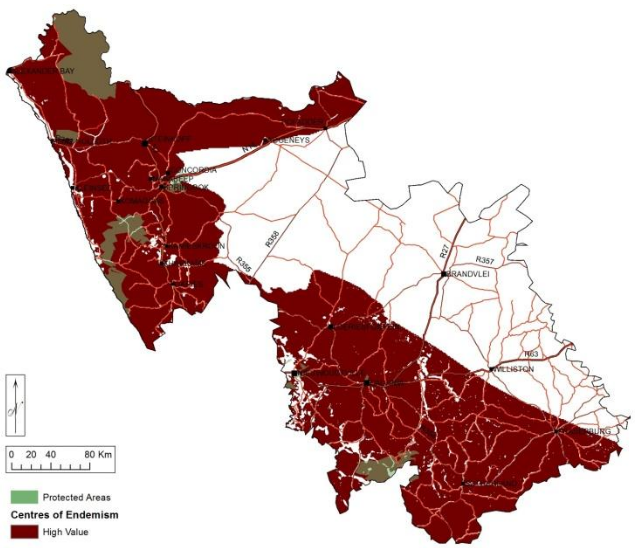

FIGURE 30: REMAINING INTACT AREAS OF CENTRES OF ENDEMISM IN THE NAMAKWA DISTRICT

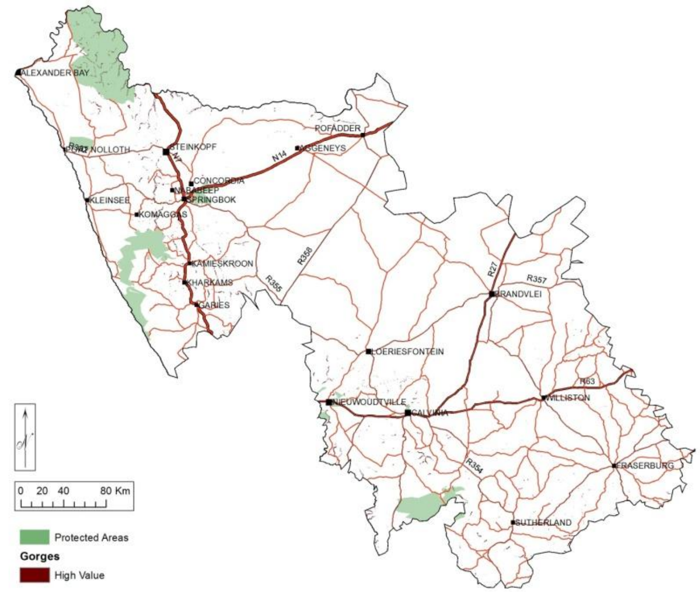

FIGURE 31: GORGES/KLOOFS IN THE NAMAKWA DISTRICT

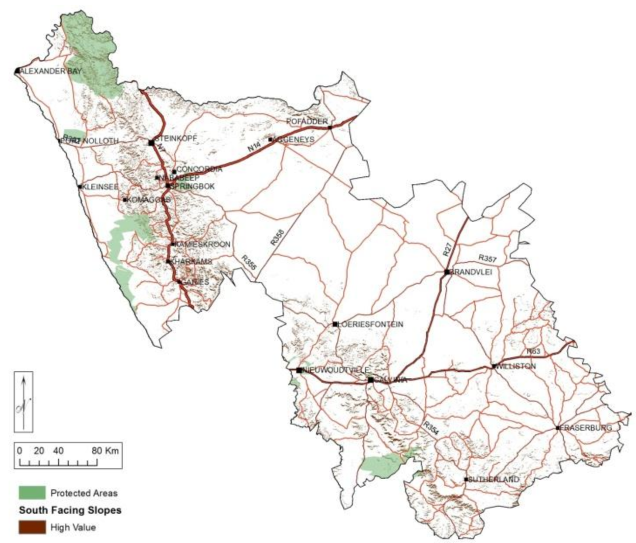

FIGURE 32: SOUTH FACING SLOPES IN THE NAMAKWA DISTRICT

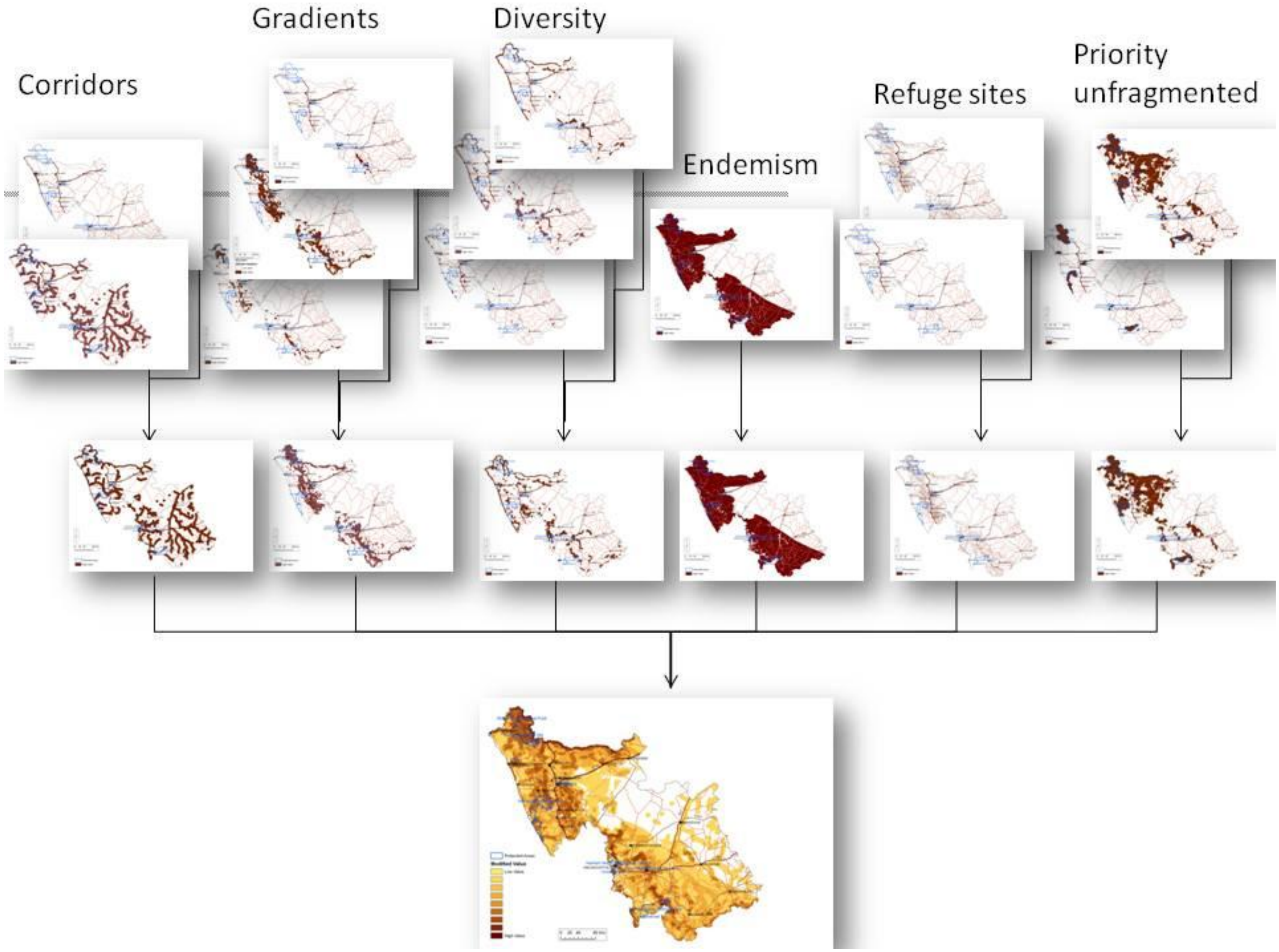

FIGURE 33: DIAGRAM ILLUSTRATING THE INTEGRATION METHOD USED TO IDENTIFY AREAS MOST IMPORTANT FOR SUPPORTING RESILIENCE TO CLIMATE CHANGE IMPACTS AT A LANDSCAPE SCALE

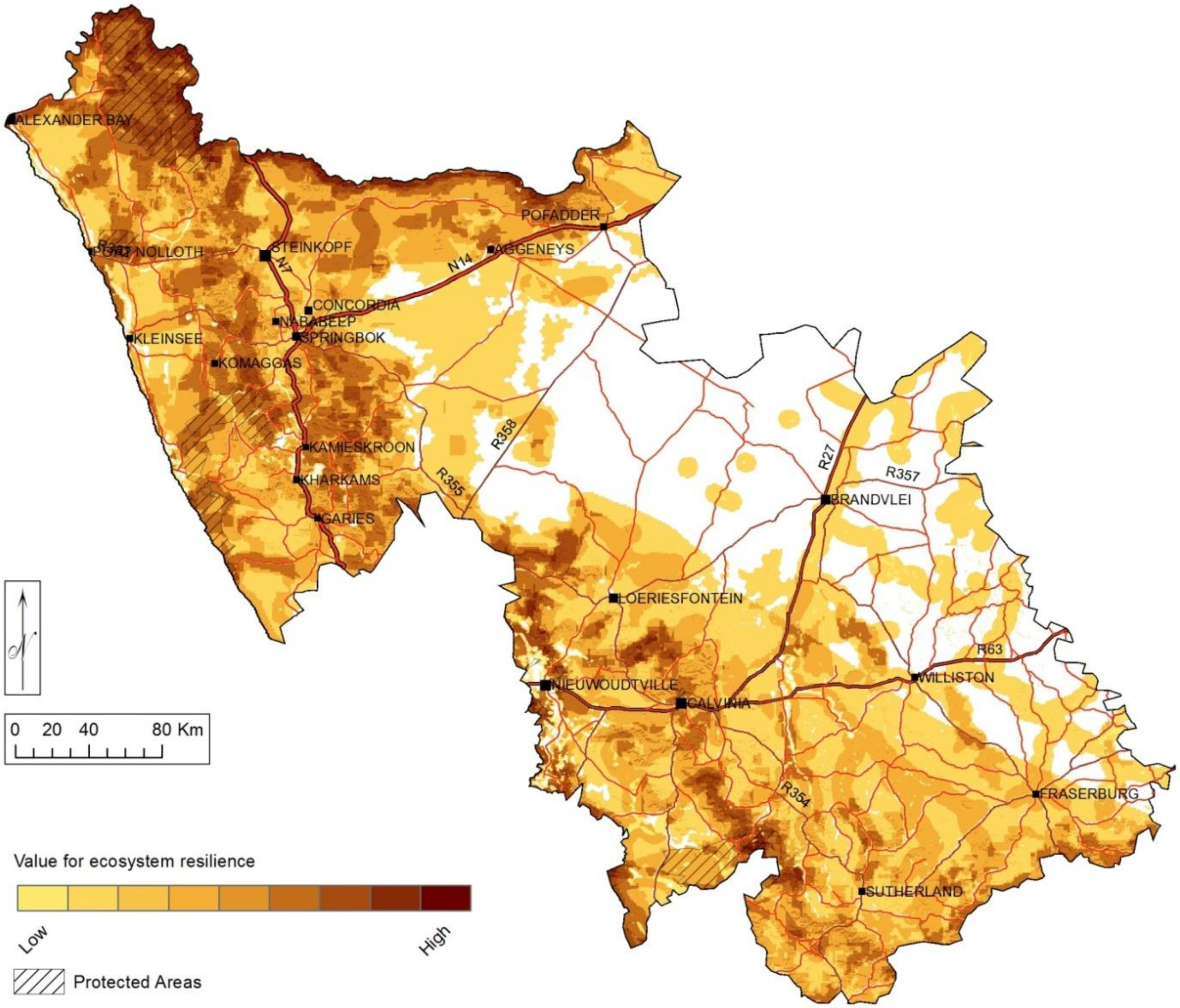

FIGURE 34: VALUE OF AREAS FOR SUPPORTING RESILIENCE TO CLIMATE CHANGE IMPACTS IN THE NAMAKWA DISTRICT

Note that although this represents an overall summary of areas important for supporting resilience to climate change impacts, when one is focusing in on a particular issue (such as riparian corridors or threatened species) then it may be more appropriate to prioritize based on that issue alone.

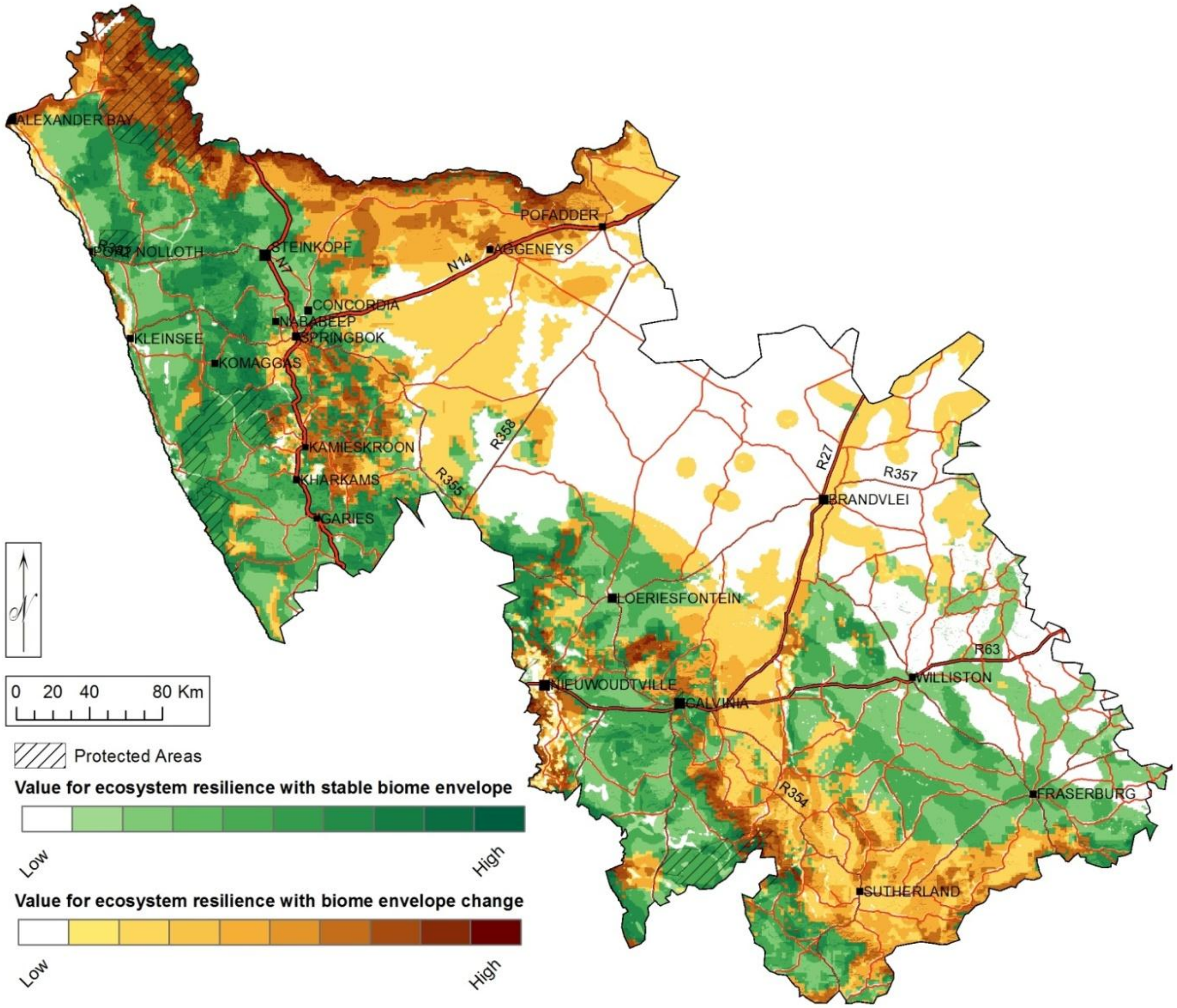

FIGURE 35: MAP INDICATING AREAS WITH HIGH VALUE FOR SUPPORTING ECOSYSTEM RESILIENCE

Areas which are likely to remain within their current climatic envelopes are green, and areas with high value for supporting ecosystem resilience in areas which are likely to experience conditions different to their current climatic envelopes are brown. In both cases darker colours indicate areas most important for supporting resilient ecosystems.

PRELIMINARY STATEMENTS ON THE POTENTIAL CLIMATE IMPACTS OF FOG, CO^2 FERTILISATION OF GRASSES, AND INCREASED SUMMER RAINFALL

Given that the impacts approach used in this study does not incorporate the effects of changing fog conditions and atmospheric CO_2 level, especially in relation to potential increases in summer rainfall that might favour summer rainfall grasses, it is important to consider how these important drivers might compromise the results developed above.

Fog is a poorly understood meso-climatological feature of the arid west coastal regions of southern Africa, and is also poorly monitored apart from the recording of fog days at limited number of coastal sites. Knowledge of how far inland fog penetrates, and how frequently, is remarkably scant and hardly more than anecdotal. Global and regional climate models for future scenario development have also not yet attempted to model this feature.

Furthermore, the importance of fog as a water input that supports biological activity has been studied in very few organisms. While there is evidence that fog is critical for some insect fauna of the hyper-arid Namib region, the evidence for its use by plants is very limited and also largely anecdotal. Recent work at SANBI indicates that while fog is important for lichens, there is inadequate evidence for its value to higher plants. For this reason, it does not seem critical to consider this potential driver as modifying results for the vast majority of endemic species in the Namakwa region.

CO_2 fertilization of plants occurs because many plants that use the most common pathway of photosynthesis are under-saturated with respect to atmospheric CO_2 under pre-industrial and current CO_2 levels. In theory, an increase in atmospheric CO_2 concentrations might lead to an increase in productivity in these plants. Of major concern is the potential for such an increase in productivity to lead to a change in the life form composition of the vegetation of the Namakwa region, in particular because the proliferation of grasses might threaten the slower-growing and less competitive succulent flora. In addition, increased grass biomass has the potential to introduce wildfire into some of the more mesic regions as grass biomass is a flammable fuel source. This effect has been observed in western American desert ecosystems with significantly adverse impacts, but has been caused by the invasion of alien grass species. Recent work at SANBI has explored the potential for increased invasive potential of alien grasses in this region, and found that the trend of climate change projected is likely to reduce and even reverse the rate of invasion by introduced grass species. Combining these insights with global projections that have used mechanistic modelling approaches, such as that represented in Figure 36 below, shows that there is a low likelihood of grass biomass increase in the Namakwa region due to CO_2 fertilisation.

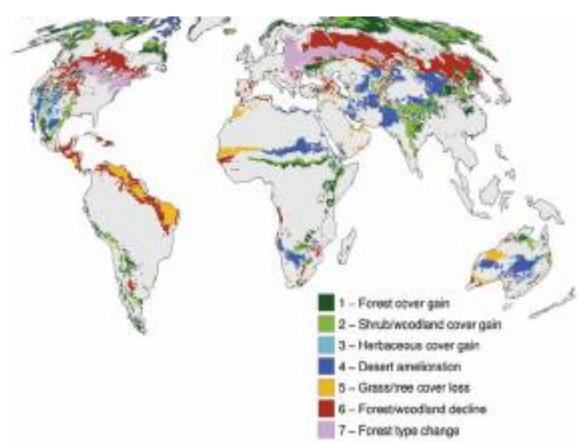

FIGURE 36: GLOBAL MAP OF SIGNIFICANT PROJECTED BIOME STRUCTURAL CHANGE FROM IPCC FOURTH ASSESSMENT REPORT

Finally, summer rainfall amounts and proportions are shown by recently developed regional climate projections to be very unlikely to increase significantly in the Namakwa region, and under the current understanding of climate change this is therefore not a significant concern. In our scenarios, total summer rainfall showed small decreases from current conditions to the intermediate case scenario - averaging just over 3mm across the whole District, and ranging from no projected change in the northern Richtersveld and Gariep Valley, to a 1 mm drop across most of the Succulent Karoo. Slightly greater reductions in the Nama Karoo of approximately 3 mm are projected across most of the area and a far larger 9 mm reduction is projected further inland.

ECOSYSTEM-BASED ADAPTATION

As described above, we have produced a map of areas important for resilience of biodiversity to climate change at the landscape scale. Keeping these areas in a natural or near-natural state will allow ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services. They should be considered vital elements of protecting the NDM's ecological infrastructure in the face of climate change, as these currently provide ecosystem services to the local communities, decreasing their vulnerability to climate change. The analysis presented here identifies core areas that are likely to continue to provide these services if adequately protected and sustainably managed.

In addition to supporting well-functioning landscapes in the long term, some of the areas important for climate change resilience may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change. For example, buffers of natural vegetation along riparian corridors and around wetlands mitigate floods, reduce erosion and improve water availability and water quality. Intact coastal ecosystems such as dunes, kelp beds and saltwater marshes help to protect human settlements and infrastructure against storm surges. Ecosystem-based adaptation has the potential to be both more effective and less costly than engineered solutions.

The concept of ecosystem-based adaptation is summarised in Figure 37, which shows how ecosystem-based adaptation contributes to three outcomes simultaneously: socio-economic benefits, climate change adaptation, and biodiversity and ecosystem conservation.

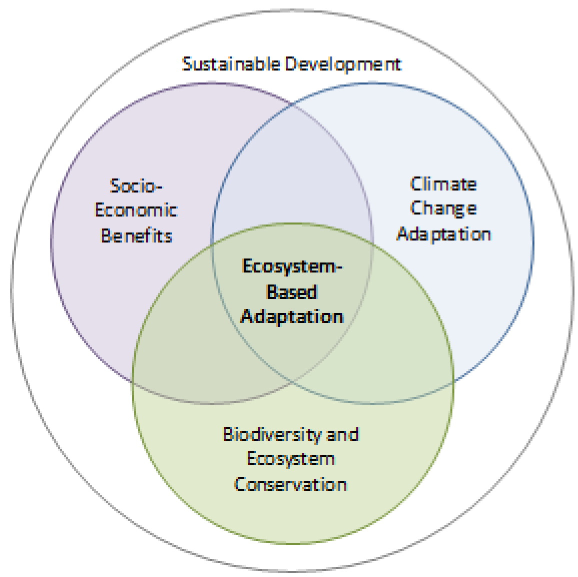

FIGURE 37: ECOSYSTEM BASED ADAPTATION GRAPHIC

PRIORITIZATION OF AREAS FOR IMPLEMENTATION OF CONSERVATION AND EBA ACTIVITIES

The spatial analysis presented in Figure 19 identifies areas that contribute both to climate change adaptation and to biodiversity and ecosystem conservation. Among these areas, we have not yet prioritised which deliver the most direct immediate value for human society, in other words which of them are also important for ecosystem-based adaptation.

A multi-criterion spatial prioritization within these areas important for resilience of biodiversity to climate change at the landscape scale was carried out to identify the areas which are important for Ecosystem Based Adaptation. Such areas are, for example, important from a water resource perspective, prioritized within the Namakwa District Conservation Plan, identified Freshwater Priorities from the National Freshwater Ecosystem Protection Area Project, located in communal lands or in close proximity to settlements.

While it is possible to include other socio-economic variables such as poverty, susceptibility to drought and flood, access to services, education level, and dependence on social grants into such an analysis, this was not included here. Separate mapping of these variables (see insert at the end of this section)was undertaken for the Namakwa District Disaster Risk Reduction Plan (Du Plessis, 2010) and indicated that these socio-economic vulnerabilities, based on data collected at the town and settlement level, were fairly constant across the NDM. Therefore mapping them in this process would not have helped to refine our spatial product.

The identified EbA priority areas are designed to direct climate change response in the NDM towards the restoration and conservation of scientifically-defined landscapes to ensure ecosystem function as a foundation for climate resilience and the development of the regional green economy. The focal areas for the EbA activities in the NDM are securing water services (both for water availability and water quality), restoring and maintaining livestock grazing services as a safety net for the poor, and controlling soil erosion as a way of avoiding infrastructure costs from damage to roads and dams. Securing ecosystem services is water-oriented, focused on restoring and protecting resource integrity in the region's water catchments, wetlands, and rivers, and other priority actions.

PRIORITIZATION METHOD

The multi-criterion spatial prioritization utilized the following input layers:

Value of areas for supporting resilience to climate change impacts in the NDM. This layer was the primary input layer. Its development is described earlier. The layer prioritizes riparian corridors and buffers; coastal corridors; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs; and priority large unfragmented landscapes. Land transformation is taken into account. Values range from 0 (no specific identified importance for supporting climate change resilience) to 60 (highest value for supporting climate change resilience).

The Namakwa District Biodiversity Sector Plan[15] (including the Critical Biodiversity Area Map) which is intended to help guide land-use planning, environmental assessments and authorisations; and, natural resource management in order to promote sustainable development. The Critical Biodiversity Area and the Ecosystem Support Areas layers are key information layers for biodiversity and ecosystem service focussed spatial planning[16]. For the current

[15] Available at http://bgis.sanbi.org/namakwa/project.asp

[16] Critical Biodiversity Areas are natural (CBA 1) or near natural (CBA 2) areas essential for the continued existence and functioning of species and ecosystems, the delivery of ecosystem services, and achieving national biodiversity conservation targets. Ecological Support Areas are not essential for meeting biodiversity representation targets/thresholds but which

prioritization we have scored Critical Biodiversity Area Ones for both terrestrial and aquatic as 10, Critical Biodiversity Area Twos as 7 and Ecological Support Areas as 2.

The Freshwater Ecosystem Priority Areas (FEPAs) as identified by the National Freshwater Ecosystem Priority Areas (NFEPA) project which was a partnership and collaborative process led by the CSIR with the South African National Biodiversity Institute (SANBI), Department of Water Affairs (DWA), the Water Research Commission (WRC), WWF South Africa, as well as expertise from South African National Parks (SANParks), the South African Institute for Aquatic Biodiversity (SAIAB) and DEA. The NFEPA project aimed to identify a national network of freshwater conservation areas[17]. For the current prioritization we have scored FEPA priority catchments as 10, and assigned a range of associated lower priority catchments (e.g. fish corridors, upstream protection areas and Phase 2 FEPAs) a value of 2.

We aimed to prioritize areas from a ecosystem service delivery perspective. This focussed on areas most important for delivering water in the district. Unfortunately existing water delivery layers for the district are not very useful as they were developed for the wetter parts of the country. This indicates that most the NDM does not have any national value from a water perspective. This may be the case nationally, but it completely ignores the critical role water plays in directly supporting communities in Namakwa via water provision and also indirectly via supporting grazing. We developed a new layer derived from the agro-hydrology dataset which identifies for each local municipality the areas which are most important from a water provision perspective. This was done by identifying areas in each local municipality which were more than one standard deviation above the mean precipitation for a municipality. This recognizes the fact that a particular amount of precipitation may be insignificant in one portion of the landscape, but represents a key resource in another. We scored these high water production areas as 10.

From a social perspective we prioritized commonage areas, as these areas are critical for supporting community livelihoods. These areas are also a focus for implementation activities of conservation and EbA by CSA. We scored commonage areas as 10 and other areas as 0.

From a social and an implementation logistical perspective we prioritized areas in proximity to towns. This was done on a relative scale with areas closest to towns and villages receiving a score of 10, the areas in the district which are furthest away from towns and villages scored a 1, with intermediate areas receiving a linearly decreasing score between these two extremes.

Combination method: The layers were combined to ensure that all identified areas were within the identified areas important for supporting resilience to climate change impacts, as well as being identified Critical Biodiversity Areas or Ecological Support Areas. Within these areas the sites were further prioritized based on their status as commonage, proximity to towns, being identified FEPAs or being important for delivering water. Finally, all the identified areas important for supporting resilience to climate change impacts for biodiversity were added in at the end to ensure all these areas are reflected, albeit at a lower value, even if they are not identified in other layers.

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nevertheless play an important role in supporting ecological functioning and the delivery of ecosystem services for social and economic development.

[17] Available from http://bgis.sanbi.org/nfepa/project.asp

Formula:((Climate change resilience value)x(Critical biodiversity area value)x(NFEPA Value + Town Proximity + High water Yield + Commonage))+ (Climate change resilience value).

The Climate Change Resilience value is entered twice to ensure the outcome of the calculation highlighted climate adaptation priority areas over the other indicators.

Namakwa District Disaster Management Plan

Anton Du Plessis of Watees Disaster Management Specialists produced an assessment of disaster risk for the Namakwa District (Du Plessis, 2010), which included sections relevant to climate change, concurrently with our more specific study. In almost all cases, ***the areas identified in our study, represent the specific areas where Ecosystem-based Adaptation could be used to respond to the hazards more generally identified within the Watees assessment.***

Within the list of risks of disasters assessed, those with either an impact or response potential for ecosystem-based adaptation are summarized in the table below. The key message of this table is that the hazards associated with the drought susceptibility of communities, flooding, poor road infrastructure, health services and poverty are fairly consistent across local municipalities within the NDM. Our prioritization model considers this basis and further refines priorities within the landscape based on other spatial features presented in Figures 37-42 below.

NAMAKWA DISTRICT MUNICIPALITY: HAZARD IDENTIFICATION USING INDIGENOUS KNOWLEDGE						
Hazard	Local Municipality					
	Karoo Hoogland	Hantam	Kamiesberg	Nama Khoi	Richtersveld	Khai-Ma
Drought	Red	Red	Red	Red	Red	Red
Water Availability	Orange	Red	Red	Red	Red	Red
Flood	Orange	Orange	Orange	Orange	Orange	Orange
Soil Erosion	Yellow	Yellow	Orange	Orange	Orange	Yellow
Coastal Storms	Dark green	Dark green	Red	Red	Red	Dark green
Rising sea level	Dark green	Dark green	Orange	Orange	Orange	Dark green
Rising ocean temperature	Dark green	Dark green	Red	Red	Red	Dark green
Road Infrastructure	Red	Red	Red	Red	Red	Red
Health Services	Red	Red	Red	Red	Red	Red
Poverty	Red	Red	Red	Red	Red	Red
Mine activities	Dark green	Orange	Yellow	Red	Orange	Light green

Red	Most Vulnerable
Orange	
Yellow	Somewhat Vulnerable
Light green	
Dark green	Not Vulnerable/Not affected

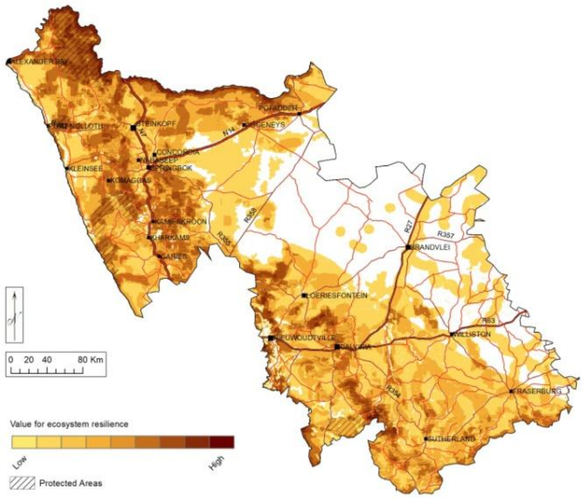

FIGURE 38: AREAS IMPORTANT FOR SUPPORTING ECOSYSTEM RESILIENCE TO CLIMATE CHANGE IMPACTS

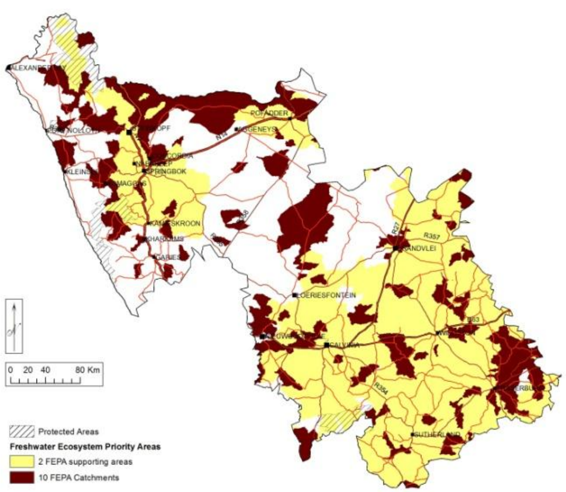

FIGURE 39: PRIORITY AREAS IDENTIFIED IN THE NATIONAL FRESHWATER ECOSYSTEM PRIORITY AREA PROJECT

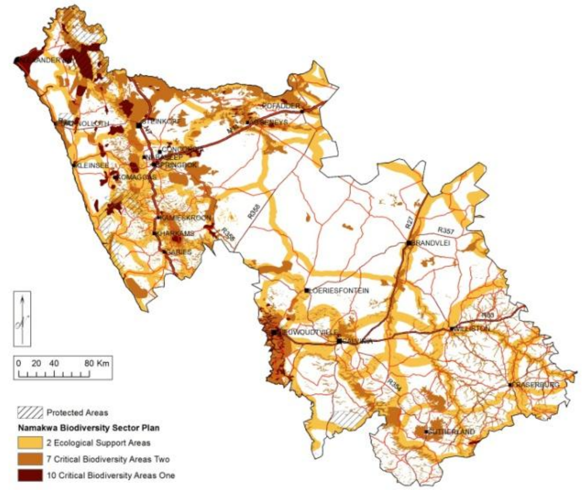

FIGURE 40: PRIORITY AREAS IDENTIFIED IN THE NAMAKWA DISTRICT BIODIVERSITY SECTOR PLAN

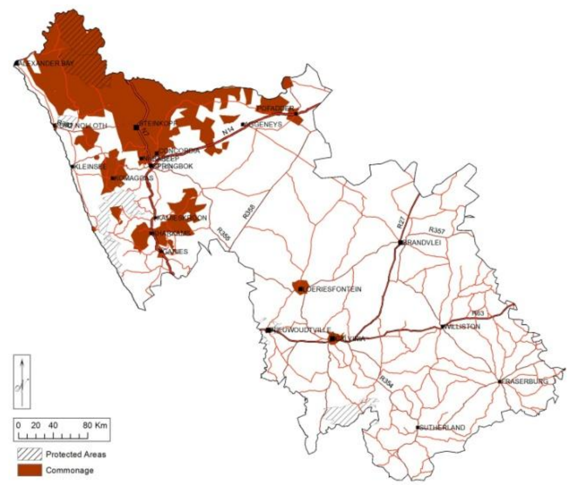

FIGURE 41: COMMONAGE AREAS IN THE NAMAKWA DISTRICT

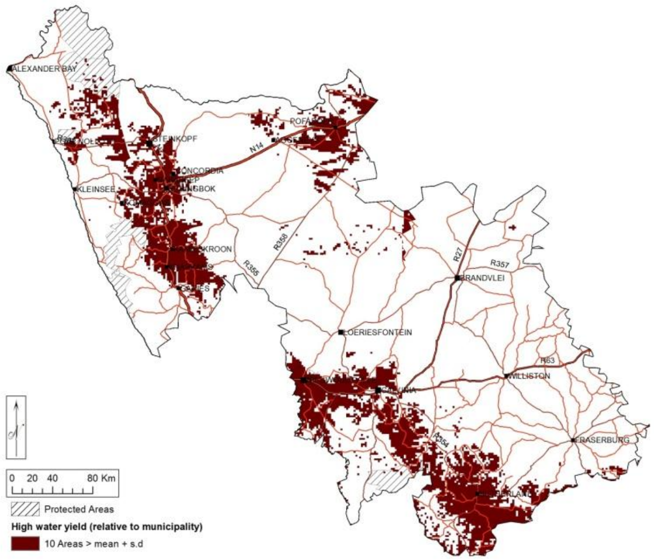

FIGURE 42: HIGH WATER YIELD AREAS FOR THE NAMAKWA DISTRICT

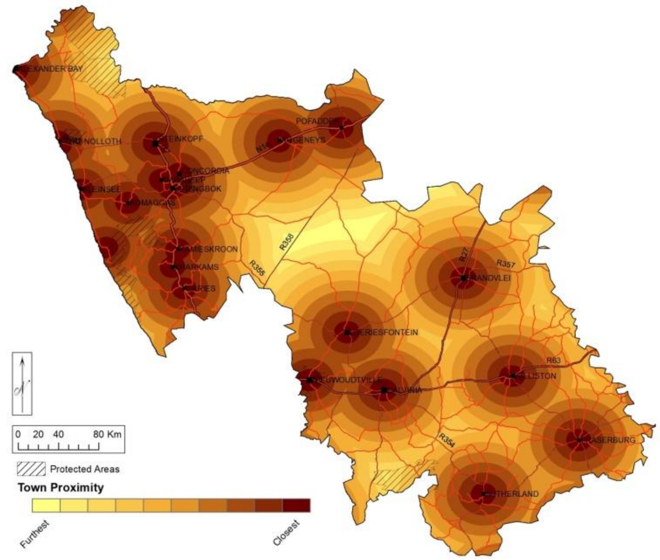

FIGURE 43: PROXIMITY TO TOWNS AND SETTLEMENTS

This was done by identifying areas in each local municipality which were more than one standard deviation above the mean precipitation for that municipality.

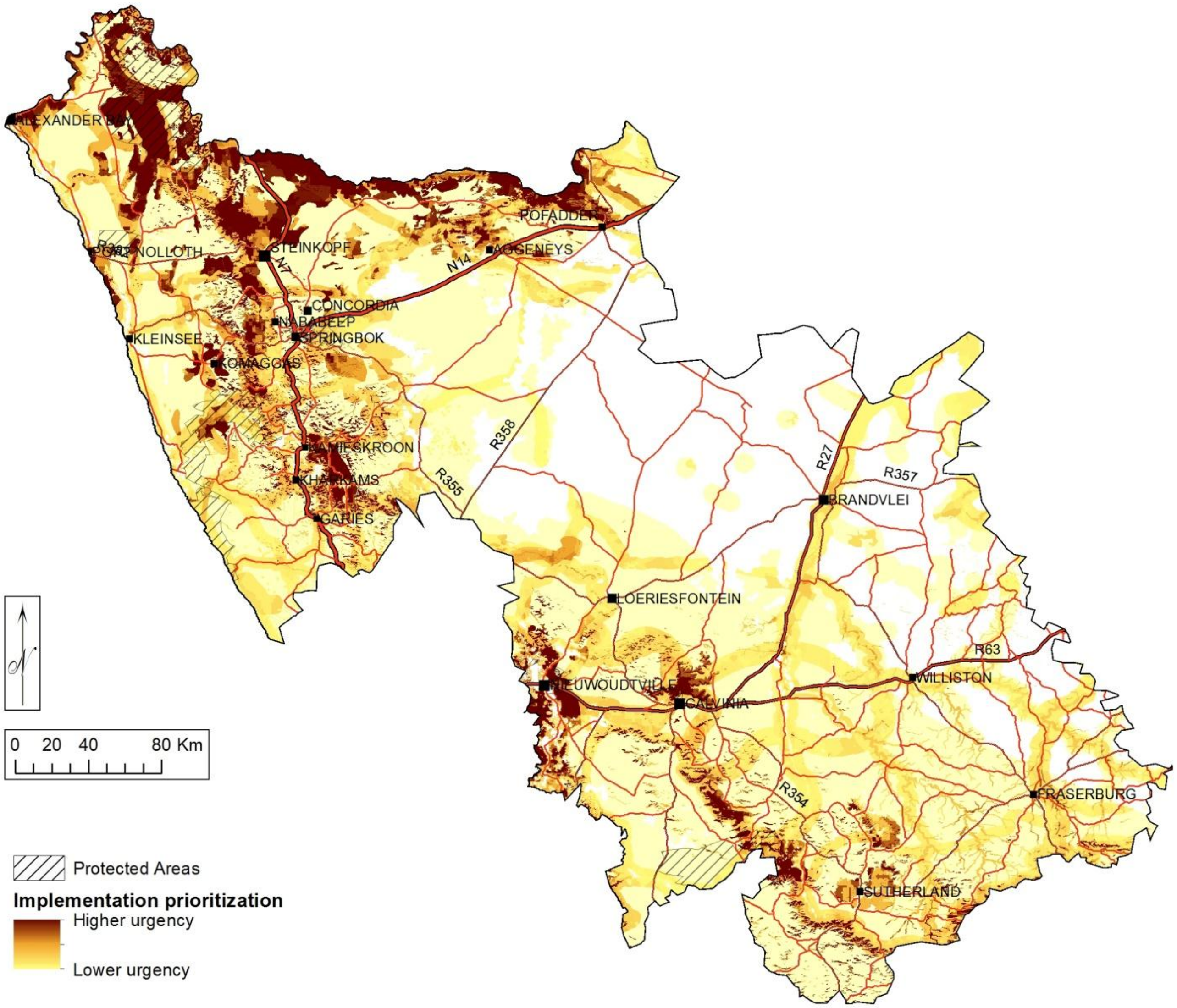

FIGURE 44: FINAL INTEGRATED PRIORITIZATION OF AREAS FOR IMPLEMENTATION ACTIVITIES RELATED TO SUPPORT ECOSYSTEM-BASED ADAPTATION TO CLIMATE CHANGE

SUMMARY OF THE CLIMATE CHANGE HAZARDS FOR THE NDM

This chapter updates the early work developed for the semi-arid winter rainfall region of South Africa in a way that allows climate scenario uncertainty to be better addressed, employs statistically-based impacts models, and current GIS methods of incorporating landscape and other features in assessing priority conservation areas in the Namakwa Region of this semi-arid winter-rainfall climatic zone. It also considers the value and credibility of these modelling approaches given two key climatic and non-climatic drivers that are not yet well incorporated into climate impacts models, namely atmospheric CO_2 and fog inputs.

We report that climate impacts on the potential distributions of the four biomes represented in the Namakwa District are potentially far less disruptive that previously estimated under a low-risk climate scenario that combines the lowest levels of warming and least decrease in rainfall amounts. Under a median and high risk scenario, signficnant ingress of a climate supportive of the Desert Biome is projected into the north-eastern and eastern reaches fo the District, replacing Nama Karoo. Also, reductions in Fynbos Biome areas are seen, with the Fynbos envelope almost eliminated under the high risk scenario. It is likely that the Succulent Karoo would show greater contraction under a longer term timeframe that was better able to project changes in winter rainfall frontal systems. In this report the Succulent Karoo appears stable to 2050 because winter rainfall is not predicted to reduce sufficiently to impact significantly on the alreadty arid-adapted region in the chosen time frame.

The impacts of changes in fog, rising atmospheric CO_2 and increasing summer rainfall are found not to be significant concerns at least over the next 50 years in this district.

Areas important for supporting ecosystem resilience to climate change impacts, and an analysis yielding a final integrated prioritization of areas for implementing activities related to support Ecosystem-based Adaptation to climate change highlight show that these are focused generally in the western reaches of the District, and along the Orange River in the North.

INCREASING TEMPERATURES

Under a relatively unmitigated global emissions scenario, air temperatures in coastal regions could be expected to rise by 1-2°C by 2050 and 3-4°C by 2100 and inland by 3-4°C by 2050 and 6-7°C by 2100. In the temperature maps produced for this report, in all three scenarios, greatest warming is projected for the south-central interior and along the Orange River in the north. The coastline is also projected to warm substantially, particularly towards the south. The most stable areas in terms of projected temperature change are around Sutherland in the south east and in the Kamiesberg, where higher altitudes limit temperature increases. In all three scenarios, average annual temperatures are predicted to increase by 2050. Temperature increases will be more subtle in the best case and more drastic in the worst case scenarios.

CHANGES IN RAINFALL PATTERNS

Rainfall in the NDM is highly variable from year to year (DST, 2011: 2); making projected future rainfall changes regionally complex. ‘Observations and incomplete projections over South Africa indicate increases in rainfall magnitude per event (rainfall intensity), independent of overall annual rainfall changes, as well as an increase in the duration of dry spells’ (Midgley et al, 2010:ii)

In the rainfall maps, there is greater uncertainty around projected changes. The best case scenario predicts an increase in rainfall around the Kamiesberg and into south central and south east of the NDM. The intermediate and worst case scenarios predict a reduction in rainfall across the NDM. In the intermediate scenario, projected decreases in rainfall are small, while in the worst case scenario, rainfall is projected to decrease significantly. The north remains dry across all scenarios. Most drastic projected rainfall reductions occur in the worst case scenario in the regions currently receiving the highest average annual rainfall in NDM, as well as in the north east of the NDM.

'Open water evaporation over South Africa is likely to increase by 5-10% by 2050, and by 15-25% by 2100 due to higher temperatures' (Midgley et al, 2010:ii), leading to a likely increase in overall aridity in NDM.

STORM SURGES

Bakun (1990) hypothesised an increase in intensity of alongshore winds due to warming land surface temperatures and that this would lead to more frequent and intense seasonal upwelling. An increasing trend in the intensity of upwelling has been recorded for the Benguela system over the last four decades (Scavia et al, 2002). The intensity and frequency of storms appears to be increasing but this has not been well documented to date. Although there have been devastating storms along the Namakwa coast, the coastline is steep and rocky and less sensitive to impact of storm surges than more shallow sandy shores.

RISING SEA LEVEL

Sea-level is rising around the South African coast, but there are regional differences. The west coast is rising by 1.87 mm per year, the south coast by 1.47 mm per year, and the east coast by 2.74 mm per year. Modelling has shown that some areas along the coastline will be more susceptible to sea level rise than others, but the understanding is incomplete (Midgley et al, 2010). Sea level is rising slowly, but rocky coastlines such as the Namakwa coast, are less vulnerable to erosion and damage as a result of this. Saltwater intrusion into ground water systems near the coast could increasingly become a problem.

COASTAL FOG

Fog is a poorly understood meso-climatological feature of the arid west coastal regions of southern Africa, and is also poorly monitored apart from the recording of fog days at a limited number of coastal sites. Knowledge of how far inland fog penetrates, and how frequently, is remarkably scant and hardly more than anecdotal. Global and regional climate models for future scenario development have also not yet attempted to model this feature.

Furthermore, the importance of fog as a water input that supports biological activity has been studied in very few organisms. While there is evidence that fog is critical for some insect fauna of the hyper-arid Namib region, the evidence for its use by plants is very limited and also largely anecdotal. Recent work at South African National Biodiversity Institute indicates that while fog is important for lichens, there is inadequate evidence for its value to higher plants. For this reason, it does not seem critical to consider this potential driver as modifying results for the vast majority of endemic species in the Namakwa region.

ATMOSPHERIC CARBON DIOXIDE

CO_2 fertilization of plants occurs because many plants that use the most common pathway of photosynthesis are under-saturated with respect to atmospheric CO_2 under pre-industrial and current CO_2 levels. In theory, an increase in atmospheric CO_2 concentrations might lead to an increase in productivity in these plants. Of major concern is the potential for such an increase in productivity to lead to a change in the life form composition of the vegetation of the Namakwa region, in particular because the proliferation of grasses might threaten the slower-growing and less competitive succulent flora. In addition, increased grass biomass has the potential to introduce wildfire into some of the more mesic regions as grass biomass is a flammable fuel source. This effect has been observed in western American desert ecosystems with significantly adverse impacts, but has been caused by the invasion of alien grass species. Recent work at SANBI has explored the potential for increased invasive potential of alien grasses in this region, and found that the trend of climate change projected is likely to reduce and even reverse the rate of invasion by introduced grass species. Therefore, there is a low likelihood of grass biomass increase in the Namakwa region due to CO_2 fertilisation.

ECOLOGICAL VULNERABILITY

This chapter specifically looks at the impacts of climate and weather related change on the communities and ecosystems of the NDM. Climate change in South Africa will likely be characterised by increasing temperatures and decreasing rainfall. Based on available data sets, scientists argue that the effects of climate change on species distributions, vegetation types and ecosystems in South Africa will be significant. Overall, there are likely to be major range shifts and shrinkage of all biomes and many species, particularly endemics, outright biodiversity loss, and an increase in extinctions (Midgley et al, 2010). The most concerning long-term effects are likely to be felt in the west of South Africa where particularly rich biodiversity hotspots are at risk of climate conditions becoming too harsh for the continued survival of some of their endemic species (Midgley in DST, 2011:48). As demonstrated in this chapter, climate change is likely to have an impact on biome stability in the region, but the species rich Succulent Karoo holds relatively stable to 2050, providing an opportunity for EbA and ecosystem conservation.

South Africa has developed excellent environmental legislation and the NDM in particular has a comprehensive set of spatial development plans, environmental management frameworks, and biodiversity sector plans (see chapter 4 of this report). There are also several grazing guidelines available to guide land management in the Succulent Karoo, and set limits on carrying capacity for farms have been set by the provincial Department of Agriculture in order to avoid over-grazing and consequent land degradation.

Despite the best intentions and legislature, the Succulent Karoo is exposed to a number of threats and pressures, not least of all a challenging natural environment fraught with natural hazards and climate and water related challenges. Additional pressures on the landscape include widespread and pervasive over-grazing, particularly on the over-crowded communal lands, the over-extraction of scarce water resources, ploughing of Succulent Karoo veld for dryland fodder cropping, the spread of invasive alien species, and the devastating ecological impact of mining in its various forms. Over-grazing and ploughing results in a reduction in vegetation cover that leads to increased erosion, land degradation, and loss of biodiversity. Mining has caused visible and dramatic damage throughout the district. Remote sensing has identified *Prosopis* invasion as a serious threat to biodiversity in the Northern Cape (Meadows and Hoffman, 2002; De Villiers, 2003). Arguably it is these drivers that are primarily responsible for biodiversity losses in the region. Due to the low rainfall in the region and the types of plants adapted to life in an arid environment, recovery from disturbance is slow and often virtually impossible. Changes in temperature and precipitation patterns are likely to exacerbate these drivers in many cases, with climate change acting as a risk multiplier.

Already water scarce, a combination of increased temperatures and decreased rainfall as projected in the intermediate and worst case scenarios will have an impact on water quality and water availability, as well as groundwater recharge. The regions' core economic activities are also very natural resource dependent – particularly agriculture and tourism – suggesting that the regions' economy could be adversely affected by climate change.

Rainfall variability will likely be very important over short term (next 10 to 20 years) and scientific advances relevant to the NDM are currently being made. In the medium term (up to 50 years), temperature and rainfall trends are likely to adversely affect water, agriculture, health, and human settlement, although the tourism industry will likely be buffered from climate impacts in the short to medium term. Long term (> 50 years), a drier and warmer future will very likely have severe adverse effects on all the above, as well as on marine and terrestrial biodiversity.

The priority areas identified in the report are both vulnerable to climate change and have the potential to show a benefit from EbA methods for reducing vulnerability of people and ecosystems. They correspond to Critical Biodiversity Areas and contribute to an ecological corridor for climate change adaptation.

Ecological vulnerability: medium-high (3.85)

Vulnerability is a function of the extent to which an entity is exposed to hazards, is sensitive to the impact of these hazards, and has the capacity to effectively respond. It is variable according to the influence of multiple environmental and social processes (Gbetitbuou and Ringler, 2009), including climate change which acts as a risk multiplier. It is generally accepted that the NDM is among the most *exposed* to the impacts of climate change in the country due largely to expected impacts on winter rainfall patterns over the long term and the impact of increasing temperatures on aridity and surface water quality. The biomes of the NDM differ in their *sensitivity* to climate change, with the Succulent Karoo being the least sensitive of them to 2050 and the Fynbos Biome demonstrating the highest sensitivity. Already being arid-adapted reduces the Succulent Karoo's sensitivity to high temperatures and low rainfall, at least at the biome level. The region's *adaptive capacity* is, however, quite low. The low rainfall and slow growing nature of much of the Succulent Karoo's vegetation, for example, means that it can take a long time to recover from disturbance, if it is able to recover at all.

The three parameters, exposure, sensitivity, and adaptive capacity were applied to assess ecological vulnerability. Within these, we applied two core indicators to assess exposure and one indicator to assess sensitivity. Each of the three biomes was assessed according to a composite of indicators for sensitivity and adaptive capacity:

1. *Exposure*

    - *Changes in temperature*: Under all scenarios, annual average temperature is projected to increase.
    - *Changes in rainfall:* There is greater uncertainty around projected changes for rainfall. The best case scenario predicts an increase in rainfall around the Kamiesberg and

into south central and south east Namakwa. The intermediate and worst case scenarios predict a reduction in rainfall across the District. In the intermediate scenario, projected decreases in rainfall are small, while in the worst case scenario, rainfall is projected to decrease significantly.

2. *Sensitivity*

- *Endemism:* High levels of endemism suggest high levels of sensitivity to change because endemic species evolve to take advantage of particular climate and environmental niches. Midgley and Thuiller (2007) have demonstrated that, out of 20 Karoo Succulent species, the vast majority will experience significant contractions in suitable habitat and range under climate change.

- *Succulent Karoo Biome:* The Succulent Karoo biome demonstrates stability in the climate envelope under all three scenarios presented here. Changes in winter rainfall are not significant enough to 2050 to impact on suitability for the Succulent Karoo biome in this time frame. Already adapted to dry and hot conditions, the climate envelope for Succulent Karoo is resilient to reductions in rainfall and increases in temperature. This does not necessarily mean that particular species will be unaffected by such changes.

- *Nama Karoo Biome:* The climate envelope found in the Nama-Karoo area of the Namakwa District is likely to remain stable under the best case and intermediate scenarios, but changes to a Desert climate envelope in the north under the worst case scenario.

- *Fynbos Biome*: Patches of Fynbos in the NDM are located in very specific climate niches and are projected to undergo significant contraction in habitat suitability under climate change projections in the intermediate and worst case scenarios.

3. *Adaptive Capacity*

- *Succulent Karoo Biome:* Already adapted to dry and hot conditions on a biome level, the Succulent Karoo Biome has a high capacity to withstand increased temperatures and decreased precipitation while maintaining biome structure and functioning. This does not necessarily mean that particular species will be unaffected by such changes.

- *Nama Karoo Biome:* Nama Karoo is adapted to summer rainfall conditions and is sensitive to decreases in annual average rainfall. Its adaptive capacity to 2050 is medium because it only shows a significant trend to desertification under the worst case scenario.

- *Fynbos Biome:* Adaptive capacity in the Fynbos Biome patches in the NDM is low because these plant communities exist only in small niches located in mountainous areas and likely to be impacted by decreasing rainfall and increasing temperature.

For each parameter, a score was allocated to indicate the level of vulnerability. This was allocated on a scale of 1-5. For exposure, 1 indicates low exposure and 5 indicates high exposure. For sensitivity, 1 indicates low sensitivity and 5 indicates high sensitivity. For adaptive capacity, 1 indicates high adaptive capacity and 5 indicates low adaptive capacity. A simple average was then computed to derive the ecological vulnerability Index below.

TABLE 1: PARAMETERS AND INDICATORS USED TO ASSESS ECOLOGICAL VULNERABILITY IN THE NDM

Parameter	Indicator	Value
Exposure		**5**
	Changes in Rainfall	5
	Changes in Temperature	5
Sensitivity		**3.25**
	Endemism	4
	Succulent Karoo Biome	2
	Nama Karoo Biome	3
	Fynbos Biome	4
Adaptive Capacity		**3.3**
	Succulent Karoo Biome	3
	Nama Karoo Biome	3
	Fynbos Biome	4
Vulnerability Index		**3.85**

Biodiversity Stewardship

The Nuwejaars Wetland Special Management Area (SMA) is an example of stewardship that is reducing ecological vulnerability and building socio-economic resilience simultaneously. The SMA consists of 25 private landowners, who have converted their land use practices from "conventional" agriculture towards land use dependent on biodiversity conservation, eco-tourism and carbon- and energy-neutral production. The SMA is located within a biodiversity hotspot, with biologically rich lowland Fynbos, endangered Renosterveld and irreplaceable wetlands, which after centuries of inappropriate land use practices have become highly vulnerable to two inter-related climate change impacts, increasing frequency in wild fires and floods. Building on natural and human capital, the Nuwejaars Wetland SMA is using sustainable agriculture as an economic driver, together with other biodiversity-based economic drivers, such as eco-tourism, in order to create resilience to climate change and become a sustainable venture.

RECOMMENDATIONS

Resilient ecosystems support human adaptation to climate change. Recommendations therefore focus on increasing the adaptive capacity of the biodiversity and ecosystem processes which underpin the regions' economic activities. Water will of necessity be the primary focus for much ecosystem-based adaptation in the region. The higher rainfall upland areas are critical for recharging groundwater resources and so land management in the catchments is essential in order to maintain the quality and quantity of the water resource. For example, water courses and wetlands that have been cleared for agricultural purposes, or overgrazed, will not only cause soil erosion but most importantly cause increased water runoff, reducing the amount of water that feeds back into the water table.

Action to reduce ecological vulnerability could include biodiversity stewardship, expanded protected areas, or expanded public works programmes such as Working for Wetlands or Working for Water.

Short term responses (adaptation):

- Assess water supply security and implement measures to optimise water use, especially ground water
- Restore wetlands and design and implement management processes that limit ploughing in wetlands and promote appropriate and sustainable utilisation of wetland resources
- Restore river corridors and design and implement management processes that promote the appropriate and sustainable utilisation of river corridor resources
- Design and implement management plans focused on preventing land

EPWP Projects

In South Africa, a number of environmentally focused Expanded Public Works programmes have been created by the Department of Natural Resource Management. These are aimed at either maintaining, rehabilitating or restoring ecosystems and natural landscapes, while at the same time creating jobs for marginalised communities. A strong focus is on the development of value-added industries around the core programmes. The different programmes, which include Working for Water, Working for Wetlands, Working for Land, Working on Fire and Working for Energy, all address critical political priorities of job creation and water scarcity, while at the same time supporting the expansion of South Africa's green economy. The programmes work to reduce South Africa's environmental and social vulnerability to climate change, and thus form important examples of ecosystem based adaptation to climate change. [1]

degradation through over-grazing or other unsustainable land uses

- Build on and strengthen disaster risk responses (esp. drought response and monitoring climate impact on livestock)

Medium and long term response:

- Urban planning to account for climatic trends
- Renewable energy opportunities
- Ecosystem based adaptation opportunities
- Water supply enhancement opportunities
- Assess high end risks and lobby for extensive mitigation towards a safe global temperature goal

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CHAPTER 3: SOCIO ECONOMIC VULNERABILITY TO CLIMATE CHANGE IN THE NAMAKWA DISTRICT MUNICIPALITY

By Amanda Bourne and Camila Donatti[18]

INTRODUCTION

Climate variability and change, as increasingly experienced globally, is adversely affecting human wellbeing. In the NDM, an already challenging climate will be exacerbated by rising temperatures and decreasing rainfall. Increased temperatures, causing increased evaporation and aridity, and combined with reduced rainfall will affect the ability of the environment to provide the key ecosystem services, such as freshwater, on which the population of the District is dependent. Such resources are naturally scarce in the region. Socio-economic information can 'highlight the social and economic conditions that impact…vulnerability to climate change, the ability to adapt, and the effectiveness of adaptation' (UNFCCC, 2011:1). Poverty, in particular, makes people more vulnerable to climate change and less able to recover from its impacts.

The objectives of this chapter are to provide a socio-economic profile of the NDM's population and to determine the vulnerability of the social and economic arrangements to the expected impacts of climate change.

[18] Manager – Climate Change Adaptation, Science and Knowledge Division, Conservation International

SOCIO-ECONOMIC PROFILE: NAMAKWA DISTRICT MUNICIPALITY

The most recent South African National Census was conducted in October 2011 but the result had not yet been released at the time of writing. The analysis presented here was therefore completed from mainly external data sources (e.g. NDM, 2010, Du Plessis 2010a, DSD, 2010).

The Northern Cape Province is geographically the largest in the country and home to the smallest percentage of the population – 2.17% of the total South African population according to Stats SA (2011). Within the Northern Cape, the NDM is the largest district with the smallest population, home to 11% of the total Northern Cape. The NDM is geographically the largest district municipality in the country, covering an area of 126,747km^2. It has an estimated population size of 126 515 (NDM, 2010 – using data from Stats SA's 2007 Community Survey). This means an average population density of roughly 1 person per km^2.

Of these, 43% live in Nama Khoi, the local municipality in which Springbok, the District's administrative, commercial, farming, and industrial centre, is located (DSD, 2010:1).

TABLE 2: STATS SA COMMUNITY SURVEY DATA ON POPULATION AND TOTAL HOUSEHOLDS IN EACH LOCAL MUNICIPALITY WITHIN THE NDM IN 2007 (DU PLESSIS, 2010C:130).

Name	Population	Population as % of District	Population as % of Province	No. of Households	Households as % of District	Households as % of Province
Namakwa District Municipality	126494	100	11.9	36437	100	13.7
Richtersveld Local Municipality	14613	11.5	1.3	3953	10.8	1.4
Nama Khoi Local Municipality	54644	43.1	5.1	15656	42.9	5.9
Kamiesberg Local Municipality	12117	9.5	1.1	3881	10.6	1.4
Hantam Local Municipality	21234	16.7	2	5819	15.9	2.1
Karoo Hoogland Local Municipality	10420	8.2	0.9	2982	8.1	1.1
Khai-Ma Local Municipality	12571	9.9	1.1	3787	10.3	1.4

The Northern Cape, and the NDM within it, has very low population numbers and densities. This has implications for departmental budgets as the South African government traditionally allocates budgets according to population numbers (Corcoran et al, 2009:8). In addition, the very low population density and large area increases the costs and logistical limitations of providing basic services significantly. Delivery of basic services, including health care, road maintenance, education, and water, is therefore a great challenge in the NDM.

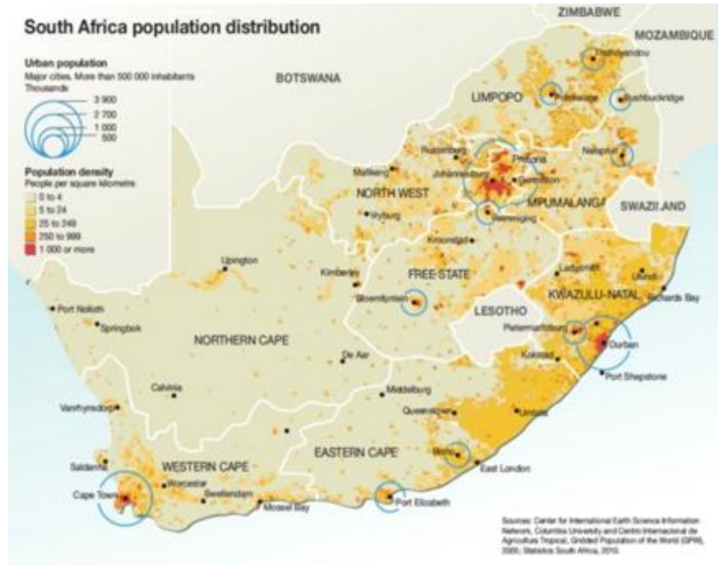

FIGURE 45: POPULATION DISTRIBUTION IN SOUTH AFRICA (UNEP, 2011)

According to Du Plessis (2010a), due to the large area of the NDM and the remote nature of many of the settlements in it, there are a lot of places that do not have a telecommunications line or cellphone signal. The road infrastructure in rural areas consists of poorly maintained gravel roads impacted by erosion – this limits access and increases vulnerability by limiting, for example, the health care and fire management services that can be provided to these settlements, as well as their access to markets. Water for human consumption or agricultural use is of central concern. Bulk water supply services transport water over very long distances from the Orange River, the only perennial river in the NDM. These pipelines are old and frequently break down. In December 2011, Springbok, the District's capital town, was without running water for a total of 14 days. Many smaller settlements rely exclusively on groundwater but water quality from the district's many bore holes is often poor and threatened by climate change and over-abstraction. Water scarcity also contributes to poor sanitation facilities in many areas.

Schools are concentrated in the urban settlements leaving little opportunity for the more remote, rural children to access education. While most people have some level of basic schooling, education levels across the NDM are low. Some 79% of the population has not finished school (Chidley et al, 2011). According to the Department of Social Development (2010:6), this figure may be as high as 90% for the population over the age of 20, with a third having completed primary school or less.

Interestingly, in 2003 the Northern Cape contributed 2.4% to the National GDP even though it has only a small percentage of the population of the country. This implies that *per capita* GDP in the Northern Cape is higher than the national average. According to the IES/LFS 2000 estimate, the Northern Cape per capita income was R15, 474 in 2000, slightly higher than the national average of R12, 411. Although both mining and livestock farming are important economic activities in the NDM, this average is a result of incomes for specialists in the mining sector that are far higher relative to other sectors and obscures an accurate understanding of socio-economic conditions for the majority of NDM's population. Many of the coastal towns, such as Kleinsee, Hondeklipbaai, and Koiingnaas, have historically depended exclusively on mining activities. The regions diverse mining products include alluvial diamonds, copper, and granite and the mines have been the main driver of economic growth and employment in the area for many years.

However, the mines across the District are rapidly reaching resource depletion and are slowly closing down, leaving many communities in poverty. In most cases, the mines have also left the surrounding environment severely degraded (see pictures in the chapter on Land Use). Abandoned mine sites are also a risk to communities and two people were killed in a mine collapse at Hondeklipbaai in 2011. Even where rehabilitation has been attempted to some extent, Blood (2009) suggests that the *Tetragonia fruticosa*[19] dominated vegetation on rehabilitation sites is insufficiently diverse and palatable to be able to contribute significantly to small-stock farming.

Small stock farming, of sheep and goats for meat, is practiced everywhere and also contributes significantly to the economy. However, productivity is being negatively affected by over-grazing and land degradation.

The closure of many mining sites and the decrease in farming productivity translates on the ground to a situation in which high levels of poverty, unemployment, and in equality persist. With the economy dependent on an increasingly unproductive primary sector based on mining and agriculture, unemployment has steadily increased from 28.3% in 1996, to 33.4% in 2001. Currently, the highest unemployment rate is 35% in the Richtersveld local municipality (Chidley et al, 2011). In the small rural towns, unemployment levels are extremely high. For example, in Paulshoek, a Kamiesberg settlement of 135 households, only 10% of residents are employed (Samuels, 2006:34). Income poverty is high in the NDM, and economic activity is low. The majority of households earn less than R3200.00 per month and many are dependent on state grants for their survival.

As is the case in the rest of South Africa, as part of the country's Apartheid legacy, income is distributed broadly along racial lines. Du Plessis (2010c) showed that white households in the NDM generally were the

[19] *Tetragonia fruticosa* is a popular plant for restoration as it establishes readily, grows quickly, and can thrive in poor soils. It has proven very effective for quickly stabilising soils in degraded areas but is not sufficiently palatable to restore degraded or disturbed land to a state with economic potential for livestock grazing.

wealthiest and African households the worst off. In fact, there is 'virtually no poverty among white and Asian people. In sharp contrast, 53.3% of coloured and 58.7% of African people are classified as poor' (Du Plessis, 2010c:132).

Coloured and African agricultural households are generally worse off than their non-agricultural counterparts. Agricultural households often 'reside in rural areas and are far removed from more lucrative employment opportunities in urban areas' (Du Plessis, 2010c:132).

The following economic analysis, taken from the draft Namakwa District Integrated Development Plan 2012-2016, indicates a very high level of poverty in the NDM with a total of 56687 in 2010 or 44,2%. This is one of the most serious concerns in the District.

TABLE 3: THE PERCENTAGE OF PEOPLE LIVING IN POVERTY IN THE NAMAKWA DISTRICT BY YEAR.

	African	White	Coloured	Asian	Total
1996	29.50%	2.00%	38.70%		32.70%
1998	44.10%	2.60%	42.60%		36.90%
2000	50.60%	2.90%	41.90%		37.00%
2002	66.70%	3.10%	49.40%		44.50%
2004	71.00%	2.30%	49.40%		45.00%
2006	71.40%	1.30%	49.50%		45.30%
2008	73.50%	0.90%	50.30%		46.40%
2010	73.10%	0.30%	47.50%		44.20%

TABLE 4: PERCENTAGE OF LOW, MIDDLE, AND HIGH INCOME EARNERS IN THE NAMAKWA DISTRICT (CHIDLEY ET AL, 2011)

Local Municipality	Percentage of Low Income Earners [0 to R3 200 pm]	Percentage of Middle Income Earners [R3 201 to R25 600 pm]	Percentage of High Income Earners [R25 601 and above pm]
Hantam	82%	17%	1%
Kamiesberg	71%	28%	1%
Karoo Hoogland	84%	14%	1%
Khai Ma	83%	16%	0%
Nama Khoi	71%	28%	1%
Richtersveld	71%	28%	1%

TABLE 5: AVERAGE ANNUAL HOUSEHOLD INCOMES (ZAR) BY DISTRICT MUNICIPALITY AND ECONOMIC SECTOR IN THE NORTHERN CAPE (DU PLESSIS, 2010C:131)

	Agricultural households					Non-agricultural households				
	African	Coloured	Asian	White	Total	African	Coloured	Asian	White	Total
Namakwa	12,955	23,347		142,333	51,696	19,721	40,601		134,049	59,603
Siyanda	9,606	23,864		404,402	102,690	32,647	22,643		227,389	69,750
Kgalagadi (tf)	13,618			505,200	170,288	28,676			187,186	48,227
Frances Baard	12,425	15,242		242,218	46,133	30,728	56,730	187,983	158,670	57,111
Karoo	11,158	10,164		242,370	43,008	13,499	26,159		84,454	29,353
Provincial average	*11,424*	*18,861*		*296,390*	*71,069*	*27,887*	*35,937*	*187,983*	*166,629*	*55,377*
National average	*15,014*	*24,250*	*132,816*	*282,151*	*26,612*	*29,777*	*57,284*	*88,642*	*166,100*	*49,990*

The tables above suggest that rural poverty is pervasive and extreme. Indeed, the Northern Cape's Gini coefficient, a standard global measure of inequality, is also very high (0.73 – higher than the national average,) indicating extreme levels of income inequality.

The unemployment rate as well as the number of unemployed people in the District increased from 2008 and are presently the highest ever recorded: 28% (Chidley, 2011).. The total employment figures indicate there is a decline in employment in agriculture, mining and trade whilst there is a marginal increase in employment in the provision of services.

COMMUNAL LANDS

Northern Namaqualand is characterised a system of communal grazing that has remained relatively unchanged over the past 100 years, and is utilised extensively by the rural populations discussed above. About 25% of land in NDM is under commonage, accommodating some 40 000 people (Boonzaaier, 1987). Since the 1920s significant numbers of commonage residents have been employed in migrant wage-labour, with the mining industry traditionally being the largest employer of migrant workers.

Initially, the diamond and copper mines along the Orange River and the Namakwa coast provided a useful alternative or supplement to what was essentially subsistence stock-farming. For those households building up herds, the income derived from migrant labour helped to speed up the accumulation of stock. Over time, many people have left the commonage permanently and settled elsewhere, but for those who remained in the commonage, grazing rights have become an invaluable adjunct to the low wages and general insecurity of wage employment (Boonzaaier, 1987).

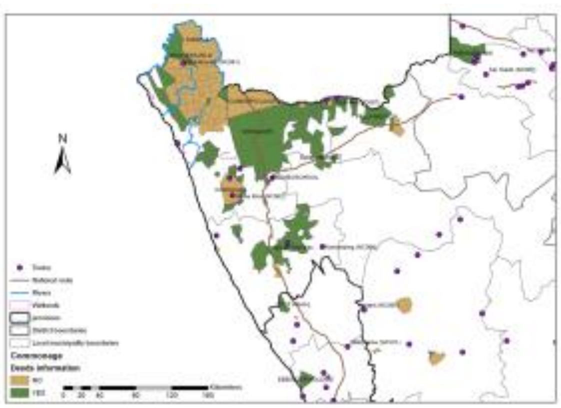

FIGURE 46: THE AREA OF NDM UNDER COMMONAGE (PREPARED FOR CSA BY MANDLA DLAMINI AT SANBI).

At various times in recent history, the drop in the demand for copper or diamonds has resulted in massive retrenchment of labour. Current exhaustion of mineral deposits has resulted in recent mine closures and further job losses. The introduction of commercial Dorper mutton sheep farming in the 1960s required less farm labour and resulted in many farm labourers losing their jobs as well. According to Hoffman and Rohde (2007:645), herders no longer needed on these farms, as well as retrenched mine workers, 'retreated to the Coloured Reserves and the number of households grew accordingly'. Unemployment has forced many people to fall back on livestock farming to get some form of income (Boonzaaier, 1987). This increase in stocking rates, coupled with the enclosure of the communal areas by neighbouring white farmers, has placed significant pressure on the natural resources of the communal areas. Significant impacts, as revealed in the differences across fence-lines between communal areas and private farms, reflect divergent socio-political and land use histories (Hoffman and Rohde, 2007). The grazing and agricultural lands available for land reform are often marginal and characterised by overgrazing and land degradation (Govender-van Wyk and Wilson, 2006).

According to Anderson and Pienaar (2003), infrastructure on the new commons is in often in poor condition. Increasingly, municipalities struggle to effectively maintain infrastructure on commonage land. Budget and capacity constraints limit the ability of responsible officials to tend to the issues that arise. Land users also struggle to maintain commonage infrastructure. Lack of individual accountability, lack of access to information and resources, plus user group structures that seldom have the strength to control members, or are themselves dominated by local elites. This results in an open access situation with which most commonage has become associated (Anderson and Pienaar, 2004). Ploughing for dryland fodder cropping has resulted in a loss of soil nitrogen and organic matter. Grazing is often concentrated in certain areas, around stock posts and water holes, causing trampling and over-grazing of those areas, erosion, and, ultimately, further land degradation (Lebert, 2006).

Access to commonage land is an essential livelihoods strategy for many rural populations, particularly with unemployment on the rise. Although small stock farming often makes only a small contribution toward household income and livelihoods, it is one of the few locally available economic opportunities (Samuels, 2006). Indeed, low input, small scale livestock farming remains a primary land use across Southern Africa. Several studies indicate that households in communal areas are dependent on livestock production and other field resources (Cousins, 1999; May et al, 2000; Shackleton et al, 2001; Bryceson, 2002).

Livestock represents an accessible store of wealth for residents, which can be sold when cash is needed, for example to pay school fees or to cover unforeseen expenses. Stock sales can be within communities or to outside buyers, such as neighboring commercial farmers. Households also derive direct benefits from livestock in the form of meat and other animal products. This benefit extends even to households which do not own livestock through received 'gifts or cheap goods and services from livestock owning households' (Dovie et al, 2011:8).

Rural populations in the NDM are dependent on a marginal and increasingly degraded communal land resource. Small stock farming provides an essential livelihoods supplement and this option is widely utilised. Environmental concerns and social problems pose ever increasing challenges to commonage land users. These are likely to be exacerbated by climate change, leaving these communities vulnerable to its impacts. The commonage model 'has primarily advocated an agrarian style development despite the decline in contribution of agriculture to the GDP' (Govender-van Wyk, 2007:14).

A case study of a typical rural town in the NDM

The settlement at Paulshoek in the Kamiesberg is made up of 135 households housing 492 people. About 60 % of household heads are male. The population of Paulshoek is characterised by high levels of poverty, illiteracy, unemployment and a general lack of access to resources. According to South Africa's 2001 Census, only 10 % of the resident population is employed and the average monthly income per household is under R250. Many people are dependent on government grants for their survival. Those with access to land frequently supplement their meagre incomes with small stock farming on the surrounding commonage. This situation is typical of rural towns in communal areas in the NDM.

Taken from Samuels (2006)

Thus, socio-economic conditions in the District combined with the unique politics and history of the area indicate an unequal, poor, and vulnerable rural population. At a workshop conducted in Springbok in March 2012, with local government and other stakeholders, farmers and rural communities were identified as the most vulnerable groups. This is shown in the chart in Figure 47.

Vulnerability is made more acute by exposure to a number of serious natural hazards set to worsen under conditions of climate change.

As part of the NDM's disaster risk reduction planning, Du Plessis (2010 a and b) conducted a study in all six local municipalities to identify and rate all the potential hazards faced by communities there. All hazards were identified and ranked using indigenous knowledge. Du Plessis (2010 a and b) and his team conducted 52 workshops with NDM communities, accessing information from community leaders, members of various government portfolio committees, ward councilors and community members. Figure 48 below represents a summary of the workshop outcomes, which we have adapted here to show only the hazards directly related to climate change adaptation.

Figure 48 clearly demonstrates that a wide variety of stakeholders, both from government and civil society, and contacted through 52 separate workshops around the NDM, one in every settlement or town, consider the NDM as a whole to be highly vulnerable to a number of service delivery and climate related stressors. The accuracy of these perceptions was confirmed by a spatial analysis of the NDM by Du Plessis (2010c), which looked at historical evidence of the hazard, its recorded impact on people and property in the past, the impact potential of the maximum threat, and the probability of the hazard occurring. Other studies have also confirmed that the NDM is vulnerable to the above socio-economic and environmental threats (DSD, 2010; Midgley and Thuiller, 2006; SARVA, 2011)

Figure 48 indicates that vulnerability to climate related stressors and access limitations is high across the district. The Nama Khoi, Kamiesberg, and Richtersveld municipalities are considered marginally the most exposed to and sensitive to the selected natural and man-made hazards listed above. The other municipalities appear less vulnerable primarily because they are exposed to fewer hazards (having no coastline, for example).

The NDM is exposed to drought, and very vulnerable to it. This situation is worsened by serious over-grazing and land degradation throughout the district. As Du Plessis (2010c:15) has argued, the 'overutilisation of natural resources puts extreme pressure on the environment especially in areas that are prone to fluctuations in rainfall. This can lead to environmental degradation and other hazards such as soil erosion', which are a powerful threat to individuals and communities dependent on their natural environment for a living. Most of the District's seasonal and perennial rivers flood in the short rainy season, putting communities and water infrastructure at risk. Coastal storms have already caused much damage to houses and infrastructure along the coast (Du Plessis 2010a:16).

Figure 48 shows that drought is the highest risk. Most areas located near rivers (perennial and seasonal) are at flood risk, even during very dry periods (due to rain outside the NDM and the fact that the NDM has both summer and winter rainfall areas). Drought and flood cycles contribute to environmental degradation. Water pollution is also a major hazard. These challenges are likely to be exacerbated by climate change. For example, malnutrition could increase due to food security challenges, flooding could introduce malaria to previously arid areas (Warsame et al, 1995), increased temperatures will likely lead to increased incidences of heat exhaustion, stroke, heart attacks, and dehydration – particularly

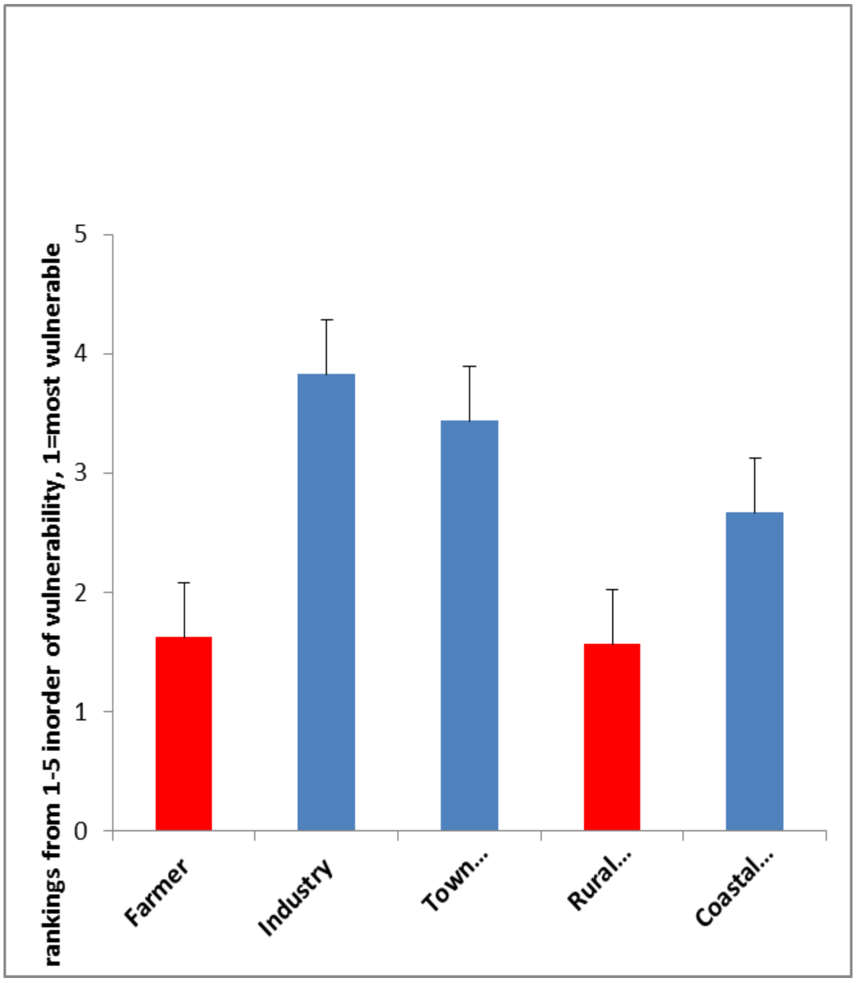

FIGURE 47: THE MOST VULNERABLE GROUPS IN THE NAMAKWA DISTRICT, BASED ON INFORMATION COLLECTED IN A WORKSHOP CONDUCTED BY CSA IN SPRINGBOK IN MARCH 2012.

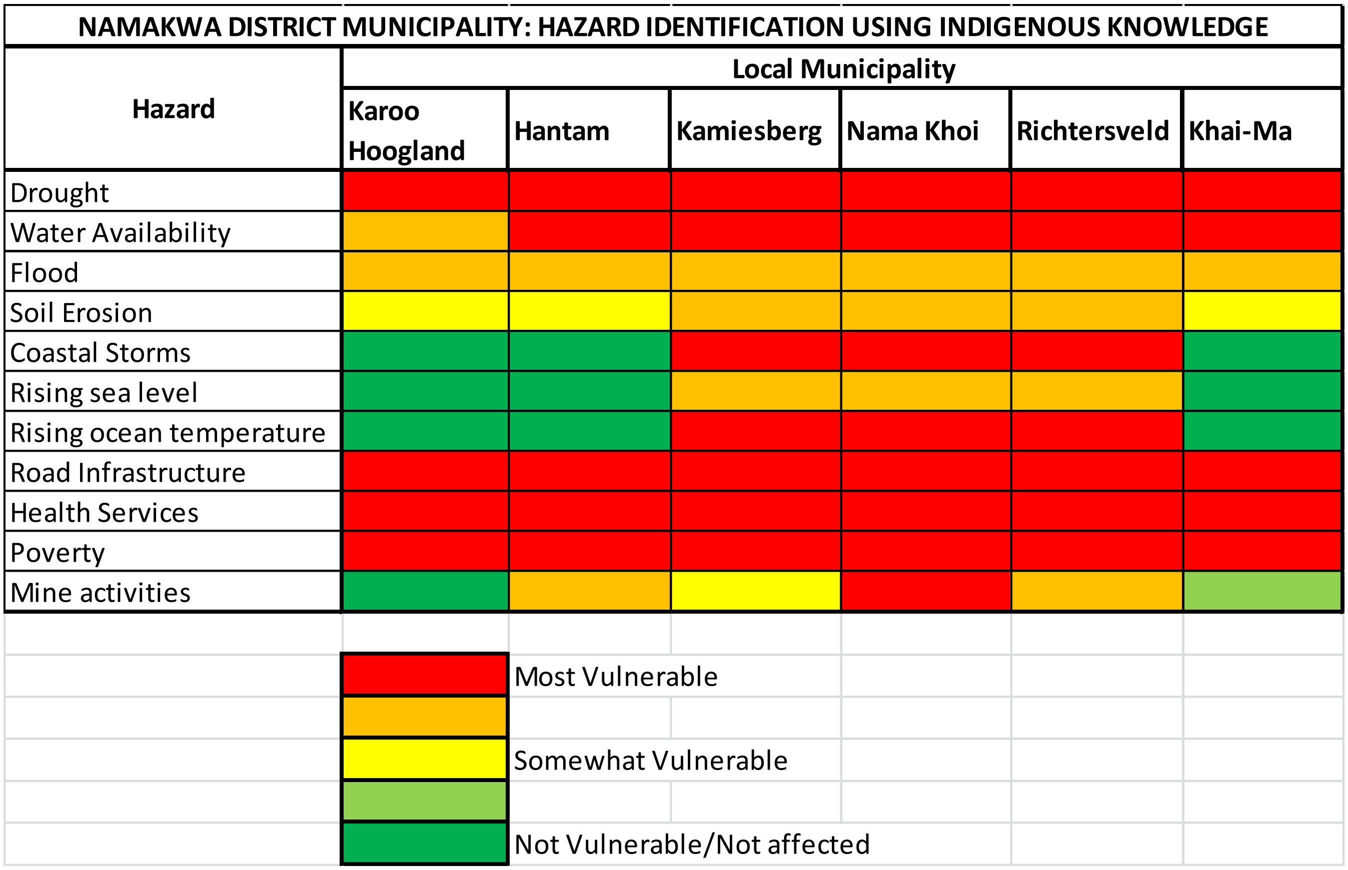

FIGURE 48: HAZARD IDENTIFICATION AND PRIORITISATION ACCORDING TO INDIGENOUS KNOWLEDGE IN THE NDM (DU PLESSIS, 2010)

affecting substance abusers, old people, or those in an otherwise poor physical condition. According to Patz et al (2005), Southern Africa has a disproportionately higher likelihood of increased mortalities related to climate change as a result of infectious diseases and malnutrition. This is because climate change interacts with background stressors and additional vulnerabilities.

A key medium through which climate change impacts will be felt is water. South Africa, and the NDM in particular, is already water scarce and many of the projected impacts have a direct impact on water quality and water availability (evaporation of surface water, changes in rainfall patterns, damage to infrastructure from floods and storm surges, salt water intrusion along the coast, reduction in groundwater recharge). In practice, while 'a direct signal attributable to climate change may be difficult to separate from background variability in South Africa's water sector' (Midgley et al, 2010:iv), climate change will be super-imposed onto an already water stressed environment.

According to Du Plessis (2010), the majority of NDM settlements depend on groundwater for consumption and industrial and agricultural activities. In addition, water is often imported over large distances, making the area vulnerable to disruptions along the pipeline, water pollution far away, and water scarcity outside the NDM area of jurisdiction. The Orange River 'which forms the northern boundary of the municipality, is critical to ecological functions in the area, and is the only perennial river in the region. Its health is currently threatened by agriculture and invasive species, most notably *Prosopis* which clogs up the river system and utilises large quantities of water otherwise available for consumption or agriculture' (Du Plessis, 2010:53)

Water is a major limiting factor on development, with demand predicted to exceed supply by 2025 (CAPE, 2010). Figure 49 was adapted by Elmariza Smith from DSD data (2009:38) and shows the percentage of the water resource available to each town that is currently being utilized in the NDM. The graph clearly shows that half the towns are currently utilising their available water resources at or beyond 80%. Several towns, including relatively large settlements such as Calvinia and Komaggas, have water resource utilisation that already exceed the available resource. Kamieskroon utilises water at close to 180% of the available resource.

MAIN ECONOMIC ACTIVITIES

Economic activity and land use in the Namakwa District is defined by livestock grazing and mining – the two primary economic drivers in the region. Approximately 90% of the NDM land surface is natural areas in various conditions used for livestock grazing. The remainder is a combination of mining, crop agriculture, urban development, and protected areas. Most of the crops grown in the NDM are either grown in the southern municipalities, where there is relatively higher rainfall, or along the Orange River where the opportunity for perennial irrigation exists. Crops include irrigated wheat and grapes and dryland rooibos tea. Livestock grazing is the most common agricultural activity and focuses on small stock such as sheep and goats.

In theory, livestock grazing is a viable and biodiversity friendly land use and the perpetuation of ecological corridors of healthy vegetation should also take the capacity of the veld to produce forage into account. In practice, over-grazing is a serious threat to ecosystem health – the biggest threat to biodiversity in the region by virtue of it being the most widely practiced land use activity.

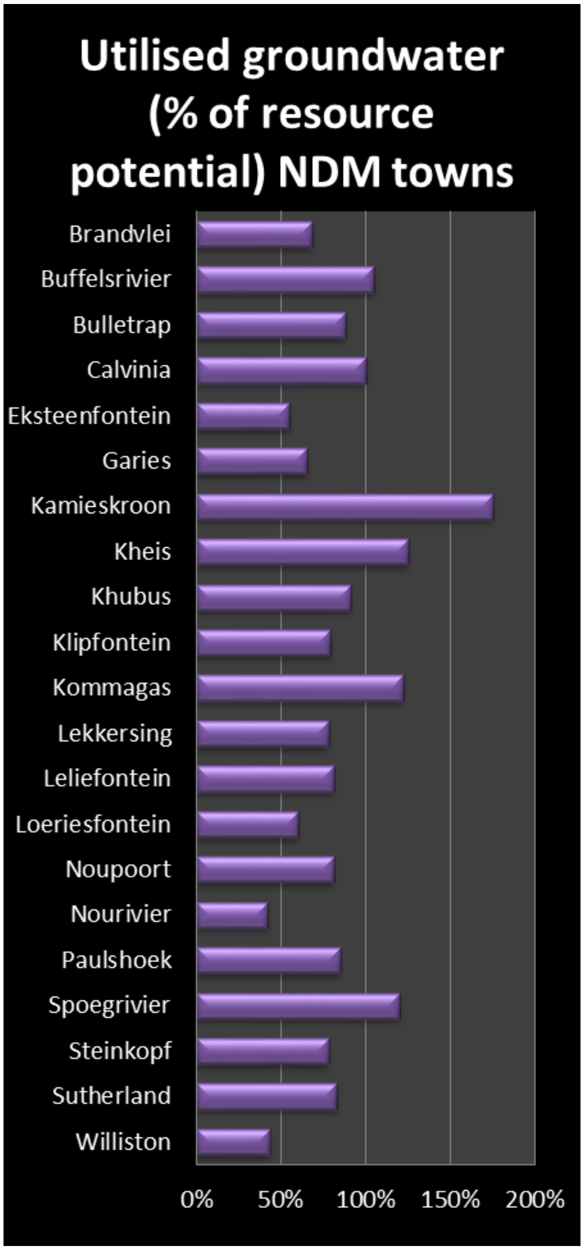

FIGURE 49: THE EXTENT TO WHICH AVAILABLE WATER RESOURCES ARE ALREADY UTILISED BY TOWNS IN THE NDM

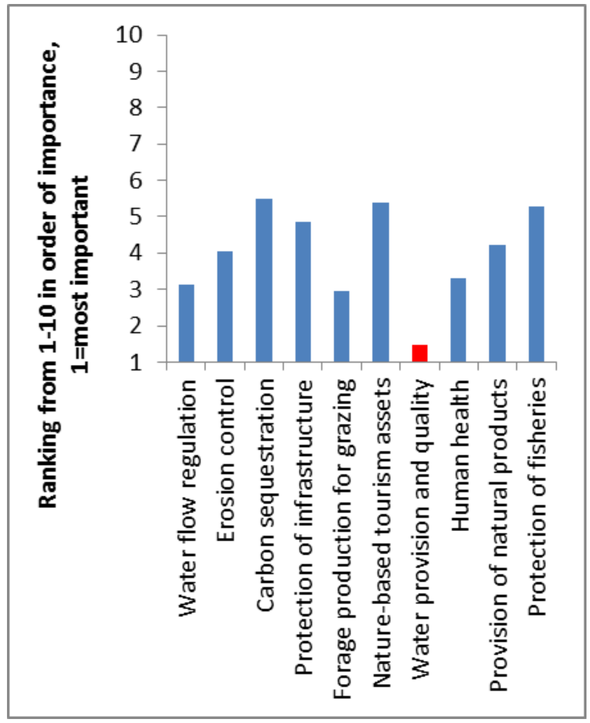

FIGURE 50: PERCEPTIONS OF THE MOST IMPORTANT ECOSYSTEM SERVICES IN THE NDM, AS IDENTIFIED BY THE PARTICIPANTS IN A WORKSHOP IN MARCH 2012

Reduction in vegetation cover, and resultant soil erosion by wind and water, affects the productivity of the land as well as water quality, dam and river siltation levels, and wetland health, thus having a direct impact on human well-being.

Future pressures on biodiversity are likely to come from new mining developments, the expansion of crop agriculture and ploughing of virgin veld for fodder, high density ostrich farming, the unsustainable use of natural resources including the over-extraction of water and overgrazing by sheep and goats, and urban development (although this is limited to some extent by water availability and other constraints).

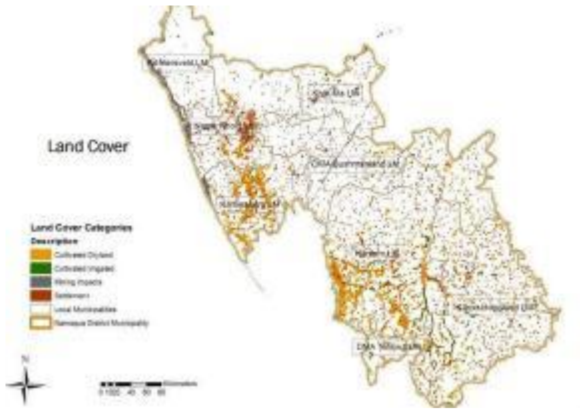

FIGURE 51: LAND USE IN THE NDM (DENC, 2010:16)

Mining

Mining is diverse and widespread in the NDM and the entire northern extension of the Succulent Karoo is mineral rich (CEPF, 2003), forming the basis of the economy and being the primary local employer for many years. The entire northern extension of the Succulent Karoo is mineral rich and with various mining applications pending throughout the region, transformation from mining operations represents a significant pressure. Open caste and alluvial mining activities for diamonds along the coast and river flood plains have nearly transformed the entire coastline. New markets and discoveries of base metals such as zinc and copper as well as gypsum, granite, sandstone, salt, and quartz deposits continue to transform large areas of limited habitat types. In addition to large corporations, uncontrolled prospecting by smaller companies and individuals is encroaching on the fragment patches of dune and coastal shrubland (SKEP, 2003).

Limestone and gypsum are mined in the Knersvlakte, marble in the Namakwa uplands, and mineral sands, yielding titanium, zirconium and magnetite are surface mined on the central Namakwa coast. Alluvial diamonds are dredged offshore, along the coast and on the shores of the Orange River in the Richtersveld region. Copper, silver and associated metals are mined below ground in the Bushmanland Inselbergs. Uranium was mined in the 1970's in the schist hills between the Richtersveld and the Bushmanland Inselbergs, and there is a high probability that it will be mined in this region on a larger scale in the next 10 years (SKEP, 2009).

The devastating ecological impact of mining activities can be clearly seen in each of the local municipalities, in the form of mine dumps and excavations. Much of the coastal land degradation and transformation reflected in Figures 52 and 53 below are a direct result of open caste diamond mining activities. Base metal vein mining along the Orange River 'coincides with areas of highest diversity for succulents' (CEPF, 2003: 10) and will lead to notable biodiversity losses.

FIGURE 52: GOOGLE EARTH IMAGE OF COASTAL TRANSFORMATION DUE TO MINING AT KLEINZEE

FIGURE 53: GOOGLE EARTH IMAGE OF COASTAL TRANSFORMATION DUE TO MINING AT HONDEKLIP BAY

Mining is a major driver of change in the Namakwa landscape, contributing to land degradation and therefore to high ecological vulnerability. Mine closures are resulting in growing unemployment in the District and fuelling socio-economic vulnerability as well. Although as yet unknown, and increase in wind velocities or frequency of wind storms along the coast could accelerate secondary degradation caused by plumes of sand blown from disturbed areas. Figure 54 below shows wind-blown damage from the slime dams at a mine near Koingnaas.

FIGURE 54: PLUMES FROM A SLIME DAM AT KOINGNAAS

Agriculture

Small stock farming with sheep and goats is the primary land use across the NDM and is the most widespread economic activity.

Although stock limits and grazing guidelines are in place, stocking rates that exceed the environment's carrying capacity are common. Such practices risk causing soil erosion and a reduction in vegetation cover, leaving large areas unable to support ecosystem function and the well-being of the people dependent on these functions for their livelihoods. While steep rocky areas remain in good condition throughout much of Namakwa, low-lying flatter sandy areas have been severely impacted by a range of land-use practices that include cultivation and grazing. These impacts are often historical and little recovery is possible.

There is no history of cultivation of crops in the District prior to the settlement of the area by European farmers (Hoffman and Rohde, 2007), when Namakwa pastoralists began to adopt a sedentary lifestyle associated with the mission stations. Wheat and lucerne are commonly grown winter crops, most often cultivated on a small scale as fodder for animals. Yields are closely linked to rainfall and dryland cultivation has continued uninterrupted since the mid-18th century. In the last 50 years, however, cropping has declined significantly in the more marginal lower rainfall areas where it is no longer economically viable. Many 'marginal croplands in Namaqualand have lain fallow for decades and are now being invaded by a range of indigenous shrubs such as *Lebeckia sericea'* (Hoffman and Rohde, 2007:451). Restoration of indigenous vegetation by natural succession is extremely slow due to low rainfall, and species composition may never fully recover from the impact of ploughing.

The photographs in Figure 55, taken from Hoffman and Rohde (2007), demonstrate the devastating impact of cultivation of fodder crops and how long it takes for ploughed areas to recover in this environment. The top photograph was taken in 1967 and the bottom photograph in 2003, showing little change over almost 40 years. Despite some small shrubs establishing themselves on the now fallow ploughed lands, the ploughed area remains clearly visible and has not returned to the species richness and composition of undisturbed areas. As Hoffman and Rohde (2007:655) demonstrate, 'many of Namaqualand's agricultural landscapes today are a result of the slow re-colonisation of croplands by pioneer shrubs that are now utilized as (rather poor) grazing lands.'

This is particularly true in over-crowded communal areas where these transformed areas are heavily utilised for grazing. In these instances, the landscape often remains fairly barren and dominated by unpalatable shrubs such as *Galenia Africana*, known locally as Kraalbos. High stocking densities in the communal areas prevent 'any increase in palatable, productive shrubs, particularly leafy succulents' (Anderson and Hoffman, 2007) from taking place over time.

The spread of invasive alien species represents a serious threat to ecosystem health and function in the District, placing immense pressure on limited natural resources. In terms of fauna, the biggest threat is that of alien fish species that have a negative impact on the populations of indigenous and endemic species. This problem is 'significant throughout the region, but of special import for the Oliphant's-Doring river system as this contains numerous endemic fish species that are threatened by the incursion of alien species' (DENC, 2010:23).

The spread of alien vegetation is also widespread and of critical importance. The most pervasive species are *Prosopis*, Black

FIGURE 55: PHOTOGRAPHS TAKEN AT A SITE OUTSIDE KAMIESKROON IN 1967 (TOP) AND 2003 (BOTTOM), DEMONSTRATING CLEARLY THE SLOW RATE OF RECOVERY OF PLOUGHED LANDS

Invasive alien species

Wattle, and Poplar trees which establish themselves in river systems, consuming large amounts of water and presenting challenges to the integrity of these river systems.

Tourism

Tourism in the NDM has traditionally been limited to a few areas and activities. Recreational activities are focused mainly on a small adventure tourism industry including 4x4 trails, hiking, and river rafting, a short (~3 weeks) busy seasonal centred on viewing seasonal spring flower displays, and get-aways for tourists seeking natural beauty and isolation. Tourism is a growth industry based almost entirely upon the NDM's natural assets. The scenic landscapes, isolation, unusual vegetation, and mass seasonal flower displays are a major tourist attraction. According to the SKEP Ecosystem Services Report (Le Maitre et al, 2009:3) 'the annual value of flower viewing tourism was calculated to be R18 million and scenic tourism has a value of R156 million.' Tourism is a growth industry. Climate change leading to increased temperature and decreased rainfall that affects ecosystem function and process may have a disproportionate impact on tourism.

SOCIO-ECONOMIC VULNERABILITY

This chapter provides a socio-economic profile of the NDM and assesses the vulnerability of particular social and economic arrangements to the expected impacts of climate change.

The economy of the NDM is based historically on agriculture (sheep, goats, and, increasingly, game, with irrigated cropping limited to the Orange River) and mining. Productivity in both of these sectors is declining. Widespread poverty, lack of access to shelter and safe water and sanitation, food insecurity, drought, and land degradation is prevalent in most of the Northern Cape' (DSD, 2009:60), undermining the development of a sustainable future. High levels of poverty are due to high unemployment, which in turn is a result of job-shedding on stock farms, increasing numbers of game farms which utilise large areas of land but employ relatively few staff, and the downscaling of mines.

The NDM is one of two main communal areas in the Northern Cape, with large areas of commonage in the Richtersveld, Nama Khoi, Khai Ma and Kamiesberg local municipalities (the other is the Northern Kalahari). Communal lands often suffer from poverty, unemployment, and service delivery problems. Economies in the (mostly small) towns are fragile, due to a small business sector and very little local industry or value-adding, and linked to grant and pension pay-out days. Many people, particularly skilled or educated youth, are moving from the rural areas to towns or out of NDM altogether due to lack of economic opportunities at home and to the poor access to basic services, health care, education, and recreational facilities.

In addition, surface and underground water supplies are inadequate and increasingly threatened by climate change and over abstraction. An increase in aridity due to climate change could exacerbate unemployment, water scarcity, and difficulties with agricultural productivity.

Although superficially relatively prosperous due to GDP figures and average incomes skewed by the mining sector, the NDM is vulnerable to a lack of basic services and the sparse geographical distribution of settlement over large areas, as well as a challenging natural environment fraught with natural hazards and climate and water related challenges. Du Plessis's (2010) hazards analysis supports the position that appropriate management of water resources as an adaptation response is critical, being likely to respond to some 40% of the hazards prioritised in the NDM.

For Du Plessis, as for CSA, increased resilience is related to decreased poverty and increased access to services, information, and infrastructure. People are ultimately fully dependent on living, functioning ecosystems and the services they provide. Loss of biodiversity tends to harm the rural poor more directly – 'poor people have limited assets and are more dependent on common property resources for their livelihoods…poverty reduction…is therefore dependent on how effectively we conserve biodiversity' (Du Plessis, 2010c:44), and reduced vulnerability is dependent on how effectively we reduce poverty.

Socio economic vulnerability: medium-high (3.8).

Vulnerability is a condition determined by the internal properties of a system and is variable according to the influence of multiple environmental and social processes (Gbetitbuou and Ringler, 2009), including climate change which acts as a risk multiplier. It is generally accepted that the NDM is among the most *exposed* to the impacts of climate change in the country due largely to expected impacts on winter rainfall patterns. This has been shown in detail in the previous chapter detailing the climate profile. It is important to note that 'vulnerability to climate change and variability is intrinsically linked with social and economic development' (Gbetibouo and Ringler, 2009:6). A great many people in the NDM are farmers or are dependent on farm income. They are, therefore, directly dependent on natural resources for their livelihoods. Tourism is a growth sector and also depends on the health of the environment. These livelihoods are, therefore, *sensitive* to climate change.

Socio-economic arrangements speak to *adaptive capacity*, the ability to respond effectively to change. People in the NDM are well accustomed to living within an extremely challenging natural environment – the NDM is dry and water scarce, subject to extreme temperatures and variability in weather patterns, and periodically impacted by drought, flood, and coastal storm surges. Many people are already living at the threshold of their ability to cope with these stressors. This is indicated by high levels of unemployment and income poverty and low levels of service provision and education, leading to outward migration from the rural areas to urban centres within and outside the district. The fact that opportunities in conservation and tourism, or other alternative livelihoods pursuits, have not been able to pick up the slack around job losses resulting from mine closures indicates a lack of adaptive capacity in the local communities and the municipalities that serve them. A function of 'wealth, technology, education, information, skills, infrastructure, access to resources, and stability and management capabilities' (McCarthy et al, 2001:18), adaptive capacity in the NDM is low. An increase in aridity due to climate change could exacerbate unemployment, water scarcity, and productivity problems.

Adaptation to climate change should not be viewed in isolation but instead 'in the context of social, economic, and political conditions, all of which shape local community vulnerability and people's ability to cope with and adapt to change' (Quinn et al, 2011:1). The alleviation of vulnerability status depends on building resilience generally in communities through education, health, and service delivery and the development of viable and sustainable alternative livelihoods. Critically, for the NDM where people are directly dependent on the health and functionality of their natural resource base, ecosystems-based measures that ensure the restoration and maintenance of key biodiversity and ecosystem services and processes should be prioritised. Resilient communities have learning processes that help them to experiment with alternatives, innovate and adapt to unexpected new threats. They share knowledge and have access to relevant information, including early warning systems. Resilient communities, first and foremost, have access to alternatives – diverse livelihoods options grounded in healthy bio-diverse ecosystems.

Based on CI-Philippines Climate Change Vulnerability Assessment, a Socio-Economic Vulnerability Index (SEVI) was devised (Boquiren et al, 2010), according to exposure, sensitivity, and adaptive capacity. Each parameter of vulnerability referenced three indicators:

1. *Exposure*

    - *Population Density*: If exposure is defined as the extent to which a population comes into contact with climate change impacts, then the smaller the population and the less dense the population, the smaller the overall impact of hazard in terms of necessary response. However, exposure for the individual or community is increased due to relative isolation. The NDM is the less populous district municipality in South Africa with a population density of 1 person per km^2 .

    - *Water Utilisation:* the NDM is already water scarce. Under projected climate change scenarios, water availability and water quality will be the key adaptation concerns. Aside from the Orange River, the main freshwater source for the NDM is groundwater. Groundwater recharge is likely to be affected by reduced rainfall in the NDM and, in average, 87% of the current available groundwater resource is already utilized across several towns

    - *Climate change hazard*: projections for temperature and rainfall under climate change indicate increased temperatures across the NDM in all scenarios and decreased rainfall for the District in the intermediate and worst case scenarios. Open water evaporation over South Africa is likely to increase by 5-10% by 2050, and by 15-25% by 2100 due to higher temperatures' (Midgley et al, 2010:ii), leading to a likely increase in overall aridity in the NDM. This is projected to have a negative impact on Fynbos and Nama Karoo biomes in the NDM. The Succulent Karoo biome is projected to remain stable to 2050.

2. *Sensitivity*

    - *Access to Services:* Taking into account road infrastructure, health care, education, electricity, water, and sanitation, we drew on Du Plessis (2010) and Chidley et al (2011) and demonstrated that service delivery in the NDM suffers from large geographic distances between settlements and budgetary constraints. Lack of access to these crucial services leaves communities more sensitive to the impacts of climate change.

    - *Dependence on Natural Resources:* The most widespread of the District's economic activities that may be affected by climate change, agriculture and tourism, are based directly on the utilisation of natural resources. This leaves the District's core economic activities sensitive to increasing temperatures and decreasing rainfall that will affect the provision of ecosystem services such as freshwater and grazing. We have not included mining in the analysis here because, although it is a large contributor to the local economy, it is not climate sensitive.

- *Perception of threat:* This indicator refers to the extent to which people have access to relevant information about the impacts of climate change and understand that future changes in climate may affect their livelihoods. A lack of such understanding would indicate sensitivity. Workshop and seminar outcomes suggest that local government and communities are able to adequately identify the primary vulnerable groups and threatened livelihoods, and are increasingly aware of predicted climate change impacts and the implications of these.

3. *Adaptive Capacity*

- *Livelihoods diversity:* If alternative livelihood options are meager, vulnerability is higher. The two core economic activities in the District are mining and agriculture. The service sector and tourism industry also provide some economic opportunities. Mining is downscaling in the region and the impacts of climate change may limit opportunities for growth, or even reduce productivity, in the agricultural and tourism sectors. Viable alternative livelihoods are extremely limited at the current time.

- *Income:* Incomes are negatively affected by declining productivity and increased operational costs, which has led to declining employment and income levels over time. Poverty threshold levels were used as benchmarks and income vulnerability was a measure of the possible divergence of income levels from this threshold. Annual per capita poverty thresholds are estimated at 70%. Unemployment is as high as 75% in some towns. Income inequality is pervasive and extreme. Low incomes reduce adaptive capacity by reducing access to alternatives and to the resources necessary to assist with effective adaptation.

- *Education:* Most people in the NDM have had access to secondary schooling but very few go on to any kind of tertiary training. Access to education, knowledge, information, and skills training reduce opportunities for effective adaptation by limiting options and alternatives.

For each parameter, a score was allocated to indicate the level of vulnerability. This was allocated on a scale of 1-5. For exposure, 1 indicates low exposure and 5 indicates high exposure. For sensitivity, 1 indicates low sensitivity and 5 indicates high sensitivity. For adaptive capacity, 1 indicates high adaptive capacity and 5 indicates low adaptive capacity. A simple average was then computed to derive a Socio-Economic Vulnerability Index.

TABLE 6: Parameters and indicators used to assess socio-economic vulnerability in the NDM

Parameter	Indicator	Value
Exposure		**3.6**
	Population Density	3
	Water Utilisation	4
	Ecological Vulnerability	3.85
Sensitivity		**3.6**
	Access to Services	3.3
	Dependence on Natural Resources	4.5
	Perception of threat	3
Adaptive Capacity		**4.3**
	Livelihood Diversity	4
	Income	5
	Education	4
Vulnerability Index		**3.8**

RECOMMENDATIONS

- Place climate change within the broader developmental context. An effective way to address the impacts of climate change would be to integrate adaptation measures into sustainable development strategies, thereby reducing the pressure on natural resources, improving environmental risk management, and increasing the wellbeing of the poor.

Adaptation for human development

The Heiveld Co-operative in Nieuwoudtville is a good example of successfully locating climate change adaptation within the development context. In this example, a resource-poor community in the Northern Cape of South Africa has established and grown a solid, member-owned, for-profit company. The Heiveld Co-operative is grounded in sustainable management of rooibos plants, it has organic and Fairtrade certifications and the capacity to process 100 tonnes of tea per season. This tea realizes premium prices on the local and international market supporting local economic diversification. Through a process of participatory action research, between farmers, academics, NGOs and practitioners, the farmers continuously work to develop and adapt sustainable practices and strategies, in order to deal with the uncertainties of future climate and the fluctuating business environment. The farmers are also involved in daily climate monitoring which informs their short and long term farming strategies.

- Acknowledge that Namaqualand's biodiversity provides an important and increasingly widely recognised basis for economic growth and development, providing rangelands that support both commercial and subsistence farming, supporting horticulture, forming the basis of agricultural industries based on indigenous species; tourism; parts of the local film industry; commercial and non-commercial medicinal applications of indigenous resources; and the provision of ecosystem services such as water.
    - Implement habitat protection and improved land management
    - Encourage the participatory development of lower impact well managed agricultural activities
    - Restore and maintain ecosystem services, particularly those relating to potable water, fodder for grazing animals, and the prevention of soil erosion.
- Demonstrate successes in the development of alternative nature-based livelihoods strategies to build confidence in their viability. Provide funding for and training in these new skills where possible.
- Build on existing and encourage new collaborations with partners in government, civil society, and research institutions.
- Recognise that 'the ability and capacity to adapt makes a significant difference to the level of vulnerability a person or community experiences. Community capacity building will have to be stepped up and residents who are not part of the existing community-based organisations or NGOs should be particularly targeted' (DSD, 2009:82). Since the poor are the most vulnerable to climate change,

Livelihoods diversification

Community Markets for Conservation (COMACO) in Zambia uses a business approach to address ecosystem protection and poverty among small-scale rural farmers. The non-profit company creates economic incentives for improved land management and practices and resistance to poaching, by marketing farmers' organic produce to high end urban consumers. COMACO also supports diversification of livelihoods by training and assisting farmers and previous poachers with starting new nature-based small ventures such as honey farming, animal husbandry and fish farming. With regional branches projected to be self-sufficient by 2013, COMACO represents a cost effective approach to creating sustainable livelihoods and food security that is grounded in healthy ecosystems.

poverty and adaptation should be tackled together.

- Invest in the development and implementation of participatory, site specific weather monitoring, disaster preparation, and local natural resource focused adaptation

Effectively reducing socio-economic vulnerability to climate change relies on recognising the vital ties between people's livelihoods and security and their natural environment, and acting to ensure that this is as sustainable as possible. It also rests on reducing those indicators which cause vulnerability generally – poverty, unemployment, lack of sufficient quality education, or a lack of sustainable economic opportunities.

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CHAPTER 4: INSTITUTIONAL VULNERABILITY TO CLIMATE CHANGE IN THE NAMAKWA DISTRICT MUNICIPALITY

By Amanda Bourne

INTRODUCTION

When addressing vulnerability, one must 'take into account the role, strengths, and weaknesses of institutions at the regional and...national level' (Harmeling et al, 2011:4), as well as institutional processes locally.

South Africa is a world leader in legislation in many sectors, including environmental governance. South Africa is an active participant in the **United Nations Framework Convention on Climate Change (UNFCCC)** and **Convention to Combat Desertification (UNCCD)** processes and played host to the 17th annual Conference of the Parties (COP17) climate negotiations in 2011. True to form, the South African government has been a committed member of the **Convention on Biological Diversity (CBD)** since 1995, working internationally towards the conservation of biological diversity, the sustainable use of the components of biological diversity, and the fair and equitable sharing of benefits arising out of the utilisation of genetic resources. National government has submitted a **National Biodiversity Strategy Action Plan (NBSAP)** and a **Fourth National Report** under the convention. Furthermore, South Africa, as a member of the United Nations, has committed to the achieving the **Millennium Development Goals** by 2015. Goal 7 is to ensure environmental sustainability.

Regionally, South Africa is a member of the **Southern African Development Community (SADC).** The first binding agreement between SADC member states, drafted in 1995 and revised in 2000, was the **Protocol on Shared Water Course Systems**, clearly illustrating the important role of water in the region. The Protocol is the key legal instrument for promoting regional cooperation around shared water resources. SADC also launched a **Climate Change Adaptation Strategy for the Water Sector** at COP17. Water is the natural resource projected to be most affected by climate change in the region.

Nationally, South Africa has developed extremely thorough, coherent and powerful environmental legislation (Muir and Marais, 2009). The country's internationally celebrated **Constitution** contains a **Bill of Rights** (Chapter 2 of the Constitution) which states that:

everyone has a right (a) to an environment that is not harmful to health or well-being; and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that

i. *Prevent pollution and ecological degradation;*

ii. *Promote conservation;*

iii. *Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*

Section 24 in the Constitution provides the 'enabling environment' for some inspired pieces of environmental legislation. Unfortunately, enforcement of this legislation, and its uptake at the local level, has been severely weakened by a lack of resources and capacity. South Africa faces many and varied stressors and vulnerabilities even before the added complications of environmental change in general, and climate change in particular, are considered. As Boquiren et al (2010: 75) have noted, many problems of vulnerability around the worlds are 'institutional in nature and can be resolved even without having to factor in climate change'. These include competing directions in development and priorities in the use of public funds, the sanctioned destruction of natural resources through activities such as mining and over-utilisation, corruption, a lack of political will, and conflicting laws or their weak enforcement. In South Africa, institutional challenges are characterised by a widespread crisis in service delivery characterised by spatial differentiation in development, impending water and energy supply crises, the prevalence of HIV/AIDS and TB, as well as land use change and transformation (DST, 2011: 1).

'Environmental governance in South Africa is complex, spanning many sectors as well as national, provincial, and local spheres of government' (Reyers et al, 2009:40). South Africa has a relatively high per capita emissions level, ranked as the 16th largest emitter in the world and producing some 1.5% of the total global anthropogenic emissions. In this section of the assessment, we provide an overview of national and provincial environmental management legislation to provide the context. You will see that these frameworks and programmes are coherent and strong, indicating strong adaptive capacity in the institutions. It is, however, at the local and municipal scale that land and natural resource use decisions are made and implemented' (Reyers et al, 2009: 40-41). Although the structures are in place and there is broad recognition of South Africa's dependence on natural resources, local level implementation is very limited. Locally, due to South Africa's socio-political climate, priorities are on service delivery and job creation. We have focused much of the enabling environment review at this level, including policy, processes, institutions, capacity, and budget allocations.

LEGAL FRAMEWORKS

NATIONAL POLICY

The following section lists South Africa's legal frameworks relating to environmental management.

Conservation of Agricultural Resources Act (CARA) 1983. Legislation about the utilisation of the natural agricultural resources, the document promote the conservation of soil and water sources and contains the only currently active legislation on weeds and invasive plants in South Africa.

Environmental Conservation Act (ECA). 1989. Makes provision for generally applicable environmental principles around the protection of the environment, the sustainable utilisation of natural resources, and sustainable environmentally aware human development.

Mountain Catchment Areas Act (MCAA). 1970. Provides for the conservation, use, management, and control of mountain catchment areas, with a particular focus on water quality.

National Environmental Management Act (NEMA) 1998. Forms the framework within which the rest of the nation's environmental management acts were developed and is based on the principles laid out in Section 24 of the Constitution, reproduced above (Laidler, 2011).

National Environmental Management: Air Quality Act (NEMAQA). 2004. Recognises the impact of GHGs and deals with air quality and air pollution.

National Environmental Management: Biodiversity Act (NEMBA). 2004. Provides for the management and conservation of South Africa's biodiversity. It is of great importance as 'it is intended to protect biodiversity per se' (Muir and Marais, 2009:7), where is occurs, and not restricted to protected areas.

National Environmental Management: Integrated Coastal Management Act (NEMCMA). 2008. 'Allows for the designation of a coastal protection zone' (Muir and Marais, 2009:10).

National Environmental Management: Protected Areas Act (NEMPAA). 2004. Provides for the declaration and management of national parks and for the protection of ecologically viable areas that are representative of South Africa's natural biodiversity, its landscapes and seascapes.

National Environmental Management: Waste Act. 2008. Regulates for the environmentally sound management of waste.

National Heritage Resources Act. 1999. Introduced an interactive and integrated system to manage and preserve national heritage resources.

National Minerals and Petroleum Resources Development Act. 2002. Provides for matters connected with prospecting, mining and exploration rights for the mining sector and states South Africa's obligation to protect the environment and ensure the sustainable use of non-renewable resources.

National Water Act. 1998. Requires a catchment management strategy to consider resource quality and the ecological reserve, promotes integrated, adaptive water resource management, and contains a suite of, mostly unused, tools for the protection of watershed services (Botha, 2011).

Environmental Impacts Assessments are required by law for all new developments.

South African National Communication, 1997 and **Second National Communication, 2010.** Involved extensive, multi-disciplinary research into the expected impacts of climate change as part of South Africa's obligations as a member of the UNFCCC.

PROVINCIAL POLICY

Generally speaking provincial environmental and climate change policy falls between national and local policy. In terms of the Constitution, the responsibility for the environment is shared with the national government while responsibility for planning is shared with local government. Provinces can form policies by utilising existing national legislation or drafting their own legislation.

LOCAL POLICY

The local municipalities have 'large spatial jurisdictions, demarcated based on the size of the populations' (DSD, 2009:60). Physical planning and implementation is the function of local government and is primarily undertaken through the provincial Growth and Development Strategies and the municipal Integrated Development Plan (IDP). Most IDPs focus in the Northern Cape focus on traditional service delivery concerns (education, housing, and services) and are largely weak or silent on sustainable resource use and biodiversity conservation issues. Other important planning tools are environmental management frameworks.

DEVELOPMENT AND RESOURCE MANAGEMENT PLANS

NATIONAL

National Spatial Development Perspective (NSDP). 2003. Provides an overview of the South African spatial economy and the impact of this on national government commitments to social reconstruction, sustainable economic growth, and social and environmental justice. The document guides the allocation of limited resources to infrastructure investment and development spending.

National Framework for Sustainable Development in South Africa (NFSD). 2008. Lays out South Africa's vision for sustainable development and indicates strategies and targets for South Africa's development path. Resource use efficiency and intergenerational equity are the core principles. The document recognises the value of and threat to ecosystem services embedded in South Africa's current economic growth and development trajectory. The framework explicitly recognises the value of ecosystem services for the poor who are most directly reliant on them and clearly states the need not to degrade such ecosystems to the point where the services are lost.

National Climate Change Response Strategy (NCCRS). 2004. The strategy is designed to support national policies relating to waste management, pollution, energy, agriculture, and water. It is intended to address South Africa's particular climate change priorities and is firmly rooted in achieving national sustainable development objectives (NCCRS, 2004:iii). It is recognised in the document that climate change will likely be irreversible and the strategy therefore highlights the need for adaptation.

National Green Economy Plan. 2011. South Africa is in the process of finalising a Green Economy Plan. The plan will focus on opportunities for job creation, service delivery, and poverty alleviation in environment-related sectors such as renewable energy and energy efficiency, water and waste management, and public transport.

National Protected Areas Expansion Strategy (NPAES). 2008. The strategy outlines South Africa's priorities for expanding the protected area network to achieve spatially efficient and cost-effective ecological sustainability and increased resilience to climate change. The strategy provides a set of targets and spatial priorities that enables coordination between many role players involved in conservation and human development. NPAES priority areas in Namaqualand (Kamiesberg Bushmanland Augrabies; Richtersveld; and Namaqua) represent the largest remaining natural areas in the country for expanding the protected area network. They are also SKEP and CSA priority areas and fall into the Global Biodiversity Hotspot – Succulent Karoo.

National Expanded Public Works Programme. Several large scale, government funded programmes, known collectively as the 'Working fors', aimed maintaining, rehabilitating, or restoring ecosystems and ecosystem services while also creating large numbers of jobs for people in marginalised communities. The various programmes include Working for Water, Working for Wetlands, Working for Land, Working on Wildlife, Working on Fire, and Working for Energy. All address critical priorities around sustainable development. Working for Water, for example, focuses on the removal of invasive alien plant species in riparian zones to ensure water security. In Namaqualand, Working for Wetlands is very active in the Kamiesberg and Working for Water operates extensively along the Orange River. These programmes reduce South Africa's environmental and social vulnerability to climate change by implementing large scale ecosystems-based adaptation activities.

PROVINCIAL

Provincial Growth and Development Strategy 2004-2014. The document lists the province's development vision, objectives, and targets. The focus is on reducing poverty and promoting economic growth in the province, with a focus on the extractive sectors – agriculture, fishing and mariculture, mining – as well as manufacturing, infrastructure development, and tourism.

MUNICIPAL

Namaqualand Biodiversity Sector Plan. 2008. The Namakwa District is the only District with a Biodiversity Sector Plan. The document ensures the accessibility and appropriateness of biodiversity information for local municipalities in the District to use in their land use and development planning. This information has been incorporated into the environmental planning sections of each local Spatial Development Framework. Irreplaceable Critical Biodiversity Areas (CBAs) and priority areas for the maintenance of ecosystem services are identified and mapped in the document. These are produced at a fine scale for each of the local municipalities.

Namakwa Bioregional Plan. 2010. Based on the Biodiversity Sector Plan above, the Bioregional Plan also focuses on making biodiversity information useful and accessible as a spatial planning tool. This document looks at CBAs and ecosystem priority areas at the scale of the District as a whole.

Namakwa District Integrated Development Plan (IDP). 2006-2011. IDPs are the long-term growth and development strategies providing direction for social, economic, infrastructural, and environmental activities. IDPs are informed by national and provincial Spatial Development Perspectives and Sustainable Development Frameworks and subject to an annual implementation plan. Namakwa District's IDP focuses on poverty alleviation and service delivery but also includes reference to the need to ensure clean water for all and a target aligned with the NPAES to 'conserve and protect 6.5% of our valuable biodiversity by 2014' (Namakwa DM IDP, 2006:8). This is aligned with the Northern Cape's goals and the local municipality IDPs align with this.

Namakwa District Environmental Management Framework and Strategic Environmental Management Plan. 2011. High level plan for sustainable development in the District. The spatial section of the study provides a series of environmental management zones designed to guide appropriate development in sensitive areas. The focus is to restrict development in the most sensitive areas and to facilitate development in the least sensitive areas.

The above plans are well-researched, quality documents. Despite several solid plans and strategies at the District municipal level, however, implementation is severely limited by insufficient staff capacity and minimal budget allocations.

TOWN AND COMMUNITY-LEVEL GOVERNANCE

There are serious capacity limitations in service delivery at the local level, particularly outside of South Africa's major cities and towns, and this is recognised by the South Africa government. At the town and community level, the majority of development activities are governed by a variety of formal governmental and non-governmental community development committees and associations, with some support from international and national NGOs and informal institutions. The majority of poorer people remain unable to access the full potential of existing government programmes. Many of the local level structures suffer from a lack of capacity, are severely under-resourced, and have very little decision-making power.

Ward Committees: Ward Committees are made up of elected residents drawn from a variety of interest groups relevant to the municipality's key performance areas. Specific duties may be delegated to the ward committees by the municipality, but their role in the community is usually quite general and vague and focuses on communicating decisions made by government.

Community Development Initiatives: Many government departments have community development initiatives. These are quite often sectoral, e.g. focused on HIV/AIDS, early childhood development, fishing and mariculture. South Africa also has a network of **Community Development Workers** who live in the local communities and are responsible for linking people with government programmes and ensuring that the quality of service delivery is improved. They are often grossly under-capacitated.

Advice Offices: Most towns have one of these multi-purpose resource centres. They are usually donor-funded and loosely coordinated by the **Northern Cape Coalition of Community Development Associations (NC COCDA).** Residents approach these offices for a wide range of general assistance, e.g. accessing social grants, paralegal services, help with identity documents and licences, general information.

Non-governmental Organisations (NGOs): A number of NGOs, including small-scale local organisations and associations and larger national and international bodies, work at the local level, mostly in a variety of social development capacities. The conservation sector in Namaqualand is very small.

Political Party Offices: Political parties also occasionally serve as resource centres in some towns. The main political parties in Namaqualand are the African National Congress, the current ruling party, and the Democratic Alliance, the official opposition party.

Commonage Committees: Tasked with preparing and implementing commonage management plans, these committees are the link between the municipality and the communal farmers.

Churches: Churches play a vital and vibrant role in most Namaqualand communities. The dominant faith is Christianity and the largest churches are Roman Catholic, Dutch Reform, and Methodist.

Youth Organisations: Some towns have active and vocal youth organisations that have a strong interest in community development

Police Forums: Some towns have active and vocal police forums that have a strong interest in community development

There are also other informal institutions, local traditions, historical practices, and norms that play a significant role in land management and livelihoods in the District, particularly on the large areas of communal land. Farmers have their own formal and informal agreements guiding land use, grazing, and access to water. Many communal farmers allocated sowing plots in wetlands and drainage lands to particular farmers while using the larger rangelands around these as common property. This means there are opportunities to productively engage individuals around management of the wetlands, but that there a frequent conflicts over access to grazing in the rangelands and much less clear management arrangements.

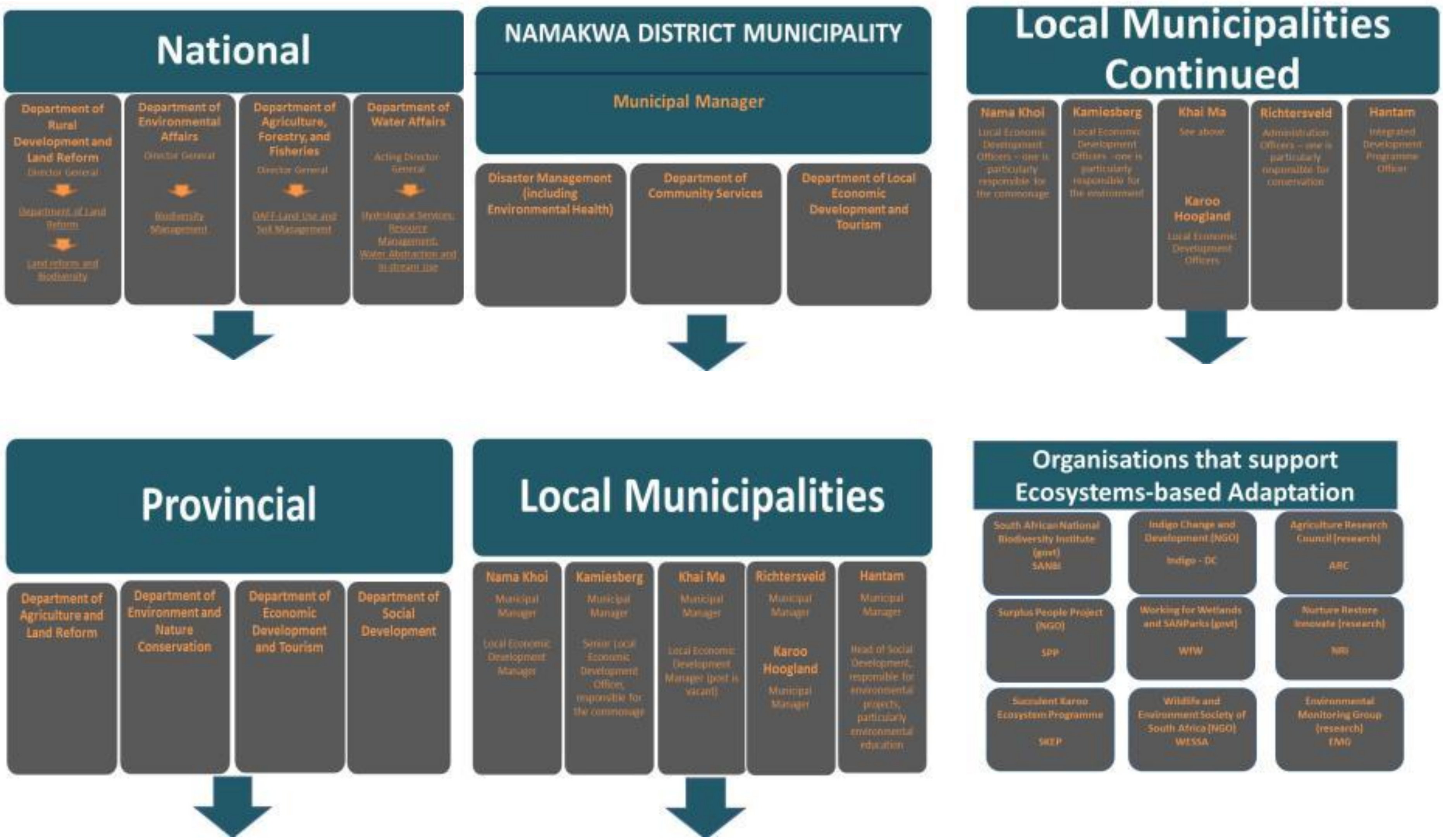

FIGURE 56: INSTITUTIONAL ORGANOGRAM FOR THE NDM

BUDGET ALLOCATIONS FOR ECOSYSTEM-BASED ADAPTATION

This section of the chapter on institutions reviews the current budget allocations in the District and Local municipalities to EbA related activities. For the purposes of this analysis, we have defined these activities as those which directly address nature conservation, ecosystem restoration, green economic development, and ecosystems-based adaptation to climate change. As will be demonstrated here, very little district and local budget is allocated to EbA activities at the present time. Those activities that do take place generally occur within the framework of national Natural Resource or Protected Areas Management Programmes. For example, South African National Parks has four large formal reserves in the District (/Ai/Ais Richtersveld Transfrontier Park, Augrabies Falls National Park, Namaqua National Park, and Tankwa Karoo National Park) totaling 515, 438ha (3.8% of the total land in the District); Working for Wetlands spent R 1,767, 000.00 in 2011 on restoring priority wetlands in the Kamiesberg area; and the SANBI's Early Detection and Rapid Response of Invasive Alien Plants task team spent R300,000 on alien plant control in the Northern Cape in 2011.

Even then, the Northern Cape is the largest province in the country, but has the lowest population numbers and population densities. As Corcoran et al (2009: 8) have shown, this has

'implications for the departmental budgets, as Treasury allocates budgets according to population numbers. This has resulted in a significantly depleted conservation agency for the province, with many posts unfilled (only 45% of the posts in the Conservation Directorate were filled in 2008). This has left protected areas without sufficient staff and operational budgets, with resulting implications for the integrity of these protected areas. In addition, the conservation extension services have been non-existent'

NORTHERN CAPE PROVINCIAL GOVERNMENT

Provincial, District and Local Municipalities in South Africa are responsible for raising their own funds for service delivery to their constituents, although national government does make conditional grants for particular projects. The Northern Cape obtains much of its revenue from rates on services rendered as well as gambling taxes and liquor licences. 75% of the provincial budget is allocated to service delivery, with large chunks going to health and education. The department does not formally allocate any funds to managing natural disasters, biological, land, and sub-soil assets, or for ecological infrastructure or restoration. They do, however, routinely spend funds on some of these line items. These funds then have to be reallocated from other budgets or take the form of a conditional grant from national government. Table 7 below shows the funds that had to be spent on EbA related activities. The R45, 000,000.00 spent in FY2007/08 was for fodder that had to be trucked in to farmers hit by a drought.

TABLE 7: NORTHERN CAPE PROVINCE EMERGENCY FUNDS FOR ECOLOGICAL INFRASTRUCTURE

	Agricultural Disaster Management	Biological Assets	Land and Sub-soil Assets	
FY				
2007/08	R 45,000,000.00	R 3,502,000.00		
2008/09	R 6,219,000.00	R 1,079,000.00	R 486,000.00	
2009/10	R 5,134,000.00	R 1,076.00	R 912,000.00	
Sub-total	R 56,353,000.00	R 4,582,076.00	R 1,398,000.00	
Total				R 62,333,076.00

The Department of Environment and Nature Conservation (DENC) receives approximately 1% of the Provincial budget every year as an allocation. This is the department's only source of income, with which they manage 6 provincial nature reserves and fulfill several other conservation planning and environmental education functions. The allocation of R91, 963,000.00 for 2010/11 represents the only provincial funds formally allocated to the environment. Out of this meagre budget, the department funds salaries for 216 staff. This is a very low number of staff, considering the size of the province and number of important conservation areas and activities within it, and translates into very limited capacity for implementation in the department. While the reserves are generally well managed, environmental education, biodiversity stewardship, and extension services suffer. As Table 8 demonstrates, much of the provincial environment budget is used for administration and planning, and for biodiversity management in the reserves, with little left for climate change adaptation, extension, and ecosystem service restoration activities.

TABLE 8: BUDGET 2011, DEPARTMENT OF ENVIRONMENT AND NATURE CONSERVATION

Summary of Payments and Estimates: Department of Environment and Nature Conservation							
	Outcomes				Medium term estimates		
R thousand	Audited 2007/08	Audited 2008/09	Audited 2009/10	Estimate 2010/11	2011/12	2012/13	2013/14
Administration	30,241	33,457	42,606	45,295	44,296	46,558	47,580
Environmental Policy, Planning, and Coord.	3,354	5,310	5,848	7,276	8,190	8,450	9,303
Compliance and Enforcement	3,467	2,269	3,289	3,751	4,173	4,372	5,005
Environmental Quality Management	6,495	7,075	7,745	9,056	10,731	11,506	12,234
Biodiversity Management	14,581	17,649	16,662	21,062	20,647	21,577	22,759
Environmental Empowerment Services	2,800	3,439	5,791	5,523	6,687	7,146	7,953
Total	60,938	69,199	81,941	91,963	94,724	99,609	104,834

TABLE 9: NAMAKWA DISTRICT MUNICIPALITY BUDGET 2011/2012 SHEET A2 – FINANCIAL PERFORMANCE STANDARD CLASSIFICATION

Standard Classification Description	Ref	2007/8	2008/9	2009/10	Current Year 2010/11	2011/12 Medium Term Revenue & Expenditure Framework		
R thousand	1	Audited Outcome	Audited Outcome	Audited Outcome	Full Year Forecast	Budget Year 2011/12	Budget Year +1 2012/13	Budget Year +2 2013/14
Revenue - Standard								
Economic and environmental services		**34,279**	**38,079**	**22,451**	**55,358**	**25,334**	**13,319**	**13,996**
Planning and development		10,562	10,555	1,078	24,793	22,106	12,257	12,876
Road transport		23,717	27,524	21,373	30,565	3,228	1,061	1,120
Environmental protection		–	–	–	–	–	–	–
Total Revenue - Standard	2	**66,119**	**73,094**	**60,987**	**105,705**	**71,983**	**51,934**	**54,164**
Expenditure - Standard	-							
Economic and environmental services		**36,026**	**40,850**	**27,057**	**58,128**	**28,358**	**16,327**	**17,170**
Planning and development		12,308	13,326	9,416	28,963	25,130	15,265	16,050
Road transport		23,717	27,524	17,641	29,165	3,228	1,061	1,120
Environmental protection		–	–	–	–	–	–	–
Other	4	**868**	**1,025**	**1,236**	**1,830**	**1,719**	**1,811**	**1,910**
Total Expenditure - Standard	3	**58,355**	**69,786**	**55,897**	**109,400**	**72,087**	**50,754**	**53,411**

References

1. Government Finance Statistics Functions and Sub-functions are standardised to assist the compilation of national and international accounts for comparison purposes

2. Total Revenue by standard classification must reconcile to Total Operating Revenue shown in Budgeted Financial Performance (revenue and expenditure)

3. Total Expenditure by Standard Classification must reconcile to Total Operating Expenditure shown in Budgeted Financial Performance (revenue and expenditure)

4. All amounts must be classified under a standard classification (modified GFS). The GFS function 'Other' is only for Abattoirs, Air Transport, Markets and Tourism - and if used must be supported by footnotes. Nothing else may be placed under 'Other'. Assign associate share to relevant classification

TABLE 10: RICHTERSVELD MUNICIPALITY BUDGET EXTRACT 2011

Budget Documents for the Year 2009/2010 - Richtersveld Local Municipality						
	Preceding	Current Year		Medium Revenue and Expenditure Framework		
Schedule 2 (a)	Year	Current Year		Budget Year	Budget Year +1	Budget Year +2
	2007/2008	2008/ 2009		2009/ 2010	2010/ 2011	2011/ 2012
	Approved	Adjusted	Full Year	Budget	Budget	Budget
OPERATING EXPENDITURE BY GFS	Budget	Budget	Forecast			
	B	C	D	E	F	G
Operating Expenditure by GFS:						
Executive and Council	4,216,668	3,516,822	2,952,718	3,605,005	3,889,078	4,214,961
Finance and Administration	10,579,238	11,648,317	10,225,600	11,917,816	12,461,131	13,536,268
Planning and Development	271,197	276,697	162,571	280,855	272,095	279,166
Health	149,697	129,697	87,363	134,959	145,756	157,417
Community and Social Services	1,443,628	1,424,835	1,133,873	1,491,403	1,224,218	1,321,152
Housing	22,500	22,500	28,680	23,715	25,613	27,661
Public Safety	1,083,060	1,000,540	925,794	1,079,994	1,141,859	1,234,286
Sports and Recreation	1,841,883	1,820,787	1,672,098	1,941,875	2,078,728	2,249,886
Environmental Protection	0	0	0	0	0	0
Waste management	775,025	758,271	790,259	823,401	863,171	932,226
Waste water management	1,532,586	1,517,565	1,568,319	1,631,341	1,732,387	1,861,158
Road Transport	6,208,410	6,355,119	4,781,846	6,784,783	7,291,258	7,416,302
Water	5,068,349	4,664,533	4,378,898	4,964,943	5,247,460	5,667,251
Electricity	5,461,539	5,518,142	4,969,198	6,748,934	7,537,998	8,133,312
Other	0	0	0	0	0	0
Total operating expenditure by GFS	38,653,780	38,653,825	33,677,217	41,429,024	43,910,752	47,031,046

TABLE 11: NAMA KHOI MUNICIPALITY BUDGET EXTRACT 2011

Standard Classification Description	Ref	2007/8	2008/9	2009/10	Current Year 2010/11	2011/12 Medium Term Revenue & Expenditure Framework		
R thousand	1	Audited Outcome	Audited Outcome	Audited Outcome	Adjusted Budget	Budget Year 2011/12	Budget Year +1 2012/13	Budget Year +2 2013/14
Expenditure - Standard	-							
Economic and environmental services		**8,355**	**11,485**	**10,425**	**10,051**	**12,987**	–	–
Planning and development		607	608	692	821	1,594	–	–
Road transport		7,728	10,678	9,469	9,230	11,393	–	–
Environmental protection		-	199	264	-	-	-	-

NAMAKWA DISTRICT MUNICIPALITY

Environmental work in the Namakwa District Municipality is clustered together with economic development under the budget line: "Economic and Environmental Services". While it is at first encouraging to see the coupling of economic and environmental services in a municipal budget, seeming to suggest that the two are related and even inter-dependent, a summary of the revenue and expenditure generated with respect to environmental conservation in recent years and a forecast up to 2014 given in Table 9 above shows that budget allocated to environmental protection was, in fact, zero.

From the table above, it is clear that there has been no budget allocated to environmental protection since 2008 and this trend is projected to continue until 2014. As such, there is no revenue being generated from environmental protection included in the budget. Likewise, no expenditure has been budgeted for environmental protection. All of the revenue and expenditure under economic and environmental services is taken up by infrastructure projects, with the bulk of the expenditure going to road transport. To note, however, is that the percentage of revenue and expenditure for infrastructure is expected to go down between 2012 and 2014. This has been attributed to National Treasury discontinuing two of the grants they are allocating to NDM, namely, the Expanded Public Works Programme Grant and the Infrastructure Grant. The Chief Financial Officer for NDM explained that environmental activities within the district rely on donors, NGOs and provincial government funding. As demonstrated above, provincial funding maintains the protected area network and invests in some environmental education but their allocation, too, is an unsupplemented 1% of the total budget. Specific projects that are implemented in the district municipal area are funded directly from provincial government and are therefore not included in the NDM budget.

Namakwa District's IDP focuses on South Africa's core development concerns – job creation, service delivery, and economic growth. The current IDP does not mention ecosystems or conservation directly and so we cannot count on government funding to support EbA. However, there are opportunities to engage local government around these issues if we can show that EbA contributes to job creation, service delivery, and economic growth. The impacts of climate change are noted as a pressing priority in the District and local government is called upon in the document to find creative and effective solutions to the climate change challenge. The provincial Department of Social Development carried out extensive desktop research on the possible effects and impacts of climate change on human settlements and population development in the Northern Cape, detailing the expected impacts of climate change on the environment, people, and the economy. Ecological resources such as Namaqualand's coastline, its scenic beauty, and the Orange River are recognised in the IDP, providing an opportunity to engage around the proper management of these resources for sustainable utilisation and effective EbA. Finally, Namakwa District prioritises human development solutions that follow the EPWP principle, training and employing local people in productive jobs that contribute to the well-being of society as a whole. CSA is pursuing opportunities to engage with this national job creation programme on the local level and is in discussions with the District on the development of EbA EPWPs. With no money behind the rhetoric, however, the municipality remains vulnerable to the impacts of climate change.

LOCAL MUNICIPALITIES

Each local municipality has its own IDP, linked to the District IDP, and a standardised financial performance budget for previous and future years. Each LM also has a standardised framework for Key Priority Areas (KPA) which lists priority areas, targets, and activities, allocates responsibility, and reviews progress to date. As in the District IDP, most the LMs recognise the climate change challenge and the importance of healthy environments but allocate no resources to addressing these needs. See Table 10 as an example.

The only exception is Nama Khoi municipality, which spent around R200,000.00 a year in 2008/09 and 2009/10 on cemeteries. Budget projections from then on show the standard R0.00 for environmental protection. See Table 11.

INSTITUTIONAL VULNERABILITY

Vulnerability in South Africa in generally recognised as relatively low in comparison to other countries in Southern Africa, and the continent as a whole (SARVA, ; Davies et al, 2010). This is generally understood as a factor of South Africa's strong natural resource based economy and functioning institutions. As shown above, South Africa has strong institutions and powerful legislation, setting the context for judicious natural resource management nationally. South Africa is also generally competent at responding to natural disasters and creating well-researched, multi-stakeholder plans and strategies for natural resource management and adaptation to climate change. There is high level understanding of South Africa's socio-economic dependence on a healthy environment and commitment to the need to adapt to the projected impacts of climate change on the environment. This has resulted in well-developed biodiversity management plans nationally and in the provinces and some districts, including the Namakwa District. South Africa is a world leader in environmental planning and legislation, providing an exceptionally strong broader enabling environment for ecosystem-based adaptation and effective climate change response.

There are many challenges on the ground, however, at the level of local municipalities responsible for the implementation of centrally developed plans and strategies. Preparedness remains limited in South Africa despite the availability of instruments through which planning for climate change can be done. Although South Africa's economy is relatively strong, it experiences 'jobless growth' and there is very high unemployment and poverty all over the country. It is a challenge to deliver services without furthering environmental degradation. Local government in Namaqualand faces the pressing need to respond to and address poverty and unemployment in the district. The district is very large and sparsely populated, with many small rural settlements facing problems with access to basic services. There is extremely limited staff capacity and no funds at the local level for environmental work of any kind. Likewise, while climate change and adaptation are on the agenda for many local politicians and officials, there are no official bodies dedicated to adapting to climate change.

Opportunities exist to engage with local economic development and disaster risk reduction task forces. There are also opportunities to channel national and provincial funds towards local adaptation efforts, particularly through the NPAES and EPW Programmes. Engagement must be strategic and should align with national and local priorities for job creation and service delivery.

Another factor in Namaqualand is its large areas of communal land. Characterised by a lack of individual accountability and user group structures that seldom have the strength to control members, or are themselves dominated by local elites, the commonage has become associated with a poorly managed, contested, and highly vulnerable open access system (Anderson and Pienaar, 2003:3). Commonage makes up close to 40% of the land use in the District.

Institutional vulnerability: Medium (3)

Three indicators were applied to assess institutional vulnerability:

1. *Climate change related programmes and stakeholder participation.* There are 6 local institutions researching or implementing ecosystem-based adaptation in the District. These are Conservation South Africa, the Agricultural Research Council, SANBI, Indigo Development and Change, the Environmental Monitoring Group, and SANParks and Working for Wetlands. All of these institutions participate in local government forums and contribute to decision-making and implementation in the NDM. However, activities are often limited to particular communities and sites.
2. *Enabling legislation to support climate change adaptation*. Nationally, in the Northern Cape Province, and in the District, existing legislature, plans, and strategies, as well as large scale programmes and processes, provide an encouraging enabling environment for effective adaptation to climate change. At the local level, many appropriate institutions, forums, and legislation exist that could take the lead on climate change response. Staff capacity around climate change is limited. Local level resource allocation focuses on traditional service delivery and funding for ecosystem based climate adaptation projects in local government is absent. Although increasingly integrated into local economic development and disaster risk reduction planning, adaptation concerns and EbA remain peripheral. This leads to on the ground challenges for implementing EbA at scale.
3. *Governance and leadership.* The Namakwa District is increasingly taking the lead on climate change planning and response, hosting climate change workshops and training, and integrating EbA into various plans and forums. Local municipalities continue to experience capacity and resource problems, leading to limited implementation of EbA. Widespread poverty and a lack of access to services, education, and employment limits effective community level organisation. Land management challenges on the commonage and inaccessible mining lands also influence the ability of the NDMs' key institutions to implement EbA.

Strong, organised, well-informed, well-prepared, and well-funded local institutions will ensure the most effective possible adaptation response. The context of climate change vulnerability is critical, including multiple local non-climate stressors. Strong community-based institutions and local advocates can ensure that relevant local knowledge is incorporated into EbA practices. Strong institutions refer as much to conditions in the enabling environment as to local leadership and implementers on the ground.

TABLE 12: Parameters and indicators used to assess institutional vulnerability in the NDM.

Indicator	Value
Climate change related programmes and stakeholder participation • Community and stakeholder organisations • Participation in decision making	2
Enabling legislation to support climate change adaptation • Management body • Formal and informal networks supporting climate change adaptation • Management plans and frameworks • Enabling legislation • Resource allocations • Implementation and compliance	3
Governance and leadership • Effective community level leadership and organisation • Community based climate change response • Capacity for implementation • Climate Change leadership in government • Climate change leadership in local institutions	4
Vulnerability Index	3

RECOMMENDATIONS

- Set up a strong adaptation committee in local government that 'can be the driver for a more coherent, effective, and ambitious approach to adaptation' (Harmeling et al, 2011:5). The key functions of this representative government based committee would be to ensure

Integrated Adaptation for Municipalities

eThekwini Municipality has developed a locally rooted climate change adaptation strategy (Roberts, 2008). This is measured against four institutional markers: climate change advocates among local politicians and civil servants; inclusion of climate change as a significant issue in municipal plans; staff and funds allocated to climate change issues; and a serious consideration of climate change issues within local government decision-making. Climate change must be rooted in local realities and focused on the ecological changes and water supply constraints brought about by climate change. eThekwini takes the importance of building local knowledge and capacity about climate change risks and adaptive responses very seriously. Without this, decision makers will continue seeing environmental issues as constraints on development rather than as the essential underpinnings of and contributors to development that they are.

alignment of activities across sectors, champion EbA, receive and disseminate research findings, provide a discussion forum for climate related challenges and ecosystem services, review implementation of EbA, and be the vehicle for the development of the local green economy strategy.

- Seek out opportunities to align EbA priorities with existing related programmes across all levels of government including Provincial, District, and Local, for example disaster risk reduction, agricultural extension, nature conservation, and local economic development.
- Frame EbA approaches in terms relevant to local and national priorities, around job creation and economic growth where possible
- Work closely with partners to avoid duplication and share information as widely as possible.
- Strengthen the capacity of local institutions such as farmer's unions, commonage committees, and community development workers to be confident applying EbA as a workable climate change adaptation solution for them. Aim to include planning for climate change into land management plans in priority areas for adaptation and ecosystem services.

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CHAPTER 5: HOW TO USE THIS REPORT

PRIORITISATION

Two prioritisation tools were developed as part of this vulnerability assessment. The EbA priority areas map was developed to support spatial planning for ecosystem based climate change response in the NDM and to prioritise sites for EbA research and implementation to the maximum benefit of the NDM's communities and biodiversity. The vulnerability index was developed to highlight key indicators and levels of climate vulnerability in the NDM in order to inform priority actions and the allocation of budgets to most effectively reduce vulnerability locally.

SITES FOR IMPLEMENTATION OF ACTIVITIES FOR ECOSYSTEM-BASED ADAPTATION

The EbA priority areas maps is intended to guide land-use planning, environmental impact assessments, authorisations in a number of sectors including mining and renewable energy, and, natural resource management in order to promote sustainable local; economic development. It is a spatial tool prioritising locations in the NDM that are both threatened by the impacts of climate change and are likely to respond well to EbA approaches in terms of delivering ecosystems services that will help the District respond effectively to climate change. It has been developed to further the awareness of the unique biodiversity in the area and the value this biodiversity represents to people as a climate adaptation tool. The tool is compatible with and complementary to existing spatial planning tools in the NDM including Critical Biodiversity Areas maps, the Namakwa Biodiversity Sector Plan, and the NDM Spatial Development Framework.

Figure 57 shows the priority sites for implementation of activities for Ecosystem-based Adaptation to climate change. The map was developed through a combination of layers. The primary input layer represented areas for supporting resilience to climate change that contribute both to climate change adaptation and to biodiversity and ecosystem conservation. This primary layer was developed based on the presence of several current and intrinsic features, such as riparian corridors and buffers, coastal corridors, areas with temperature, rainfall and altitudinal gradients, areas of high diversity, areas of high plant endemism, refuge sites including south-facing slopes and kloofs, and priority large unfragmented areas. Within those areas that support resilience to climate change, priority sites for EbA activities were further identified based on the presence of critical areas for biodiversity and ecological support, commonage areas, proximity to towns, Freshwater Ecosystem Priority Areas and importance for water provision. Therefore, this map identifies sites that contribute to biodiversity and ecosystem conservation that deliver the most direct and immediate value for human communities in the Namakwa District Municipality and will contribute most to effective EbA.

The darker areas are priority areas and should be tackled first where budgets or capacity are limited in order to ensure the maximum EbA benefit for the NDM.

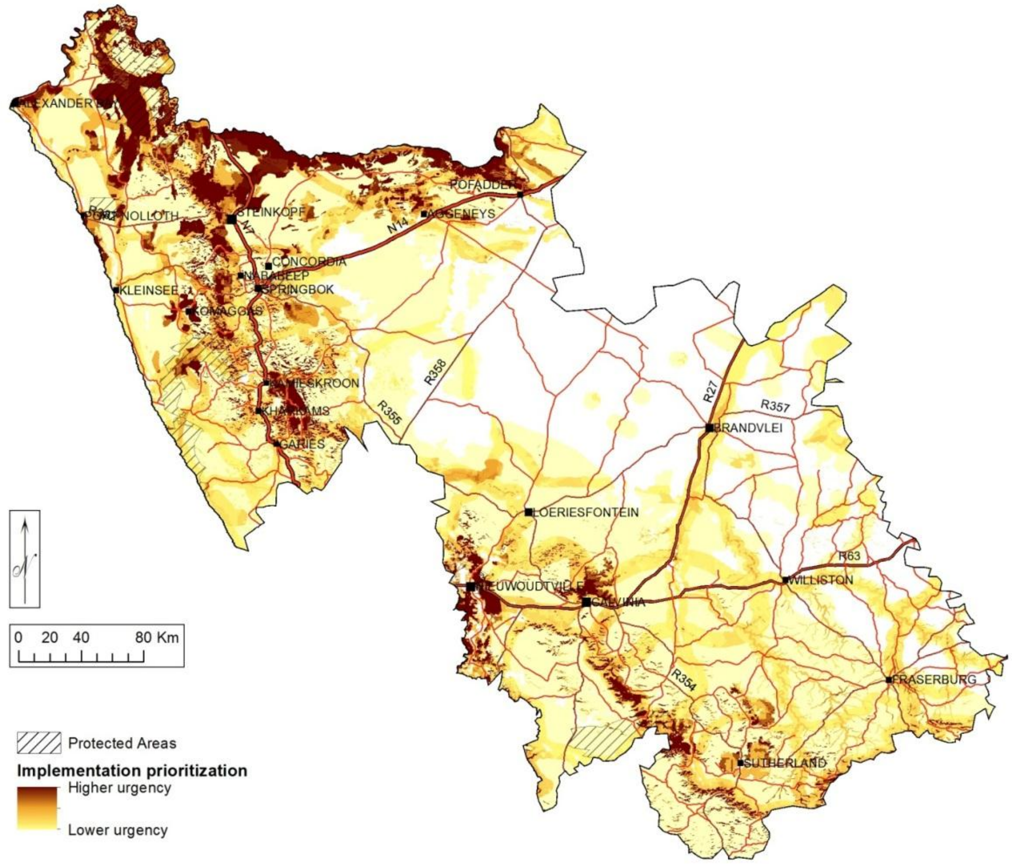

Figure 57: Final prioritisation map for Ecosystem-based Adaptation Implementation in the Namakwa District

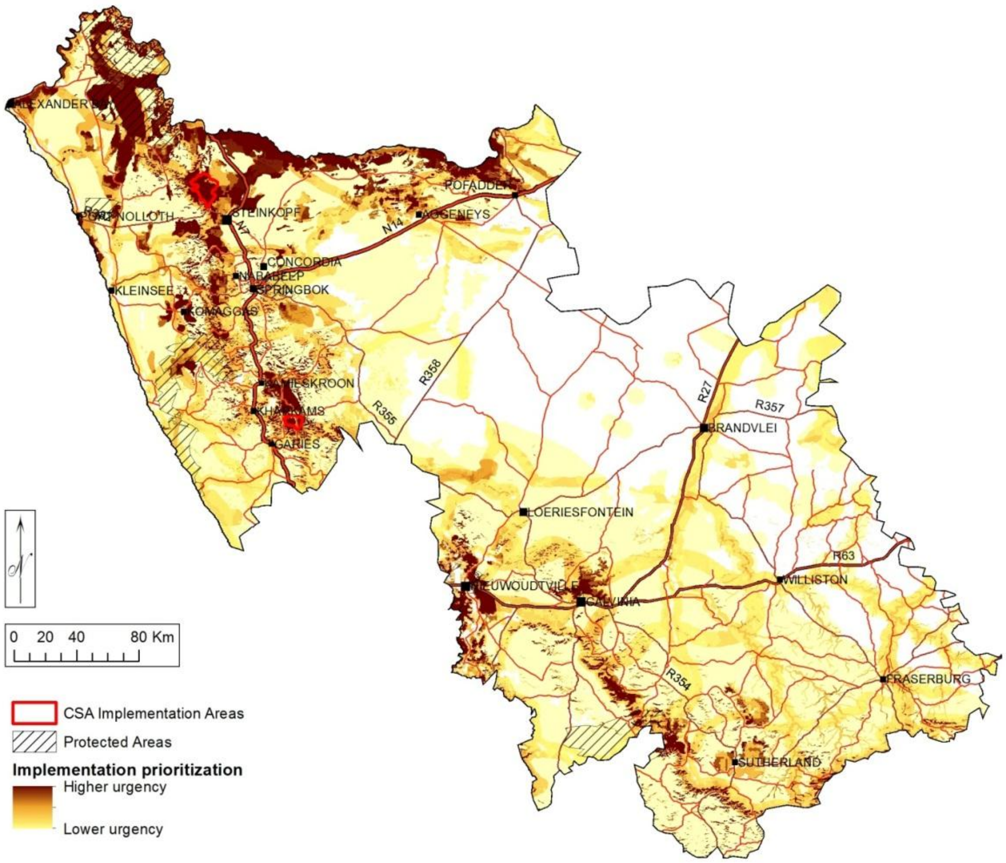

Figure 58: Final prioritisation map showing Conservation South Africa's EbA priority areas

Figure 58 is an example of how Conservation South Africa has used the methodology developed here to prioritise pilot sites for EbA research and implementation action in their Namakwa field office.

This is the first time this methodology has been applied in South Africa and it was developed exclusively for the NDM climate change vulnerability assessment. This methodology can now be replicated and applied in other Districts in South Africa or to facilitate provincial prioritisation.

VULNERABILITY INDEX

In assessing Ecological and Socio-Economic Vulnerability, three parameters were applied, with several indicators informing each parameter. The parameters in each category are Exposure, Sensitivity, and Adaptive Capacity, and were based on current socio economic and ecological data and the climate change modelling outcomes presented in Chapter 2 of this report. **For exposure, a ranking of 1 indicates low exposure and 5 indicates high exposure. For sensitivity, 1**

indicates low sensitivity and 5 indicates high sensitivity. For adaptive capacity, 1 indicates high adaptive capacity and 5 indicates low adaptive capacity.

To assess institutional vulnerability, three indicators were applied, without considering the three above parameters**.** Strictly defined exposure, sensitivity, and adaptive capacity parameters were less relevant to a climate appropriate understanding of local institutional vulnerability than was an assessment of the current enabling environment and institutional context. **Each indicator of institutional vulnerability was ranked on a scale of 1-5, whereas 1 indicates high institutional support and 5 indicates low institutional support.**

For each category, ecological, socio-economic and institutional, an average vulnerability score was derived. A simple average was then computed to derive an Overall Vulnerability Index for the District, representing the average of the socio-economic, ecological, and institutional vulnerability scores. The NDM has an overall vulnerability score of 3.5. This translates as medium-high overall vulnerability.

The indicators under each category can be used for prioritising action and budget allocation for reduced vulnerability to climate change in the District. Achievements can be measured against each of these indicators over time

The summary index below provides a general indication of vulnerabilities for the Namakwa District based on the parameters selected.

TABLE 13: SUMMARY VULNERABILITY INDEX FOR THE NAMAKWA DISTRICT MUNICIPALITY

Overall Climate Change Vulnerability – 3.5 (medium-high)

Ecological Vulnerability	3.85
Socio-economic Vulnerability	3.8
Institutional Vulnerability	3
Overall Vulnerability Index	**3.5**

Ideally climate change vulnerability in the NDM will be reduced over time. While it will be challenging to reduce ecological vulnerability given that this is based on an assessment of external climate change threats and the inherent sensitivities and adaptive capacities of particular species, ecosystems, and biomes, ecological vulnerability can be reduced by ensuring that natural areas persist, providing refuge habitats, critical ecosystem services and functions, and corridors along which species can move in order to adapt to changing climate niches locally.

A central recommendation of this report is to focus on reducing socio-economic and institutional vulnerabilities as the primary method for building local resilience to climate change, as local livelihoods are inextricably linked to and reliant on functioning natural systems, we recommend an ecosystem services and ecosystem-based adaptation approach in addressing core socio-economic vulnerabilities. Effort must be made to build local institutional capacity to respond effectively to climate change. Critically, this institutional capacity must be supported with appropriate budget allocations to achieve climate adaptation goals and implement EbA activities at the necessary scale.

An analysis of the summary index suggests policy-making, budget allocations, and project development will be most usefully focused improving environmental adaptive capacity, building institutional capacity with attendant necessary budgets to fulfill their mandates, addressing water availability and utilisation concerns as a matter of urgency, diversifying livelihoods, and reducing poverty.

Currently, the Overall Vulnerability Index for the NDM is 3.5, where 1 indicates low vulnerability and 5 indicates high vulnerability. A score of 3.5 indicates medium-high vulnerability. A reduced Overall Vulnerability Index of 2.5 (medium) would represent a considerable improvement in local climate resilience. Progress towards an Overall Vulnerability Index of 2.5 for the NDM can be measured against each of the indicators listed in the Index above. This assessment should be repeated and updated every 5 years to assess progress made and to facilitate adaptive management of the climate change challenge. Likewise, climate change adaptation projects should allocate part of their budgets to monitoring and evaluating interventions to measure their effectiveness in decreasing climate change vulnerability.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

Based on a review and consolidation of existing information and new expert inputs on the current socio-economic, institutional, and ecological status of the Namakwa District, the Vulnerability Assessment provides a profile of climate hazards for the region and identifies critical areas for EbA. These areas must be conserved and sustainably used to provide environmental stability and long-term water provision for the region. A priority areas map provide the District Municipality with an important spatial planning tool that, when used in the development of Municipal Integrated Development Plans, Spatial Development Frameworks and Disaster Risk Management Strategies, can reduce the vulnerability of people and ecosystems to the impacts of climate change.

The stakeholder engagement process generated greater awareness of the climate vulnerability profile of the NDM and resulted in agreement on the value of EbA for human development, key biodiversity priority areas, most vulnerable groups, and critical ecosystem services to support building resilience at the landscape level. Opportunities for EbA interventions, such as key partnerships, comprehensive legislation and land management frameworks, and communication networks, were identified. Participants also identified core challenges facing EbA implementation, including capacity and budget challenges and a lack of awareness around climate change and its impacts. There is currently extremely limited staff capacity and no funds allocated at the local level for environmental works. While climate change and adaptation are on the agenda for many local politicians and officials, there are no official bodies dedicated to adapting to climate change.

However, there is now agreement on the priority sites for EbA within the Namakwa District. This allows focus for the allocation of resources and effort. The development of a response strategy, and how it can be adequately funded, is a key next step that will be facilitated by the end of 2012. This assessment provides the framework on which a climate change adaptation strategy and long-term monitoring can be based as part of improving the ecological conditions, socio-economic conditions, and institutional capacity that are the foundation for resilience to changes in climate.

Global best practice indicates that partnerships between civil society and government are essential for avoiding disasters from climate change. In the Namakwa District, stakeholders have agreed that science, political will, public participation and adequate financing are essential components of making sure the District can proactively reduce its vulnerability and ensure sustainable development. The NDM is establishing itself as a model for other Districts. Partners must urgently integrate the information from this report into current projects and future planning. Interactions with experts and local communities can be expanded to devise innovative approaches that will secure the future of Namakwa. Local level implementation challenges are recognised.

While this report is focused particularly on adapting to projected changes in climate locally, it is essential to be familiar the causes of climate change and with the worst case scenario for climate change for the region – presented here on page 27 - and to lobby strongly, now, for extensive mitigation towards a safe global temperature goal.

RECOMMENDATIONS

ECOLOGICAL

- Use the EbA priority areas map presented in this report to guide and inform climate change adaptation planning in the NDM.
- Manage wetlands and river corridors: restore wetlands and river corridors for biological diversity and the provision of potable water, fodder for grazing animals, and the prevention of soil erosion. Design and implement management processes that limit ploughing in the wetland and promote sustainable utilisation of wetland resources. Design and implement management processes that promote the appropriate and sustainable utilisation of river corridor resources
- Protect groundwater resources and restore wetlands and terrestrial vegetation cover to secure groundwater recharge
- Conserve water catchments and other critical biodiversity areas for key ecosystems services delivery and to build resilience to climate change, create protected areas that facilitate biodiversity corridors, and design and implement land management plans focused on preventing land degradation through over-grazing or other unsustainable land uses
- Monitor species and ecosystem responses to a changing climate. This could be done by monitoring species responses to extreme events, such as long periods without rain, as a proxy for climate change. This will give a more practical sense of how species may respond to climate change. A biome level approach has been used in this report. Climate change responses of species and ecosystems were not addressed here, but should be taken into account in future studies.

SOCIO-ECONOMIC

- Locate adaptation to climate change within the broader developmental context. An effective way to address the impacts of climate change would be to integrate adaptation measures into sustainable development strategies, thereby reducing the pressure on natural resources, improving environmental risk management, and increasing the social wellbeing of the poor.

- Promote knowledge and learning around Namaqualand's biodiversity and its crucial importance as the basis for local economic growth and development, providing rangelands that support both commercial and subsistence farming, supporting horticulture, forming the basis of agricultural industries based on indigenous species; tourism; parts of the local film industry; commercial and non-commercial medicinal applications of indigenous resources; and the provision of ecosystem services such as water.

- Demonstrate successes in the development of alternative nature-based livelihoods strategies to build confidence in their viability. Provide funding for and training in these new skills where possible.

- Encourage participatory processes around improved land management and lower impact agricultural activities. This could include participatory and collaborative wetlands management, predator management, and monitoring.

- Recognise that 'the ability and capacity to adapt makes a significant difference to the level of vulnerability a person or community experiences. Community capacity building will have to be stepped up and residents who are not part of the existing community-based organisations or NGOs should be particularly targeted' (DSD, 2009:82). Since the poor are the most vulnerable to climate change, poverty and adaptation should be tackled together.

INSTITUTIONAL

- Create a strong adaptation committee in local government that 'can be the driver for a more coherent, effective, and ambitious approach to adaptation' (Harmeling et al, 2011:5). The key functions of this representative government based committee would be to ensure alignment of activities across sectors, champion EbA, receive and disseminate research findings, provide a discussion forum for climate related challenges and ecosystem services, review implementation of EbA, and be the vehicle for the development of the local green economy strategy.

- Integrate identified EbA priority areas into existing related programmes across all levels of government including Provincial, District, and Local, for example disaster risk reduction, agricultural extension, nature conservation, and local economic development.

- Frame EbA approaches in terms relevant to local and national priorities, around job creation and economic growth where possible

- Collaborate closely with partners to avoid duplication and share information as widely as possible.

- Strengthen the capacity of local institutions such as farmer's unions, commonage committees, and community development workers to be confident applying EbA as a workable climate change adaptation solution for them. Aim to include planning for climate change into land management plans in priority areas for adaptation and ecosystem services.