agriculture, rural development, land & environmental affairs
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Climate Support Programme (CSP) – Climate Change Adaptation Strategies

Adaptation Strategies for Mpumalanga Province

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

EXECUTIVE SUMMARY

South Africa is already witnessing evidence of climate change,[1] and is located in one of the three regions of the African continent that is most likely to suffer significant adverse impacts from climate change.[2] Within South Africa, Mpumalanga province is no exception to observed and projected national trends. In fact, recent climate change science from within the country indicates that the region within which Mpumalanga province is located could face a potential increase in temperatures by as much as 2°C by 2035, by 1-3°C between 2040 and 2060 (or even 1-4°C in the high-end scenarios), and by 3-5°C between 2080 and 2100 (or as much as 4-6.5°C in the high-end scenarios). These are all outside the range of present-day variability. Thus, Mpumalanga faces a warmer, and potentially hotter future. In terms of rainfall, available science is less precise; while some models project decreased rainfall over Mpumalanga in the long term (with the decrease ranging from mild to a very significant pattern of drying, based on the model and scenario used), other models suggest that there may be moderate future increases in the total volume of rainfall in the region, reflecting the uncertainty in model projections for this region of Southern Africa within the existing body of knowledge.[3] Such studies indicate that volume of winter rainfall, in particular, is going to increase, but that total frequency of rainfall events is unlikely to alter significantly (indicating an increase in heavy rainfall events).[4] However, what emerges out of such uncertainty is that the region is likely to experience greater variability in rainfall, and will almost certainly witness an increase in evaporation rates.[5]

However, what emerges out of such uncertainty is that the region is likely to experience greater variability in rainfall, and will almost certainly witness an increase in evaporation rates,[6] implying a drier future even in the presence of greater rainfall and heavy rainfall events.[7]

In a welcome development, Mpumalanga province has taken the commendable step of starting to be better prepared for such climate change impacts and uncertainty. In policy terms, one of the first formal steps towards building climate change resilience is to identify areas of vulnerability and thereafter to identify high-level strategies that could reduce vulnerability by strengthening the ability to respond and cope well, i.e. by building adaptive capacity. The present report captures a set of initial adaptation strategies for each of the key sectors in Mpumalanga that exhibit high climate change vulnerability (based on the findings of a vulnerability assessment) or sectors that are critical to the province's economy (based on stakeholder observations shared at two workshops in the province). The identification of sectors and overall project approach and methodology were validated with stakeholders and experts in a workshop in Mpumalanga province in March 2015, and the strategies were presented to and reformulated by stakeholders in a second such workshop in

[1] DEA, "South Africa's Second National Communication Under the United Nations Framework Convention on Climate Change," *UNFCCC,* 2011. http://unfccc.int/resource/docs/natc/zafnc02.pdf
[2] Alex Kirby, "Three African Regions at High Risk from Climate Change," *ClimateCentral,* May 11, 2014. http://www.climatecentral.org/news/climate-hotspots-imperil-parts-of-africa-17417
[3] Long Term Adaptation Scenarios, "Climate Trends and Scenarios," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltasclimate-trends-and-scenarios-tech-report2013low-res.pdf
[4] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf
[5] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010 http://www.rvatlas.org/download/sarva_atlas.pdf
[6] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010 http://www.rvatlas.org/download/sarva_atlas.pdf
[7] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

the province in May 2015. Thus, the strategies enumerated here were endorsed (and in many cases proposed) by stakeholders within the province (during discussions at the May 23, 2015 workshop).

The strategies (as well as the project approach and methodology) are described in greater detail in the body of the report. In summary, the strategies are as follows:

Agriculture

I. Formally establish and strengthen strategic long-term partnerships for Climate Smart Agriculture.
II. Secure, dedicate, and allocate substantial funding to carry out studies within the province.
III. Fund and implement a comprehensive climate change awareness and skills-building programme within the farming communities.

Forestry

I. Conduct further research into the development of more climate resilient trees.
II. Revise site classification models.
III. Review the Sector Disaster Management Plan for Forestry

Rural and Urban Livelihoods and Settlements

I. Devote resources to identifying and providing training on alternate sources of livelihood for different regions and communities within Mpumalanga.
II. Create and strengthen support business development mechanisms for smallholder farmers.
III. Redouble efforts to improve overall socio-economic security and wellbeing.
IV. Improve building practices and strengthen monitoring.
V. Leverage existing financial mechanisms.
VI. Enhance disaster management and response.
VII. Improve information dissemination.
VIII. Make better use of SPLUMA.

Terrestrial and Aquatic Ecosystems

I. Develop a specialized climate change management programme to focus on protection of Mpumalanga's two main terrestrial ecosystems in the face of climate change.
II. Identify and integrate specific climate-change related priorities and metrics when next revising the Mpumalanga Biodiversity Sector Plan (MBSP).
III. Expand protected areas and promote the protected area expansion strategy.
IV. Enhance the use of ecological infrastructure to create natural buffers that create resilience against extreme weather events.

Tourism

I. Formally establish and draw resources to a scientific research project to better understand the impact of ecosystem and biodiversity changes on the tourism sector in Mpumalanga.
II. Identify suitable buffers around protected areas so as not to negatively impact on tourism on reserves.
III. Identify most sensitive or vulnerable tourist sites and site-specific adaptation measures.

Water Supply

I. Establish a cross-sectoral, inter-departmental governance framework to help integrate and mainstream climate change adaptation into all water related operations.
II. Ensure that proposed water related infrastructure projects explicitly integrate climate change resilience into their planning and design stages.
III. Raise performance and efficiency of water service delivery for domestic use, with aggressive quantitative targets.

Human Health

I. Formally join, participate in, and leverage capacity and information from global climate change health networks and knowledge-sharing platforms.
II. Secure, dedicate, and allocate substantial funding for better climate-related health surveillance and monitoring in the province and to carry out studies within Mpumalanga on health impacts of climate change.
III. Fund and implement a comprehensive public health and climate change awareness and adaptive capacity building programme.

Disaster Management

I. Secure, dedicate, and allocate funding for research on specific climate-related disaster risks for Mpumalanga, based on climate change scenarios, including identifying geographic hotspots for each major disaster type.
II. Develop and implement public awareness and training programmes based on this evidence base to educate people about climate change related disaster risks and responses.
III. Strengthen overall disaster prevention, disaster management, and disaster response in the province through broad-based capacity building of first responders and relevant officials.

It is recommended that these strategies be further developed into an implementation plan by the relevant sectors within Mpumalanga, so that they can be mainstreamed into provincial policy.

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List of Acronyms

AFOLU – Agriculture, Forestry, and Land Use
ARC - Agricultural Research Council
AGWA – Alliance for Global Water Adaptation
CCAFS - Climate Change, Agriculture, and Food Security
CoGTA - Department of Co-operative Governance and Traditional Affairs
CSA – Climate Smart Agriculture
CSIR – Council for Scientific and Industrial Research
DAFF – Department of Agriculture, Forestry, and Fisheries
DEA – Department of Environmental Affairs
DRDLR – Department of Rural Development and Land Reform
DWS – Department of Water and Sanitation
FANRPAN - Food, Agriculture and Natural Resources Policy Analysis Network
FAO – Food and Agricultural Organisation of the United Nations
FSC – Forest Stewardship Council
GHG – Greenhouse Gas
ICFR - Institute for Commercial Forestry Research
IDP – Integrated Development Plan
IFPRI – International Food Policy Research Institute
IPCC – Intergovernmental Panel on Climate Change
IUFRO International Union of Forest Research Organizations
IUCN – International Union for the Conservation of Nature
LTAS – Long Term Adaptation Scenarios
MBSP – Mpumalanga Biodiversity Sector Plan
NAFU - National African Farmers' Union
SANBI – South African National Biodiversity Institute
SARVA – South African Risk and Vulnerability Assessment
SDG – Sustainable Development Goals
UNEP – United Nations Environment Programme
UNFCCC –United Nations Framework Convention on Climate Change
WFP – World Food Programme
WHO – World Health Organisation

1. INTRODUCTION AND KEY CONCEPTS IN CLIMATE VULNERABILITY

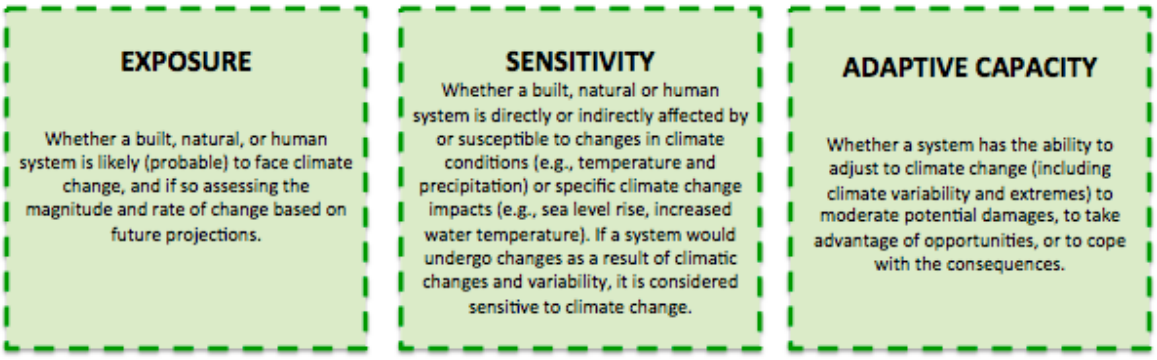
1.1. Assessing Climate Change Vulnerability

As climate change impacts become increasingly apparent in Mpumalanga, it is incumbent upon decision makers in the province to gain a strong comprehension of what makes a community, region, sector, or system vulnerable to climate change, the extent of such vulnerability, and then develop strategies and action plans to reduce the level and extent of vulnerability by improving the ability to cope with expected changes. This imperative is at the heart of any climate change vulnerability assessment and adaptation strategy development process. The steps involved become easier to grasp when one understands what climate change vulnerability is, and what it is comprised of.

According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability to climate change can be defined as follows:

"*Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is* ***exposed****, its* ***sensitivity****, and its* ***adaptive capacity***."[8] (Emphasis added.)

Climate change vulnerability has some key components, each of which has a specific relationship with the other components. These elements are defined differently by different sources, but at their core they can be identified as follows (largely as the IPCC does):

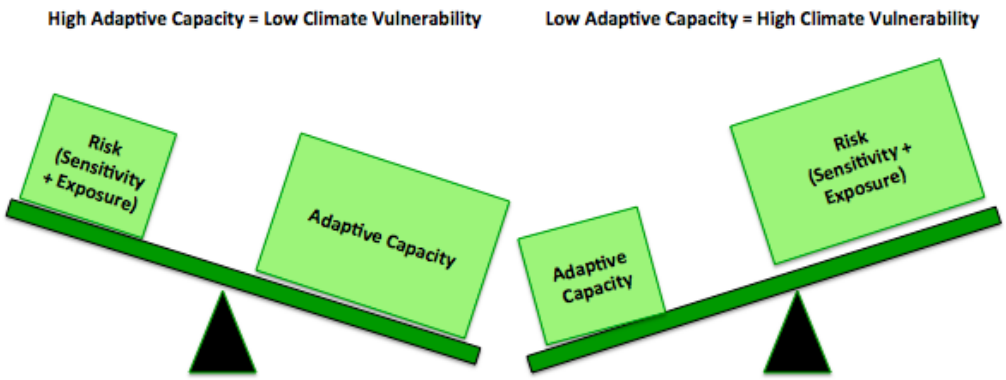


In simple terms, exposure is the extent to which a given system will be subject to or come into contact with a climate change impact – in this case, increased temperatures and changes in rainfall patterns. Sensitivity is the extent to which a given system can be affected by a particular climate change impact. Sensitivity is based on inherent qualities and characteristics of an entity or system, and is an internal characteristic. In this case, the biophysical features of the sector or sub-sector, which influence how it responds to changes in temperature or rainfall. Together, the combination of exposure and sensitivity amount to the *potential climate impact*, or "risk."

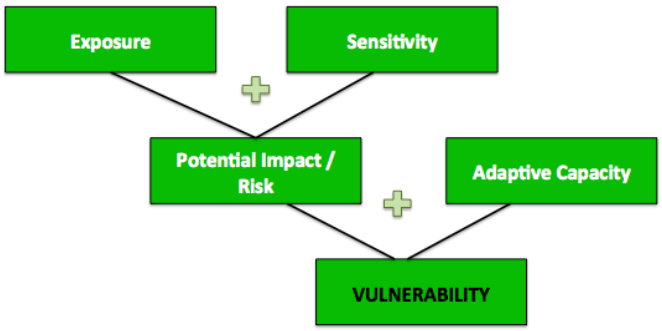
[8] Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (2007), Report of Working Group II on Impacts, Adaptation, and Vulnerability, (Section 2.4) http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=8

Merely because a sector or sub-sector (or any entity or system) is exposed to climate change, it does not automatically qualify as being at risk of potential impacts. If the sensitivity to climate is low, then the risk is moderated. (Similarly, if something is sensitive to changes in climate but not exposed to climate change, then risk is low as well. However, this is somewhat moot because all entities and systems on the planet are exposed to climate change – the difference is the degree to which the exposure occurs, i.e. the magnitude and rate, given that some parts of the world are warming faster than the rest or are expected to experience more significant impacts in terms of precipitation changes etc.).

In the same vein, merely because a sector or sub-sector (or any entity or system) faces a risk of climate change impacts, this does not automatically make it vulnerable. Vulnerability in the face of climate risk is also a function the entity or system's adaptive capacity. Put simply, adaptive capacity is the extent to which a system is able to exploit opportunities and resist or adjust to change. Adaptive capacity is often estimated based on proven historical ability to cope with the changes in question, and for the future it is assessed through proxies such as levels of education and income or even effective programs or policies being put in place to help the sector cope with changes in a positive manner. As the figure below illustrates[9]: the greater the adaptive capacity, the lower the vulnerability, and the lower the adaptive capacity, the greater the vulnerability.



Thus, this project arrived at the determination of vulnerability of various sectors in Mpumalanga through the process that is typical of most climate change vulnerability assessments:



[9] Adapted from "Adapting Urban Water Systems to Climate Change – A Handbook for Decision-makers at the Local Level," SWITCH Training Kit, 2011. As seen at Adapting to Rising Tides http://www.adaptingtorisingtides.org/vulnerability-and-risk/

1.2. Adaptation vs. Mitigation

It must be noted that the methodology described above is aimed at assessing sector vulnerability to climate change. The ultimate objective of this project is to suggest strategies that the province of Mpumalanga can use to facilitate the development of interventions for adaptation of the vulnerable sectors to projected risk. In this regard, it is useful to clearly articulate the difference between mitigation and adaptation. The figure below provides a summary definition of the climate change mitigation and adaptation. The aim is to help readers of this document to appreciate the difference between the two concepts and their constituent elements.

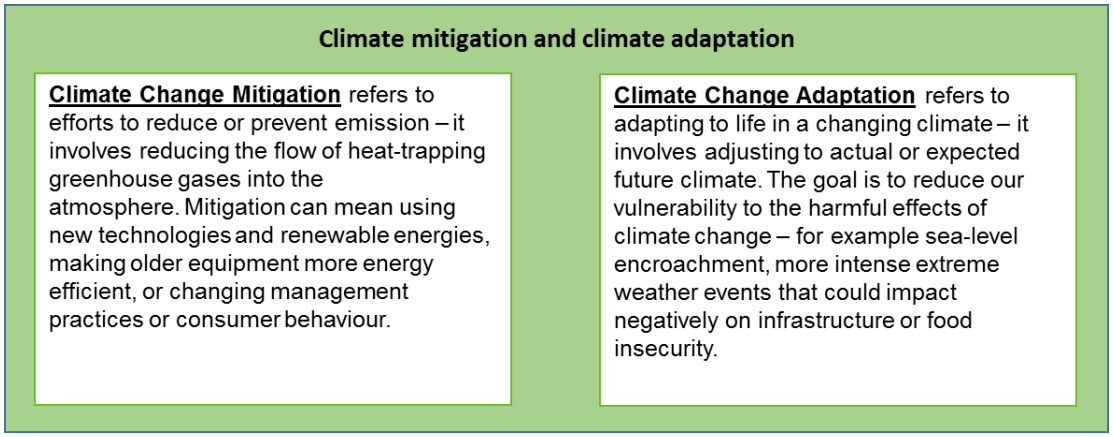


Figure 1: Mitigation vs. Adaptation

Mitigation thus focuses on actions aimed at reducing or preventing emissions. This is not within the scope of the current project or report. Climate change adaptation involves adjusting to current and expected future climatic impacts. It is adaptation that is the focus of this project and report.

1.3. Project Overview

This report is the culmination of a five-month project aimed at developing climate change adaptation strategies for three of South Africa's nine provinces – Limpopo, Mpumalanga, and North West. The consultant was commissioned to assist DEA, through funds provided by GIZ. The project was conducted in two phases. The first phase of three months entailed conducting climate change vulnerability assessments in each of the three provinces, focusing on several sectors and sub-sectors:

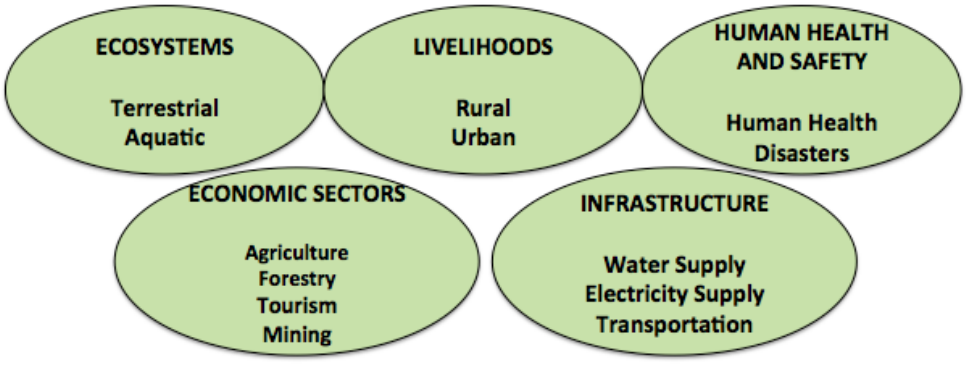
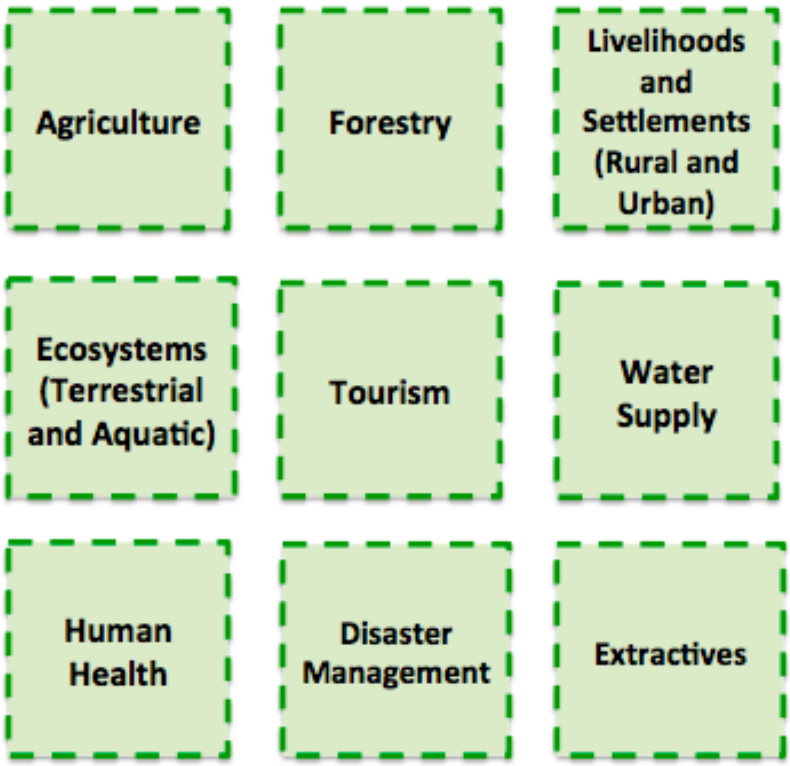


Figure 2: Sectors and sub-sectors examined

Phase one also involved seeking and integrating stakeholder input from experts and relevant sector officials in each of the three provinces, through provincial workshops in Limpopo, Mpumalanga, and North West.

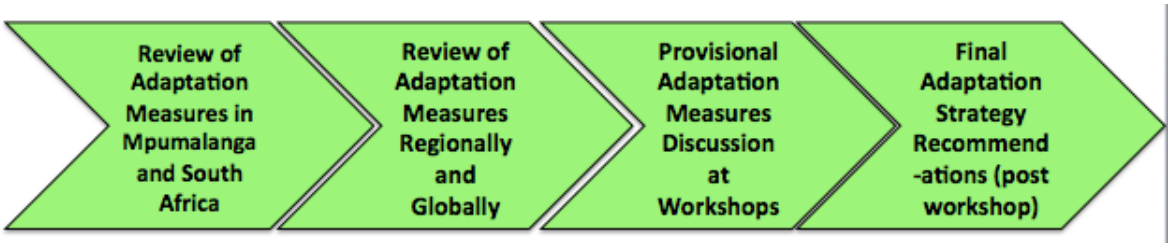
Findings from phase one (captured in three province-specific reports that serve as background feeder documents into the present report) highlighted specific sub-sectors that display relatively high vulnerability to climate change, relative to other sub-sectors. As agreed upon at the project inception stage, phase two of the project hones in on these priority sub-sectors, so as to allow more focused work on the development of adaptation strategies for the province. In response to stakeholder interest, the list of target-sectors was expanded from solely those that were identified through the vulnerability assessment process to include additional sectors deemed important to the province (even if their relative vulnerability was lower than the sectors originally evaluated as having High vulnerability in the assessment stage). For instance, even though according to the initial vulnerability assessment findings, urban livelihoods and settlements are less vulnerable to climate change than rural livelihoods and settlements in relative terms, nevertheless the urban segment has been included in this report as a focus for adaptation strategies, in deference to stakeholders in Mpumalanga who indicated that urban livelihoods and settlements should not be neglected.

For Mpumalanga, the final sectors that were chosen for Adaptation Strategies are:



Phase two involved the identification of adaptation measures that can build adaptive capacity in the relevant sectors/sub-sector, and then evolving strategies for the province to thereafter take forward into an action plan and into subsequent implementation. Adaptation measures have been identified through literature review of past or current adaptation efforts in the appropriate sector in Mpumalanga or South Africa; an exploration of relevant best practices in the corresponding sectors elsewhere (similarly situated provinces or countries); validation, verification and guidance of provincial environmental department

officials in Mpumalanga; and input and refinement by stakeholders and sector experts in a provincial workshop. The strategies have been developed based on this foundation and with an understanding of governance processes and institutional frameworks in Mpumalanga in relation to climate change adaptation (such as existing plans and policies within various departments in the province).



In identifying approaches to climate change adaptation, it is typical for jurisdictions (countries, states and provinces, or municipalities) to first embark on the development of strategies, i.e. strategic directions and guidelines identifying certain areas where attention is required. Strategies answer the question of "what do we do?" Once strategies have been framed and approved (i.e. the objective of this present project), the appropriate government entities or responsible institutions then set about the task of answering, "how do we do it?" In other words, the strategy is typically followed by local or domain experts drawing up a detailed adaptation plan, which includes specific actions, responsibilities, clear timelines, budgetary allocations, and accountability mechanisms. It is expected that such an implementation plan will follow in Mpumalanga province after the conclusion of the current project, informed by the present report.

2. PRIORITY SECTORS FOR ADAPTATION STRATEGIES

The Long Term Adaptation Scenarios (LTAS) project suggests that the region within which Mpumalanga province is located is could face a potential increase in temperatures by as much as 2°C by 2035, by 1-3°C between 2040 and 2060 (or even 1-4°C in the high-end scenarios), and by 3-5°C between 2080 and 2100 (or as much as 4-6.5°C in the high-end scenarios). These are all outside the range of present-day variability. LTAS projects decreased rainfall over Mpumalanga in the long term, with the decrease ranging from mild to a very significant pattern of drying, based on the model and scenario used[10]. Other studies suggest that there may be future increases in the total volume of rainfall in the region (especially around the escarpment), attesting to the uncertainty in model projections for this region of Southern Africa within the existing body of knowledge. Such studies indicate that winter rainfall, in particular, is going to increase, but that total frequency of rainfall events is unlikely to alter significantly (indicating an increase in heavy rainfall events).[11] However, what emerges out of such uncertainty is that the region is likely to experience greater variability in rainfall, and will almost certainly witness an increase in evaporation rates.[12] While fewer studies suggest a dryer future for Mpumalanga than they do for its neighbour Limpopo, there are chances of the province experiencing a drier future even in the presence of greater rainfall and heavy rainfall events.[13]

A recent study noted with concern that even though in South Africa there is a growing body of work focusing on understanding medium to long term changes and corresponding adaptation required, "*most adaptation responses still focus on reducing vulnerability to present-day climate exposure…There is little practical experience of implementing adaptation programs related to longer-term climate change*"[14]. Even though the timeframe identified and the scope of this project is until the year 2035, and the recommendations have been framed with a view to being fully acted on and implemented within the decade (2015 to 2025), an effort has been made to identify adaptation measures (to be effected through adaptation strategies) that would still have relevance even in the mid-century timeframe.

Investigations into climate change vulnerability in Mpumalanga revealed the following sectors as high priorities areas for which adaptation strategies are required. The strategies follow in the next section.

- Agriculture
- Forestry
- Livelihoods and Settlements (Rural and Urban)
- Ecosystems (Terrestrial and Aquatic)
- Tourism
- Water supply
- Human Health
- Disaster Management
- Extractives

[10] Long Term Adaptation Scenarios, "Climate Trends and Scenarios," 2013.
http://www.sanbi.org/sites/default/files/documents/documents/ltasclimate-trends-and-scenarios-tech-report2013low-res.pdf
[11] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010.
http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf
[12] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010
http://www.rvatlas.org/download/sarva_atlas.pdf
[13] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013
http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf
[14] Gina Ziervogel et al., "Climate Change Impacts and Adaptation in South Africa," WIRE's Climate Change (2014) 5:605-620.
http://www.egs.uct.ac.za/downloads/Ziervogel%20et%20al%20Climate%20change%20impacts%20and%20adaptation%20in%20SA%20WIRES%20Sept%202014.pdf

2.1. Agriculture

2.1.1. Agriculture in Mpumalanga

Mpumalanga is South Africa's second largest producer of citrus fruit, and thus citrus cultivation is a major component of the agriculture sector in the province. The province also produces sub-tropical fruit including mangoes, avocadoes, litchis, bananas, papayas, granadillas, and guavas. Mbombela alone accounts for a third of the country's orange exports.[15] Other crops grown in Mpumalanga include sugarcane, potatoes, sweet potatoes, tomatoes, carrots, pumpkins, and beans. Maize and sorghum are the winter staple crops, while wheat is grown in the summer.[16] An estimated 18% of people in Mpumalanga are employed in the agriculture sector, with forestry being the main occupation.[17] The agriculture sector, which also includes animal husbandry and livestock rearing, contributes an estimated six percent to the province's annual average Gross Domestic Product (GDP)[18].

2.1.2. Vulnerability to Climate Change

Across South Africa, climate change is expected to exacerbate already-rising irrigation demand in the agriculture sector, create spatial shifts in the growing areas for some crops, result in changes in yield for certain crops (on the balance, a fall in yields, especially in a significantly hotter future), and a shift as well as expansion in the range of several agricultural pests and parasites. Additionally, warmer temperatures are expected to increase heat stress amongst cattle, which has been linked to reduced milk yield and fertility in dairy cattle.[19]

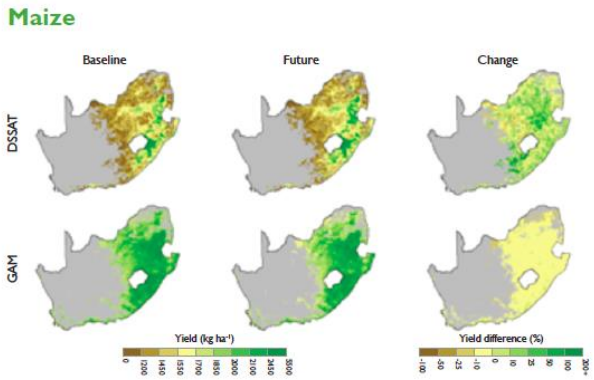


Figure 3: Median Change in Crop Yield for Rain-fed Maize

The above figure is one illustration (based on two distinct models) of how yields of maize (one of Mpumalanga's main crops) may be affected by climate change, with a potential range of a 25% decrease (yield loss) or even a 10% increase (yield gain). In contrast, the commercial forestry sector in Mpumalanga is expected to see slight gains from the effects of climate change, with more areas becoming suitable for commercial plantations[20].

An assessment by the International Food Policy Research Institute (IFPRI) identified Mpumalanga as one of South Africa's five most sensitive provinces in terms of the susceptibility of the agriculture sector to

[15] South Africa Info, "Mpumalanga Province, South Africa," last accessed May 2015. http://www.southafrica.info/about/geography/mpumalanga.htm#.VUxc30saWs0
[16] Match Deck, "Mpumalanga Offers Agric Opportunities in SA," June 26, 2012. http://www.matchdeck.com/article/425-mpumalanga-offers-agric-opportunities-in-sa#/index
[17] Agriseta, "Sector Analysis – Agriculture," June 2010. http://www.agriseta.co.za/downloads/news/AGRISETA_Sector_Analysis_290610-version_2.pdf
[18] Agriseta, "Sector Analysis – Agriculture," June 2010. http://www.agriseta.co.za/downloads/news/AGRISETA_Sector_Analysis_290610-version_2.pdf
[19] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf
[20] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

climate change (however, with the predominance of commercial farmers, it is not assessed as being as vulnerable as provinces like Limpopo, with more smallholder farmers)[21].

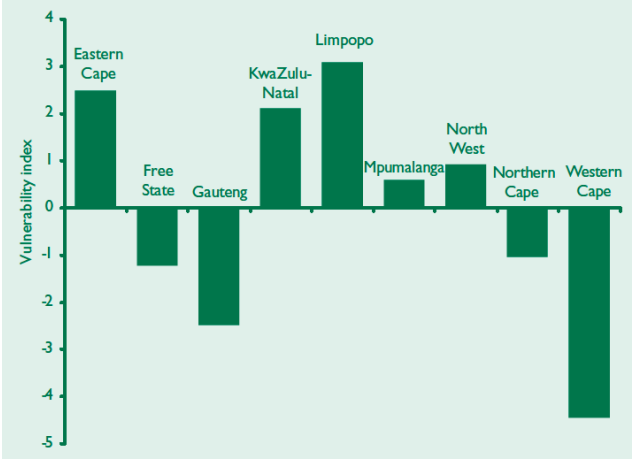


Figure 4: Climate Vulnerability of Agriculture - Ranking in South Africa by Province (Source: IFPRI)

Another assessment that looked at the impact of climate change on agricultural revenues found Mpumalanga to be even more vulnerable. The study noted that due to the role of sugarcane in the province's overall agricultural revenues, and due to sugarcane crops being heavily reliant on abundant rainfall, the province would likely see a fall in revenues by as much as ten percent in a scenario where temperatures rose by 2°C and rainfall decreased by five percent.[22]

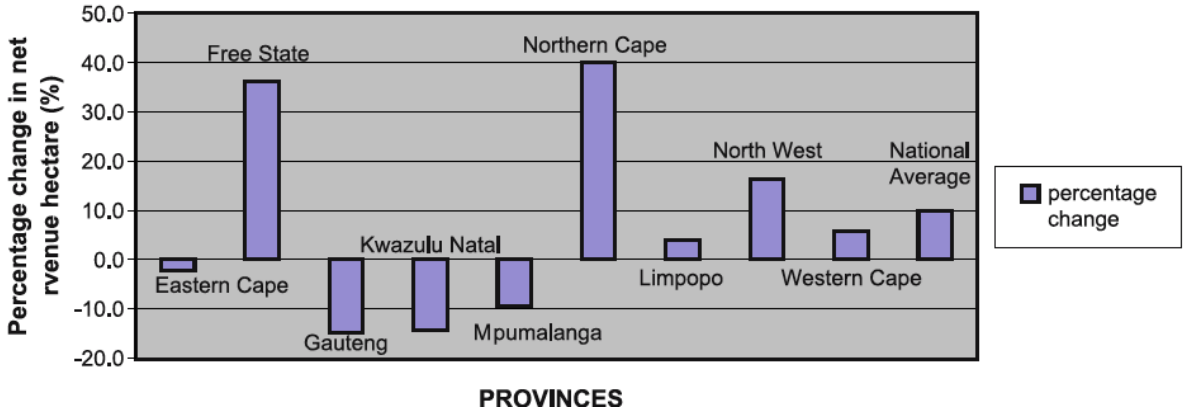


Figure 5: Distributional effects of a two degree temperature increase and five percent rainfall reduction across South African provinces (Source: G.A. Gbetibouo, R.M. Hassan Global and Planetary Change 47 (2005) 143–152).

2.1.3. Agricultural Adaptation in Mpumalanga and South Africa

A nationwide survey of farmers in South Africa indicates that several farmers have already, to varying degrees, considered and even adopted adaptation measures in response to increased climate variability. These include adjustments in farming operations (changing planting dates; adopting shorter planting

[21] Glwadys Aymone Gbetibouo and Claudia Ringler, "Mapping the South African Farming Sector's Vulnerability to Climate Change and Variability – a Sub National Assessment," IFPRI Research Brief 15-3 (2009).
http://www.ifpri.org/sites/default/files/publications/rb15_03.pdf

[22] G.A. Gbetibouo and R.M. Hassan, "Measuring the Economic Impact of Climate Change on Major South African Field Crops: A Ricardian Approach," Global and Planetary Change 47 (2005) 143–152.
http://www.researchgate.net/profile/Rashid_Hassan2/publication/222558101_Measuring_the_economic_impact_of_climate_change_on_major_South_African_field_crops_a_Ricardian_approach/links/02e7e51cc244c2d7fb000000.pdf

periods; delaying the start of the planting period; increased use of modern machinery; collection of rainwater; increased use of irrigation; using more water-efficient crop varieties; using early-maturing varieties; and mixed farming with more livestock), increased application of chemical fertilizers and pesticides, improved water management practices, and increasing the use of shade and shelter.[23]

A survey of farmers in Mpumalanga reveals that farmers in the province do perceive long-term climate trends as changing, and identify certain measures as being beneficial to adapt to changing climatic conditions. The survey indicated that 91% of farmers sampled in Mpumalanga feel that temperatures are rising, 75% feel that rainfall is decreasing, and seven percent noted that the timing of rainfall has become more erratic in recent times. Mpumalanga farmers identified several barriers to climate change adaptation in the province: 48% cited poverty or the lack of credit and savings; over eight percent cited the lack of adequate access to water; more than eight percent also cited the lack of information about long-term climate change, and nearly six percent cited insecurity of property rights as a barrier.[24]

The same study also highlighted the types of adaptation measures that farmers in Mpumalanga province have already been undertaking. In response to temperature rise, even though over 67% of farmers said they had not tried any adaptation measure at all, over six percent of farmers surveyed said they had tried changing their crop variety; over five percent said they were using more irrigation; four percent noted that they were trying different planting dates; and four percent said they had tried changing their crop altogether. Other methods identified were changing the amount of land under cultivation, and using feed supplements. None of the farmers had tried to do crop diversification or mixed farming.[25]

Similarly, in response to changes in temperature, over 62% of farmers said they had not tried any adaptation measure at all. But the rest acknowledged trying various adaptation measures, including more irrigation (over 11%), using different planting dates (7.5%), building a water-harvesting structure (5.03%), and planting different crops (three percent). Very few had tried changing crop varieties, changing the amount of land cultivated or grazed, and using feed supplements as adaptation measures to changing rainfall patterns and water availability.[26]

However, a more recent survey found that awareness was somewhat lower. Per the second study, nearly 83% of households surveyed in Mpumalanga (of which over 60% were farming households) were not aware of climate change. An important finding from this study is that those who had greater access to extension services had more awareness of climate change and were more likely to have learnt about agricultural adaptation measures.[27]

The LTAS project recommends a host of adaptation practices for the agriculture sector in South Africa: (i) conservation agriculture, climate-smart agriculture, ecosystem-based adaptation, community-based adaptation, and agro-ecology; (ii) sustainable water use and management; (iii) sustainable farming systems; (iv) early warning systems, risk management and decision support tools; (v) integrated and

[23] James K.A. Benhin, "Climate Change and South African Agriculture: Impacts and Adaptation Options," University of Pretoria. http://www.elsenburg.com/trd/globalwarm/downloads/agriculture.pdf
[24] G.A. Gbetibouo, IFPRI, "Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability – A Case Study of the Limpopo Basin," Discussion Paper 00849, 2009. http://www.ifpri.org/sites/default/files/publications/ifpridp00849.pdf
[25] G.A. Gbetibouo, IFPRI, "Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability – A Case Study of the Limpopo Basin," Discussion Paper 00849, 2009. http://www.ifpri.org/sites/default/files/publications/ifpridp00849.pdf
[26] G.A. Gbetibouo, IFPRI, "Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability – A Case Study of the Limpopo Basin," Discussion Paper 00849, 2009. http://www.ifpri.org/sites/default/files/publications/ifpridp00849.pdf
[27] Phokele Maponya et al., "Climate Change Awareness in Mpumalanga Province, South Africa," Journal of Agricultural Science; Vol. 5, No. 10; 2013 http://www.ccsenet.org/journal/index.php/jas/article/viewFile/28380/17959

simplified policy ad effective governance systems; and (vi) awareness, knowledge, and communications. Detailed descriptions of each may be referred to in the LTAS Agriculture report,[28] to obviate duplication of the list in this present report, whose aim is rather to identify a strategy for the province going forward.

At the national level, the Department of Agriculture, Forestry, and Fisheries (DAFF) released a Climate Change Sector Plan for Agriculture (in 2010), which identified four key performance areas (institutional arrangements; vulnerability assessments; mitigation and adaptation; response and recovery), and three critical enablers (Information management and communication; education, training, public awareness, and research; and funding arrangements). Many aspects of this plan still need to be rolled out and implemented at the provincial level.[29]

Similarly, the National Climate Change Response Policy also acknowledges Climate Smart Agriculture when discussing Agriculture, Forestry, and Other Land Use (AFOLU), noting the need to, "invest in and improve research into water, nutrient and soli conservation technologies and techniques, climate-resistant crops and livestock as well as agricultural productivity in line with the National Development Plan and post 2015 Sustainable Development Goals, ownership and financing to promote the development of Climate Smart Agriculture that lowers agricultural emissions, that transitions to a low carbon sector, that is more resilient to climate change, and that boosts agricultural production." The response policy also lays out five guiding principles for the AFOLU sector, including integration with rural development, food security, and job creation; developing short term and long term land use adaptation scenarios; investing in research; investing in awareness and education programmes; and the development and use of early warning systems.[30]

2.1.4. Agricultural Adaptation Lessons and Best Practices from Elsewhere

Globally as well as across Africa, there is growing momentum behind "Climate Smart Agriculture."[31] Climate Smart Agriculture is defined as involving production systems that sustainably increase productivity, resilience (adaptation), reduces or removes GHGs (mitigation), and enhances the achievement of national food security and development goals.[32] The Food and Agriculture Organisation (FAO) has helped spur rapid uptake of Climate Smart Agriculture in different regions by providing knowledge resources and tools such as a sourcebook for implementation.[33]

In February 2014, in Tanzania, delegates from over 20 African nations attended a regional workshop on "African Agriculture in a Changing Climate – Enhancing the Uptake of Climate Smart Agriculture." They agreed that research is now increasingly pointing towards climate smart agriculture as the solution to enhancing capabilities of agricultural and food systems to cope with current climate variability in order to improve productivity and resilience.[34] Thereafter, 26 African countries have collectively launched the

[28] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf
[29] Department of Agriculture, Forestry, and Fisheries, "Climate Change Sector Plan for Agriculture," March 2010. http://www.sasscal.org/downloads/RSSC_workshop_SA_final_presentations_programme_participants_(LQ)_part_2.pdf
[30] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf
[31] The Climate Smart Agriculture Partnership, http://www.fao.org/climate-smart-agriculture/en/
[32] Climate Smart Agriculture, "About Climate Smart Agriculture," http://www.fao.org/climate-smart-agriculture/72610/en/
[33] Food and Agricultural Organisation (FAO), "Climate Smart Agriculture for Development," http://www.fao.org/climatechange/climatesmart/en/
[34] CGIAR Research Program on Climate Change, Agriculture, and Food Security, "Building Climate Resilience in the African Agricultural Sector," February 26, 2014. http://ccafs.cgiar.org/blog/building-climate-resilience-african-agriculture-sector#.VUMxFEsaWs1

voluntary Climate Smart Agriculture Alliance for Africa, which aims to trigger policy changes and increase investments that strengthen African agriculture in the face of changing climate.[35] This new alliance aims to empower six million smallholder farmers across Africa by the year 2021, and is launching its first stage of efforts in Zambia, Ethiopia, and Niger.[36]

There are emerging success stories and best practices for Climate Smart Agriculture from various parts of Africa. For instance, potato farmers in Tanzania are expecting a harvest with ten times the average yield.[37] Traditional "Kihamba" agro-forestry techniques in Tanzania are helping raise incomes by an estimated 25%. Small holder farmers in Kenya and Tanzania are adopting water and soil conservation practices. Zambia and Malawi are strengthening their institutional and policy capacity to support climate smart agriculture. Farmers in Rwanda have increased income through agricultural diversification and mixed farming.[38]

Thus, adopting some of the tenets and practices of Climate Smart Agriculture, as locally applicable and adaptable, may be of relevance for provinces in South Africa such as Mpumalanga.

2.1.5. Climate Adaptation Measures for Agriculture - Recommendations

Province-specific scientific literature on climate change impacts on the agricultural sector and on locally relevant climate change adaptation practices in Mpumalanga is lacking. While there is awareness of Climate Smart Agriculture and agricultural climate resilience more generally amongst responsible institutions or officials (and farmers in Mpumalanga are aware to some degree about climate change adaptation) available literature points to the province needing a much stronger knowledge base upon which to operationalize such efforts. Thus the recommendations suggested are geared towards laying a strong foundation for climate smart agriculture and scaling it up in Mpumalanga in the coming decade.

I. **Formally establish and strengthen strategic long-term partnerships for Climate Smart Agriculture** and foster collaboration with key organizations, including (but not limited to) CGIAR (particularly the research program of Climate Change, Agriculture, and Food Security – CCAFS), IFPRI, FAO, Africa CSA, the South-Africa based Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN), CSIR, Agricultural Research Council (ARC), National African Farmers' Union (NAFU) and other farmer co-operations in the province. This should be done with a view to launching and carrying out Mpumalanga-specific research and climate resilience projects. Such partnerships ensure knowledge-sharing and avoid reinventing the wheel. They are also relatively low-resource methods to strengthen capacity.

II. **Secure, dedicate, and allocate substantial funding to carry out studies within the province** regarding the impacts of climate change on the major food and cash crops of Mpumalanga, on livestock farming, on agricultural revenue, and to identify locally relevant Climate Smart Agriculture practices that would benefit farmers in Mpumalanga. These studies could be carried out by agricultural research centers within the province (e.g. universities) or external experts, or in partnership, and in many cases would include local trials and field tests. Both the national and

[35] CGIAR Research Program on Climate Change, Agriculture, and Food Security, "A Climate-Smart Agriculture Alliance for Africa," June 15, 2014. http://ccafs.cgiar.org/blog/climate-smart-agriculture-alliance-africa#.VUMtrUsaWs0
[36] Africa CSA http://africacsa.org/#founding-members
[37] CGIAR Research Program on Climate Change, Agriculture, and Food Security, "In Pictures: Ten-Fold Potato Yield in Lushoto, Tanzania," April 13, 2015. http://ccafs.cgiar.org/blog/pictures-tenfold-potato-yield-lushoto-tanzania#.VUMy3EsaWs0
[38] FAO, "Success Stories on Climate Smart Agriculture," 2014. http://www.fao.org/3/a-i3817e.pdf

provincial Departments for finance should be consulted to assist with this process. They would ideally produce results within a 3-5 year timeframe.

III. **Fund and implement a comprehensive climate change awareness and skills-building programme within the farming communities** of Mpumalanga province, with extensive coverage over a period of 3-5 years. Such a knowledge-sharing program would include educational outreach about the impacts of climate change on agriculture (tailored to Mpumalanga province), it would engage farmers on various practices that can strengthen climate resilience (in an effort to lower their resistance to change), and train them on best practices (to enhance their ability to reap successful results from adaptation measures). Such a programme could be designed and funded in collaboration with development partners, but should also have sustainability through domestic funding sources.

All of the aforementioned programs could be designed and developed in a one-year timeframe and then implemented on an ongoing, continuous basis (with periodic review and evaluation and recalibration as needed). Funding could be sought from development partners by seeking grants, but would also be secured from the national treasury. The lead implementation entity would be the Department of Agriculture, Forestry and Fisheries (DAFF), working in close collaboration with the Department of Environmental Affairs (DEA), the Department of Water and Sanitation (DWS), and Department of Education. At the provincial level, it would be DARDLEA that drives the implementation on the ground.

2.2. Forestry

2.2.1. Forestry in Mpumalanga

Forestry is a major economic sector in Mpumalanga province. Nearly 38% of all persons in South Africa employed in forestry work in Mpumalanga. It is estimated that nearly 6% of all of Mpumalanga's population is dependent on the forestry sector for income and livelihoods.[39]

It is not only a source of employment and revenue, but also has considerable environmental benefits. Forestry is regarded as a mitigation tool in climate change, due to the fact that forests contribute to the removal of carbon dioxide from the atmosphere, also known as carbon sequestering. Although trees are later chopped down after 10 to 20 years, when managed appropriately this does not reverse the mitigation already achieved. Trees take up and process carbon dioxide more actively when they are young and in their growing stage. As the tree reaches a certain age, growth slows or stops and carbon dioxide is taken up at the same rate as is released through respiration and transpiration. Since the forestry sector typically removed tress of a certain age for commercial use and plants and grows several successive generations of trees, the carbon sequestration benefits continue to accrue. There are several other benefits from the forestry sector as well; wood products are renewable and can replace other materials that require much larger fossil fuel inputs for their production. Furthermore, forested wood can also replace fossil fuels directly in the form of renewable energy, or wood fuel. Forested areas also play a role in flood attenuation, and it creates valuable wildlife habitat[40].

2.2.2. Vulnerability to Climate Change

Climate change has several impacts on the forestry sector. These include changing the rate of growth of trees; a rise in the frequency and intensity of forest fires (due to warmer temperatures and drier conditions); the spread of forest pests into new areas with favorable temperatures; and an increase in damage caused by extreme weather conditions such as drought, floods and storms. Such impacts in turn reduce the ability of the forestry sector to mitigate greenhouse gas emissions.

Changing temperature and rainfall patterns also affect the growing range of trees. With higher temperatures spreading to greater areas, and (in the southern hemisphere), warm termperature bands moving south, the optimal geography for growing certain trees is also projected to shift.

2.2.3. Forestry Adaptation in Mpumalanga and South Africa

In 2013 DEA published a report on South Africa's Greenhouse Gas (GHG) mitigation potential, and highlighted that the forestry sector could contribute to lowering GHG emissions. While the report is of note, it takes a mitigation lens, and thus did not address adaptation in the forestry sector.[41]

[39] Roger Godsmark, Forestry South Africa, "Employment in the South African Forest and Forest Products Industry in 2011." February 2013. http://www.forestry.co.za/uploads/File/industry_info/statistical_data/Employment%20in%20the%20South%20African%20Forestry%20and%20Forest%20Products%20Industry%202011.pdf

[40] Letter from SAPPI on Climate Change Adaptations for Forestry

[41] - Department of Environmental Affairs, 2013: South Africa's Greenhouse Gas (GHG) Mitigation Potential Analysis, Pretoria, South Africa.

DEA is currently implementing some adaptation strategies in the forestry sector through several coordinated projects being facilitated by the Institute for Commercial Forestry Research (ICFR). For instance, biomass burning is being used as an adaptive tool. Current adaptation therefore includes the proposed implementation of biomass projects for fuel and energy.

Forestry South Africa and similar institutions are conducting a great deal of resaerch into identifying and field testing tree species that are more resistant to climate change impacts, such as higehr temperatures and dryness.

On the basis of a memorandum signed with the Department of Water and Sanitation (DWS), the forestry sector in Mpumalanga is implementing the withdrawal of forested areas from riparian/wetland habitat, to reduce the impact on water availability/quantity. This helps ensure that these areas can be more resilient to the impacts of climate change.

2.2.4. Forestry Adaptation Lessons and Best Practices from Elsewhere

Both within South Africa and elsewhere, there is a great deal of literature about the way the forestry sector can contribute to climate change mitigation and the way the forestry sector can help communities adapt better to climate change. However, there is comparatively less discourse about the manner in which the forestry sector itself can adapt to climate change (which is the focus of the current project).

The International Union of Forest Research Organizations (IUFRO) notes that many existing forest management practices are compatible with climate change adaptation, and can serve a dual purpose and incorporate adaptation, even if the practices were not originally designed with climate change in mind. These include measures to tackle habitat destruction, forest land fragmentation and degradation, and general approaches towards sustainable forest management. It also recommends that traditional knowledge about forests be tapped for adaptation measures. In addition to improved forest management for adapation, there are examples of specific climate adaptation measures from several regions of the world. These include growing drought-resistant trees, reforestation with acacia or bamboo, alley cropping to reduce vulnerability to extreme weather, rehabilitating trees to promote recovery from bark beetle infestations etc.[42] A range of international best practices and case studies of adaptation in the forestry sector have been consolidated in publications by development agencies, such as institutional reform in Mozambique, mixed cropping in plantations in Sri Lanka, establishment of grass barriers, innovative insurance approaches in India, and other such approaches that could potentially offer insights for the forestry sector in South Africa.[43]

Forest Stewardship Certification (FSC) requirements have helped establish protected regions within forest plantations (grasslands, wetlands, indigenous forest), and these help with sustainable forest management overall.

[42] Risto Seppala et al., IUFRO, "Adaptation of Forests and People to Climate Change," Global Forest Expert Panel on Adaptation of Forests to Climate Change, March 2009.
[43] Secretariat of the Pacific Community and GTZ, "Adaptation to and Mitigation of Climate Change in the Agriculture and Forestry Sector," 2010. http://www.sprep.org/att/irc/ecopies/pacific_region/674.pdf

2.2.5. Climate Adaptation Measures for Forestry - Recommendations

i. **Conduct further research into the development of more climate resilient trees:** Mpumalanga province could invest additional resources, in partnership with the private sector in the forestry industry, into developing and producing more tolerant genetic material. This can help ensure that the province has a range of tree species that are at lower risk in a warmer or dryer future. This type of applied research programme would include the planting of clones and hybrids (for instance with Pine and Eucalyptus species) that are bred and tested for pest/disease and other climate tolerances.

ii. **Revise site classification models:** SAPPI has already initiated the process of fine-tuning site classification models and data, such as a frost occurrence model. This enables more informed decision-making about the deployment of trees to the most appropriate sites, where they will be less susceptible to extreme weather conditions that may be caused by climate change. This type of work should be enhanced and provided greater resources.

iii. **Review Disaster Management Plan for Forestry:** Disaster management will also need serious attention, such as the implementation of fire management due to the increase of forest fires as a climate change impact. Fire management will need to be implemented cooperatively with government departments like CoGTA, local and district municipalities, as well as Mpumalanga DARDLEA. Thus, the province should prepare a specific disaster management plan for the forestry sector, and DARDLEA should depute someone with this responsibility.

The strategies enumerated above could be designed and developed in a one-year timeframe and then implemented on an ongoing, continuous basis (with periodic review and evaluation and recalibration as needed). Given the private sector's role in forestry in Mpumalanga, a significant share of resources would ideally come from there. The lead implementation entity would be the Department of Agriculture, Forestry and Fisheries (DAFF), working in close collaboration with the Department of Environmental Affairs (DEA). At the provincial level, it would be DARDLEA that drives the implementation on the ground.

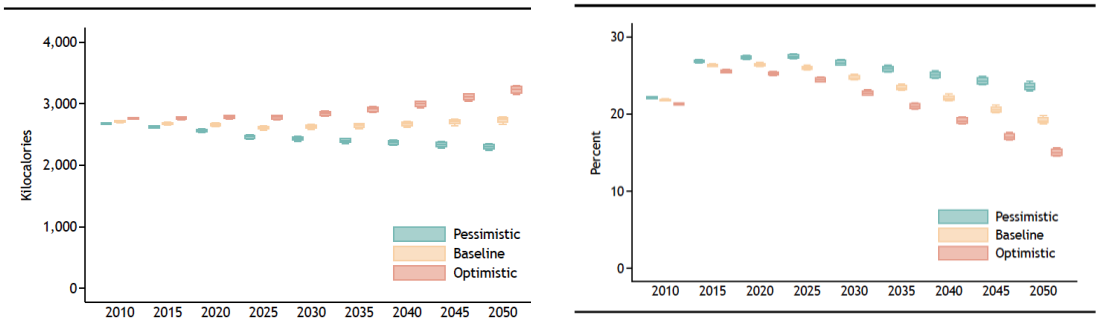
2.3. Rural and Urban Livelihoods and Settlements

2.3.1. Livelihoods and Settlements in Mpumalanga

An estimated 50% of people in Mpumalanga live in conditions of poverty, and over 60% of the population resides in rural areas.[44] Of all of South Africa's provinces, Mpumalanga had the fifth lowest per annual average household income, as recorded in the 2011 census.[45] In 2011, seven percent of Mpumalanga's population lived in shacks that were not in backyards, while four percent lived in shacks in backyards (and another four percent lived in "traditional dwellings").[46]

2.3.2. Vulnerability to Climate Change

South Africa-wide projections suggest that in a pessimistic (high-emissions) scenario, climate change will have an impact on the number of kilocalories available for consumption per capita, causing 20% slight decline by mid-century, primarily due to a decrease in agricultural yield. This is also expected to spark an initial increase (through 2025) in the number and percentage of malnourished children under five years.[47]



Figures

Figure 6: (a) Kilocalories per capita in South Africa in multiple income and climate scenarios (2010-2050); and (b) Share of malnourished children under five years of age in South Africa in multiple income and climate scenarios (2010-2050). (Source: IFPRI).

Impacts from climate variability, such a drought, are already a problem for livelihoods in Mpumalanga and are likely to become more pronounced with climate change. The level of poverty and reliance on rural livelihoods also makes the province vulnerable. In fact, the Department of Rural Development and Land Reform's climate change risk and vulnerability assessment for rural human settlements identified Mpumalanga as being amongst the most socially vulnerable to climate change.[48]

In general, resource-poor settings such as Mpumalanga are at a greater disadvantage in coping with the effects of climate change and adapting to changing conditions. Mpumalanga's climate vulnerability in

[44] Mpumalanga Provincial Government, "Mpumalanga Economic Profile," September 2009. http://www.mpumalanga.gov.za/dedt/economic%20profile/Mpu_Econ_Vol5_01_Jul_2010.pdf
[45] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[46] Housing Development Agency, "Mpumalanga – Informal Settlements Status," 2013. http://www.thehda.co.za/uploads/images/HDA_Mpumalanga_Report_lr.pdf
[47] Peter Johnston et al., IFPRI, "South Africa – Chapter 7," in Southern African Agriculture and Climate Change, 2013. http://www.ifpri.org/publication/southern-african-agriculture-and-climate-change
[48] Department of Rural Development and Land Reform, "Climate Change Risk and Vulnerability Assessment for Rural Human Settlements," July 2013. http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

terms of livelihoods is as much a function of expected climate impacts as it is a function of high levels of poverty and unemployment, dependence on agriculture for food security and employment, and inadequate access to sanitation, water supply, and healthcare.[49]

The inhabitants of rural areas in Mpumalanga are also exposed and vulnerable to climatic impacts due to poor building practices and infrastructure being used in the area. Many houses are built on flood plains and are at severe risk when there are heavy rains in the area. The inhabitants are also at risk to water borne diseases from the lack appropriate sanitation and waste management practices.

Whilst agriculture is an economic activity in the area, most crops are rain-fed. Droughts and shifts in the rainy season will negatively impact the area.

Within such settings, it is often the extremely young and the extremely old (i.e. children and the elderly, who are not part of the formal working population) who face the biggest challenges coping with climatic changes and the resultant impact on household livelihoods. Approximately 65% of children in Mpumalanga are estimated to live below the poverty line.[50] The age distribution of Mpumalanga's population is also shifting towards older age groups: the median age of Mpumalanga residents increased between the 2001 and 2011 census.[51] However, the province's proportion of elderly persons to adults is still lower than the national average.[52] In terms of out migration or in-migration between 2006 and 2011, it is unclear whether Mpumalanga experienced a net in-migration of people (as the 2011 census suggests[53]) or whether it experienced a net out-migration (as the Housing Development Agency suggests[54]). This trend influences vulnerability because of the movement of able-bodied adults (with high adaptive capacity) out of the province, leaving behind larger numbers of elderly persons with less ability to cope.

2.3.3. Rural and Urban Livelihoods Adaptation in Mpumalanga and South Africa

Given the role of agriculture as a source of subsistence and food security in Mpumalanga, adaptation to the impacts of a changing climate on livelihoods is, to a significant degree, agricultural adaptation.

Besides the information already discussion about farmers' adoption of agricultural adaptation measures (in the preceding section), there appears to be a significant lack of peer-reviewed or otherwise credible information from Mpumalanga on climate change adaptation measures already being adopted or experimented with in the context of rural livelihoods and settlements.

It may be noted that Mpumalanga adopted a Climate Change Declaration in 2011 that specifically lists the province's commitment to the creation of sustainable livelihoods,[55] but based on available evidence it does not appear as if any concerted action is being taken regarding climate change adaptation for rural livelihoods and settlements.

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[49] UNICEF, "Exploring the Impact of Climate Change on Children in South Africa," 2011. http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf

[50] UNICEF, "Exploring the Impact of Climate Change on Children in South Africa," 2011. http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf

[51] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf

[52] Statistics South Africa, "Profile of Older Persons in South Africa," 2011. http://www.statssa.gov.za/publications/Report-03-01-60/Report-03-01-602011.pdf

[53] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf

[54] Housing Development Agency, "Mpumalanga – Informal Settlements Status," 2013. http://www.thehda.co.za/uploads/images/HDA_Mpumalanga_Report_lr.pdf

[55] Mpumalanga Provincial Government, "Climate Change," http://www.mpumalanga.gov.za/dedt/news/Archive/climateChange.asp

At the national level, the National Climate Change Response Strategy White Paper suggests the following adaptation responses for rural human settlements: supporting small-scale farmers including on-farm demonstration and experimentation related to conservation agriculture; empowering local communities – especially women – to design and implement adaptation strategies; designing and implementing economic diversification; prioritizing adaptation technologies such as low water-use irrigation, water harvesting, and drought-resistant seed varieties; and enhancing disaster-management architecture in rural areas.[56] It also makes note of the need to overcome apartheid-era spatial planning challenges through approaches such as land redistribution without compromising on food security and agricultural production.

2.3.4. Rural and Urban Livelihoods Adaptation Lessons and Best Practices from Elsewhere

The UK-funded Western Odisha Rural Livelihoods Project in India offers some valuable insights, given the many demographic and development parallels between the province (state) of Odisha in India and Mpumalanga province in South Africa. The project focused on building overall resilience amongst rural communities by: "(i) building structures and processes that develop community skills and confidence, enabling them to articulate their needs and demand improved services; (ii) enabling the poor and marginalized to become actively and effectively involved in planning and development; (iii) promoting equity between socio-cultural groups and empowering rural women; (iv) promoting farm and non-farm enterprises that improve income, employment and nutritional security, relieve the debt burden, and encourage savings; (v) improving management of common property and the fair distribution of its benefits; (vi) promoting local technology that responds to specific needs, including the particular needs of women; (vii) helping communities and local service providers – government or non-government - to use modern participatory methods for planning, implementation, monitoring and evaluation; and (viii) helping to create an environment that promotes pro-poor policy change."[57] Even though the core focus of this program was not on climate change adaptation per se, the results indicate that the communities involved in the project are now better able to respond to climate variability, in terms of both droughts and heavy rainfall. The success also led to uptake of this approach by the state government.[58]

Other best practices and viable case studies to draw lessons from include the World Food Program's (WFP) Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods (MERET) project, which has worked with over 500 communities in Ethiopia to enhance livelihood resilience to weather-related shocks, and improving food security, by rehabilitating land and water resources;[59] the Food and Agriculture Organization's (FAO) demonstrations of 15 viable agricultural adaptation practices in Bangladesh, geared towards drought mitigation, climate resilience, economic robustness, increased production, sustainability and social acceptability, where communities self-selected the use of mini-ponds, homestead gardens, dry seedbeds for rice cultivation, and cultivating hardy species of trees as their preferred adaptation options amongst the over 225 activities demonstrated and tested;[60] and

[56] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf
[57] DDInternational, "Western Odisha Rural Livelihoods Project," http://ddinternational.org.uk/viewProject?project=4
[58] Virinder Sharma et al., "Sustainable Rural Livelihoods Approach for Climate Change Adaptation in Western Odisha, Eastern India," *Development in Practice* Volume 24, Issue 4 (2014). http://www.tandfonline.com/doi/abs/10.1080/09614524.2014.911817?journalCode=cdip20
[59] Inter Agency Standing Committee (IASC), "Addressing the Humanitarian Challenges of Climate Change – Regional and National Perspectives: Case Studies on Climate Change Adaptation," 2009.
[60] Inter Agency Standing Committee (IASC), "Addressing the Humanitarian Challenges of Climate Change – Regional and National Perspectives: Case Studies on Climate Change Adaptation," 2009.

Malawi's Climate Adaptation for Rural Livelihoods and Agriculture (CARLA) project,[61] which is partially underway but has begun offering key implementation lessons about capacity building and training.[62]

2.3.5. Climate Adaptation Measures for Livelihoods in Mpumalanga - Recommendations

Since rural livelihoods in Mpumalanga province are very closely tied to agriculture, the recommended adaptation measures for that sector would also be beneficial for livelihoods. In addition, however, a few other key interventions are recommended, particularly with a view to economic diversification. Mpumalanga must actively explore how to provide alternative means of livelihoods to its people, divorced from agriculture.

I. **Devote resources to identifying and providing training on alternate sources of livelihood for different regions and communities within Mpumalanga**. The provincial government should establish an applied research programme that makes a rigorous analysis of viable alternative means of livelihood for different communities in different parts of Mpumalanga, based on locally available resources, existing and potentially transferable skill-sets, and the needs and aspirations of the communities concerned. Once some viable alternatives have been determined (in the 1-2 year timeframe), the program should transition into a 2-3 year technical training and skills-building program involving demonstration projects to help the communities' adoption of the alternative livelihood sources. This program could be done in collaboration with universities, research institutes, development partners, but most importantly it should be grounded within the communities and be designed and implemented by the communities in collaboration with external and government experts, i.e. through a spirit of partnership. Given the small share of agriculture in Mpumalanga's GDP, the introduction and adoption of alternative means of livelihoods may be a way to generate more revenue than current practices are generation, i.e. to bring more value-addition into the provincial economy and generate more income for the communities and the province.

II. **Create and strengthen support business development mechanisms for smallholder farmers**. The province of Mpumalanga, in partnership with the national government (Department of Rural Development and Land Reform), with development institutions and donors, and the private sector, should enhance opportunities for rural communities in Mpumalanga (especially farmers) to develop sustainable livelihoods. This entails raising credit availability through loans, grants, and microfinance; increasing access to and participation in markets; and institutional resources in the form of sustainable rural livelihoods board or committee that can offer guidance and feedback to rural communities in order to help them identify and develop new opportunities in the agricultural value chain. There is also the opportunity to look at more hardy, climate resilient crops as well as training farmers in more advanced farming methods such as crop rotation, recycling brown water and water containment through rainwater harvesting.

III. **Redouble efforts to improve overall socio-economic security and wellbeing**. Climate change resilience is in part a function of existing human vulnerability and adaptive capacity, which are influenced by several overarching socio-economic factors. In Mpumalanga province, adaptive

[61] AfDB, "CARLA Project Appraisal Report," October 2011. http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Malawi_-_AR_-_Climate_Adaptation_for_Rural_Livelihood_and_Agricuture__CARLA_-_LOTB_-_Approved_.pdf

[62] UNDP, National Adaptation Plan Global Support Programme, "Reporting, Monitoring and Review: Experiences and Lessons Learnt from National Climate Change Programme and NAPA Implementation in Malawi," April 2014. http://www.undp-alm.org/sites/default/files/malawi_nap-gsp_africa_regional_training_workshop_element_d_malawi.pdf

capacity in livelihoods will automatically be strengthened with broad-based development and inclusive economic growth. As a corollary, no amount of sector-specific climate adaptation strategies and plans will bring about long-lived resilience unless they are built on a foundation of economic and social security. Thus, even from a climate change adaptation point of view, the province of Mpumalanga must redouble and accelerate its efforts to extend the coverage of safe drinking water supply, adequate sanitation, adequate and reliable electricity supply, formal housing, education, and access to healthcare services. In doing so, it must integrate climate change into its existing plans and policies, so as to ensure climate mainstreaming within broader development programmes and initiatives. It could also align its own targets more closely with the post 2015 Sustainable Development Goals, and thereby leverage available international support for the achievement of SDGs.

IV. **Improve building practices and strengthen monitoring:** after reviewing current practices and regulations, an effort should be made to improve building codes and regulations to encourage better building practices, for more resilient (or strong) structures, and to use higher quality construction methods and materials. This is especially needed in low-income areas and informal settlements, to increase resilience to extreme weather and to reduce vulnerability.

V. **Leverage existing financial mechanisms:** The Department of Rural Development and Land Reform (DRDLR) on a yearly basis evaluates the SDF's of all Municipalities. This provides an opportunity to ensure that climate change and the necessary adaptation strategies have been included in the spatial planning process. This can also help regulate which land uses are more/less desirable in certain locations according to the predicted impact of climate change. IDPs can also secue funding. Furthermore, the Province can possibly obtain funding from National Treasury to assist Municipalities that don't have the necessary funds. The DEDET, DRDLR and DARDLEA can be held more accountable for the rural areas and should be consulted to assist with the process.

VI. **Enhance disaster management and response:** stakeholders at the provincial workshop noted that rural communities often live in flood-prone areas. Flooding has an impact on infrastructure, especially electricity, roads and water supply. One possible adaptation strategy is to provide incentives such as land swaps and new houses with compensation to encourage people to move out of such rural and urban areas to better serviced areas. However, disaster response and management in such areas must be strengthened to ensure that those who continue to reside in flood prone areas have assistance. Such strengthening could include providing more resources (human, and equipment, and financial) to the disaster management teams, conducting more disaster management awareness programmes or drills, and building levees or embankments.

VII. **Improve information dissemination**: Information sharing is key to assisting with Disaster Management. In order to better protect rural and urban livelihoods, the Provincial Disaster Management Centre to the north of the Riverside complex in Mbombela could be used for:

a. training rural youth on adaptation measures (which could be a source of livelihood)
b. Informing the community on more climate resilient building practices
c. Informing tradition leaders and councils around impacts of climate change with the assistance of CoGTA

VIII. **Make better use of SPLUMA:** There needs to be better ulitisation of the Spatial Planning and Land Use Management Act as a tool for implementing adaptation strategies in terms of regulating land uses and development permissions – where to build what. This can be implemented through the incorporation of adaptation strategies into the Spatial Development Frameworks (SDF's) of all Local Municipalities. The SDF's are a spatial planning tool that assigns desirable land uses to all

land within a Municipality, and prevents undesirable land uses in certain locations. The DRDLR are currently conducting relevant projects, such as the Animal and Veld Management Programme (AVMP) and the identification of sites for the establishment of Agri-Parks, which are very inter-linked with the effects of climate change.

A large amount of land in the province is owned by Traditional Authorities who need to be be consulted/ and trained around issues of climate change and their impacts. The House of Traditional Leaders and Department of Co-operative Governance and Traditional Affairs (CoGTA) both have great influence in rural areas and should be involved to assist with the implementation of these strategies (as well as develop strategies based on their own insights as well). The Department of Rural Development and Land Reform also should be a key player in implementing the aforementioned strategies.

2.4. Ecosystems (Terrestrial and Aquatic)

2.4.1. Terrestrial and Aquatic Ecosystems in Mpumalanga

Both terrestrial and aquatic ecosystems in Mpumalanga are vulnerable to climate change impacts, particularly in the longer term. Given the large number of people who depend on natural resources for their livelihoods, this is a threat both to human populations as well as the biodiversity of Mpumalanga's ecosystems. Preserving Mpumalanga's ecosystems in the face of climate change pressures is key, especially in light of the fact that Mpumalanga's tourism industry is extremely dependent on the health and robustness of the province's natural resources, its animal life, and its ecological systems.

According to the South African National Biodiversity Institute, Mpumalanga Province already has one critically endangered ecosystem (Kaapsehoop quartzite grassland), eleven endangered ecosystems (Blyde quartzite grasslands, Chrissiesmeer panveld, Dullstroom plateau grassland, Malmani karstlands, Mananga-Lebombo thornveld, Mauchesburg alpine grasslands, Noordkaap greenstone bushveld, Sekhukhune mountainlands, Stoffberg mountainlands, Tsakane clay grassland, Wakkerstroom/Luneberg grassland), and twenty vulnerable ecosystems (Badplaas Mountainlands, Barberton Mountainlands, Croc Gorge Granite Mountainlands, Eastern Highveld Grassland, Eastern Temperate Freshwater Wetlands, Elandshoek Summit Grasslands, Elandshoogte Mountainlands, Kaalrug Mountainlands, KaNgwane Montane Grassland, Lebombo Summit Sourveld, Legogote Sour Bushveld, Loskop Mountainlands, Low Escarpment Mistbelt Forest, Lowveld Riverine Forest, Northern Escarpment Dolomite Grassland, Paulpietersburg Moist Grassland, Rand Highveld Grassland, Soweto Highveld Grassland, Springbokvlakte Thornveld, and the Tzaneen Sour Bushveld).[63]

2.4.2. Vulnerability to Climate Change

The predominant ecosystems in Mpumalanga are grasslands and Savanna. In general, the Savanna ecosystem has a fairly high resilience to climate variability and change, and is considered less vulnerable than many other ecosystems.[64] Grasslands, however, are extremely sensitive and thus highly at risk from climate change, with an increased likelihood that warmer temperatures and higher carbon dioxide levels in the atmosphere will support the growth of wooded plants and trees, edging out grasses. Several studies in South Africa suggest that the savanna biome is likely to shift into areas currently covered by grasslands, with species currently present at higher elevations replaced by species from lower elevations, which move up with warmer temperatures. This could substantially change vegetation in Kruger National Park, for instance, with implications for wildlife in the area.[65]

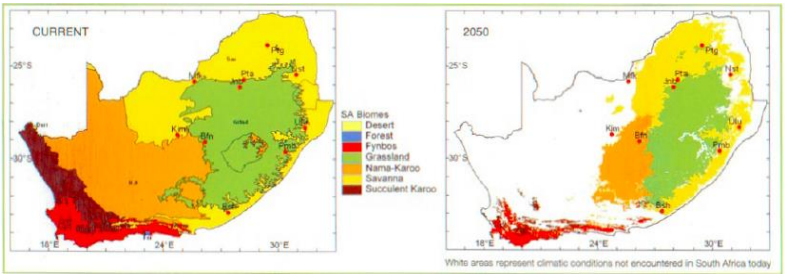

Figure 7: **Biomes of South Africa as Mapped in 2000 and Projected in 2050 (Source: SANBI, The Heat is On)**

[63] South African National Biodiversity Institute, "Summary of Listed Ecosystems by Province," http://bgis.sanbi.org/ecosystems/Summary_%20listed_ecosystems_province.pdf
[64] CSIR, Risk and Vulnerability Atlas, "Information Portal K2C," http://www.rvatlas.org/k2c/information/conservation.php
[65] South African National Biodiversity Institute, "The Heat is On," 2008 http://www.sanbi.org/sites/default/files/documents/documents/theheatison.pdf

Despite being more resilient, the Savanna biome itself may face negative impacts from climate change, as a result of encroachment by bush and woody tree vegetation.[66] This type of forest encroachment (or forest colonization) is more likely in a wetter climate scenario, with more rain (as heavy rain events could be harmful to savanna seed germination). While some studies suggest that Mpumalanga is likely to see an increase in rainfall volume and more heavy rainfall events (and LTAS suggests the opposite), what is more clear is that rising temperatures and evaporation are also likely to lead to an overall drier climate in the region, leaving it unclear whether Mpumalanga's savannas may be encroached on by forest ecosystems.[67] A better understanding is required of the impact of changing climatic conditions (carbon dioxide levels, temperature, rainfall, evaporation) in conjunction with non-climate factors (fire, grazing, changes in local megafauna etc.) on different types of savanna ecosystems in South Africa (for instance, the varied response between mesic and semi-arid savanna).[68]

Similarly, aquatic ecosystems in an already water-stressed province are likely to be negatively impacted by warmer temperatures and greater evaporation rates. Water use and availability in the province will be discussed more in the next section (the water sector) but several studies point to a decrease in water availability and decreased rainfall for the river basin, with implications for river-based biodiversity.[69] Water quality changes (such as algal blooms and lower dissolved oxygen) due to warmer water temperatures also pose a threat to aquatic ecosystems, as do invasive species.

Ecosystem changes have significant implications for Mpumalanga's tourism industry as well, given that the industry is heavily based on big game and nature tourism. As a case study, significant work has been done on assessing the potential impacts of climate change on the Kruger to Canyons biosphere reserve (which includes a section in Mpumalanga), and the study concluded that there is a real need to engage a diversity of stakeholders in developing and collectively implementing adaptation measures in the reserve.[70]

2.4.3. Ecosystem Adaptation in Mpumalanga and South Africa

In developing climate change adaptation plans for ecosystems, it is critical to recognize that a changing climate poses fundamental challenges to traditional ecosystem conservation. In a non-stationary environment, it is less valuable to demarcate certain areas for preservation or as sanctuaries, given that species ranges are themselves likely to shift. Nevertheless, a range of adaptation approaches is still useful to consider.

The Mpumalanga Biodiversity Conservation Plan is comprehensive conservation policy and guidance document, intended as a source of biodiversity information for those engaged in land use planning. It uses a "systematic biodiversity planning" approach and comprises maps of Critical Biodiversity Areas (CBAs) and land-use guidelines. Through this comprehensive process, nearly 24.2% of the province, outside of existing protected areas, has been identified for better management and to ensure a "living

[66] Vhalinavo P. Khavaghali and William J. Bond, "Increase of Woody Plants in Savannah Ecosystems," Grassroots – Newsletter of the Grassland Society of South Africa, Vol. 8, No. 2 (May 2008). http://grassland.org.za/resources/grassroots/2006-to-2010/2008/May%202008/5%20Khavhagali%20May%202008.pdf

[67] Robert J. Scholes, "Impacts and Adaptations to Climate Change in the Biodiversity Sector in Southern Africa," AIACC Project Number AF04, Final Report (2006). http://www.start.org/Projects/AIACC_Project/Final%20Reports/Final%20Reports/FinalRept_AIACC_AF04.pdf

[68] R. Buitenwerf et al., "Increased Tree Densities in South African Savannas: >50 Years of Data Suggests CO2 as Driver," Global Change Biology (2011). http://researchspace.csir.co.za/dspace/bitstream/10204/6127/1/Stevens_2012.pdf

[69] Tingju Zhu and Claudia Ringler, "Climate Change Implications for Water Availability in the Limpopo River Basin," IFPRI Discussion Paper 00961 (April 2010). http://www.ifpri.org/sites/default/files/publications/ifpridp00961.pdf

[70] Claire Davis et al., "Impacts of Climate Change on the Kruger to Canyons Biosphere Reserve," 2009-2010. http://www.rvatlas.org/k2c/download/stakeholder_engagement_strategy.pdf

landscape."[71] While the plan was created taking into account climate change (for instance, the MBCP handbook makes several references to climate change), the plan cannot be viewed as a climate change adaptation plan for ecosystems in Mpumalanga province. In fact, efforts are underway to actively explore how to integrate climate change into the MBCP, using multiple approaches such as interconnectivity enhancement.[72]

A helpful tool that is available to Mpumalanga is the SANBI-developed Biodiversity GIS Land Use Decision Support (LUDS) tool, which provides municipality-level biodiversity information and summaries, enabling planners to better understand the impacts of land use decisions on underlying ecosystems.[73] However, this too does not integrate information about projected climate change impacts to ecosystems and recommended adaptation measures.

The National Climate Change Response Strategy White Paper notes, in relation to biodiversity and ecosystem adaptation to climate change, that responses to climate change should include the following: (i) strengthening biodiversity management and research institutions for better monitoring and assessment; (ii) conservation, rehabilitation, and restoration of natural ecosystems that improve resilience; (iii) prioritizing impact assessment and adaptation planning; (iv) prioritizing research into climate change ecosystem threats in marine and terrestrial ecosystems, including effective monitoring; (v) expanding the protected area network with a perspective on climate resilience; (vi) encouraging partnerships for areas that are not under formal protected status; and (vii) expanding gene banks.[74]

2.4.4. Ecosystem Adaptation Lessons and Best Practices from Elsewhere

In recent years there has been growing interest in and uptake of Ecosystem Based Adaptation (EBA), which brings together traditional biodiversity conservation, socio-economic development, and climate change adaptation. The key elements of EBA are Community-Based Natural Resource Management (CBNRM), Community Based Adaptation (CBA), and Climate Change-Integrated Conservation Strategies.[75]

There are several examples of positive results from EBA in the field. These include IUCN's efforts in Zambia, Tanzania, and Mozambique (emphasizing the role of forests and water resources in community livelihoods), community-based fire management in Northern Australia (West

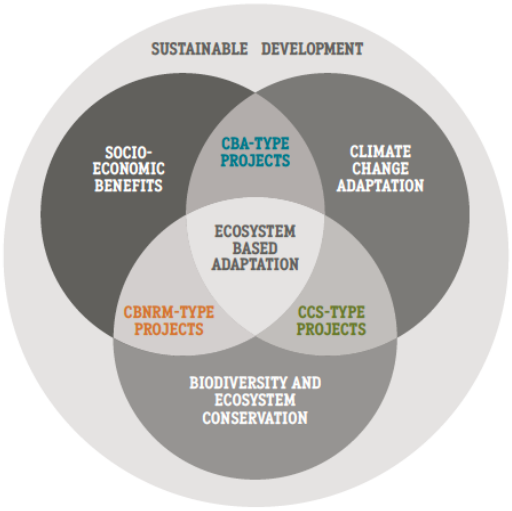

Figure 8: Ecosystem Based Adaptation

[71] SANBI, "Mpumalanga Biodiversity Conservation Plan," http://bgis.sanbi.org/MBCP/project.asp
[72] Mpumalanga Tourism and Parks Agency, "Incorporating Climate Change and Interconnectivity Into the MBCP," May 2014. http://biodiversityadvisor.sanbi.org/wp-content/uploads/2014/08/52-Lotter-MpumalangaBiodiversityPlanning.pdf
[73] SANBI, Biodiversity GIS, "Municipal LUDS," http://bgis.sanbi.org/municipalities/choose-muni.asp?prov=MP
[74] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf
[75] SANBI, "Biodiversity, Climate Change, and Sustainable Development," http://www.sanbi.org/sites/default/files/documents/documents/biodiversity-climate-change-and-sustainable-development_0.pdf

Arnhem),[76] the government of Colombia's efforts to work with local communities to build climate resilience through the protection of thousands of hectares of tropical ecosystems rich in medicinal plants,[77] debt-for-nature swaps funded by France that involve local communities in Madagascar and Cameroon,[78] grassland protection and restoration in China by the Gansu and Xinjiang Pastoral Development Project,[79] and sustainable pasture management in Mongolia to protect grasslands as well as livelihoods of local herders.[80] One of the richest sources of information in the realm of freshwater ecosystem adaptation is the World Bank's 'Flowing Forward' report, which takes a biodiversity lens to water resources management in a changing climate.[81]

There is also a great deal of literature (including case studies) about ecosystem conservation (particularly aquatic ecosystems) through the removal and management of Alien Invasive Species.[82]

2.4.5. Climate Adaptation Measures for Ecosystems in Mpumalanga - Recommendations

Across South Africa and Mpumalanga, a significant amount of attention and resources are already devoted to conservation and ecosystem preservation. However, there appears to be a need for both (a) focused programmes and initiatives that specifically take a climate change perspective when examining ecosystems; and (b) further integrating climate change into existing plans, policies, and programs, i.e. climate mainstreaming in conservation and natural resources management. To this end, a few key recommendations are offered:

I. **Develop a specialized climate change management programme to focus on protection of Mpumalanga's two main terrestrial ecosystems in the face of climate change:** There is a credible evidence-base to indicate that climate change is likely to have deleterious impacts on the grassland ecosystems in Mpumalanga, and potentially also on the savanna ecosystem. However, in addition to better understanding the climate and non-climatic dynamics that result in change, it is also essential to develop more robust studies about the biodiversity, natural capital, indigenous forests, tourism and human livelihoods impacts of these changes, as well as what can be done to reduce or better manage the change. Thus Mpumalanga could consider establishing, in partnership with other South African provinces that share grassland and savanna ecosystems, and the South African National Biodiversity Institute, a dedicated programme that strengthens the understanding of climatic changes to the two ecosystems, and simultaneously increases the knowledge-base regarding the socio-economic implications of such changes. This applied research programme could then, in conjunction with development partners, fund and implement conservation programs to arrest or manage the impacts of climate change in certain regions covered by the two ecosystems (such as in sub-sections of already protected areas). The

[76] IUCN, "Ecosystem Based Adaptation – A Natural Response to Climate Change," 2009. https://cmsdata.iucn.org/downloads/iucn_eba_brochure.pdf
[77] UNFCCC, "Ecosystem Based Adaptation," 2012 Calendar. https://unfccc.int/files/adaptation/application/pdf/nwp_cal_2012.pdf
[78] Tahia Devisscher, "Ecosystem Based Adaptation in Africa," Stockholm Environmental Institute 2010. http://www.unep.org/climatechange/adaptation/Portals/133/documents/AdaptCost/10%20EBA_AdaptCost_Final.pdf
[79] The World Bank, "Convenient Solutions to an Inconvenient Truth: Ecosystem Based Approaches to Climate Change," June 2009. http://siteresources.worldbank.org/ENVIRONMENT/Resources/ESW_EcosystemBasedApp.pdf
[80] Asian Development Bank, "Making Grasslands Sustainable in Mongolia: Adapting to Climate and Environmental Change," February 2014. http://www.adb.org/publications/making-grasslands-sustainable-mongolia-adapting-climate-and-environmental-change
[81] Tom Le Quesne et al., "Freshwater Ecosystem Adaptation to Climate Change in Water Resources Management and Biodiversity Conservation," November 2010. http://www.flowingforward.org/pdf/full.pdf
[82] Jenny Davis et al., National Climate Change Adaptation Research Facility, Australia, "Climate Change Adaptation Guidelines for Arid Zone Aquatic Ecosystems and Freshwater Biodiversity," February 2013. http://www.nccarf.edu.au/sites/default/files/attached_files_publications/Davis_2013_Climate_change_adaptation_guidelines_for_arid_zone.pdf

strategy should include the monitoring of key indicator species and ecosystems vulnerable to climate change. This can be coordinated by DEA across the various provinces, in association with the provincial government departments (such as DARDLEA).

II. **Identify and integrate specific climate-change related priorities and metrics when next revising the Mpumalanga Biodiversity Sector Plan (MBSP):** given the role of the Mpumalanga Biodiversity Sector Plan in ecosystem and natural resource management in the province, it is a critical vehicle within which to embed climate change adaptation. When the plan is next revised or updated, the latest-available research on climate change management in grassland and savanna ecosystems as well as aquatic ecosystems should inform the plan's revision (including within its quantitative targets and metrics), so as to strengthen the plan's ability to promote climate change adaptation and resilience within Mpumalanga's two primary ecosystems. In addition, it should ensure landscape connectivity and protection of climate change resilient areas. One of the ways to achieve this is to implement the MBSP and its land-use guidelines as well as the gazetting of the MBSP as bioregional plans for each district (Biodiversity Act), incorporate within SDFs, EMFs etc. The implementation and roll-out of the MBSP is of key importance in this Province.

III. Expand protected areas and promote the protected area expansion strategy:

Even though climate change makes the use of protected areas challenging (because delineating a protected area today may prove ineffective and meaningless in a few decades if climatic changes result in a shift in species range and habitat outside of the bounds of the designated protected area), stakeholders in Mpumalanga felt this strategy had significant promise even despite the challenges. Thus, it has been suggested here to reflect this.

a. Protected areas help society cope with climate change impacts by maintaining essential services upon which people depend. Without them, the challenges would be even greater, and their strengthening will yield one of the most powerful natural solutions to the climate crisis.
b. Protected areas have a role to play in adaption. They maintain ecosystem integrity, buffer local climate, reduce risks and impacts from extreme events such as storms and droughts; and they maintain essential ecosystem services that help people cope with changes in water supplies, water purification, flood attenuation and disease caused by climate change.
c. Opportunities to use protected areas in climate response strategies need to be prioritised by national and local governments.
d. Although many natural and managed ecosystems can help to mitigate or adapt to climate change, protected areas offer several advantages: recognition (often legal); long-term commitment to protection; agreed management and governance approaches; and management planning and capacity. They are often the most cost effective option. In many situations they contain the only natural or semi-natural habitats remaining in large areas.
e. The province should promote opportunities for protected area systems to maintain and increase their role in climate change mitigation and adaptation, through:
    i. Increasing the total area within protected area systems

ii. Extending existing protected areas through landscape management approaches that integrate protected areas within a matrix of land uses and as part of local adaptation strategies through community-based approaches
iii. Increasing the level of protection within existing protected area systems to ensure that they are effectively addressing threats and storing carbon
iv. Improving and adapting management of protected areas
v. Encouraging different protected area governance models including indigenous and community conserved areas and private reserves

f. Protected area systems will need to be adjusted and often expanded to fulfil their potential climate response roles of mitigation and adaptation, with implications for planning, assessment, policy and training. Individual protected areas will need adaptive management to meet changing conditions. In addition, protected area agencies have the potential to be major facilitators of natural resource management in the wider landscape, thereby contributing to sectoral and community-based adaptation.

IV. Enhance the use of ecological infrastructure to create natural buffers that create resilience against extreme weather events:

a. Ecological infrastructure is the nature-based equivalent of hard infrastructure, such as roads, bridges and water pipelines, and is just as important for providing the vital services that underpin social development and economic activity. It is the stock of functioning ecosystems that provides a flow of essential ecosystem services to human communities — services such as the provision of fresh water, rangelands for grazing, climate regulation and soil formation.
b. We need to identify and spatially map important ecological infrastructure that supports climate change adaptation.
c. A related effort is to protect genetic animal and plant diversity as this is also natural capital. For this, national parks and zoos need to be involved in the strategy.
d. This ecological infrastructure needs to be managed correctly to improve provisioning of ecosystem services.
e. Rehabilitation of important ecological infrastructure is important.
f. Such rehabilitation and preservation can form part of a Green Economy plan and can support job creation.
g. This would require a cross-cutting mandate that can be implemented across all levels of government (national, provincial, local).

All of the aforementioned initiatives must become ongoing, continuously implemented approached. While it may require a year or more to fully operationalize these strategies through more detailed sector-specific implementation plans, once there is a mandate for the strategies enumerated here they must be mainstreamed into existing operations. At the provincial level, DARDLEA would be the main driver, but significant support and political buy-in must come from municipalities, DEA and DAFF. Funding support would be necessary from the national treasury.

2.5. Tourism

2.5.1. Tourism in Mpumalanga

Mpumalanga is home to the world famous Kruger National Park, one of the most celebrated wildlife refuges around the globe. Much of Mpumalanga's tourism is, in fact, nature tourism. The vast majority to Mpumalanga identify their reason for visiting as leisure tourism. Besides Kruger, visitors to Mpumalanga are drawn by Blyde River Canyon, Echo caves, 'God's Window,' Sabi Sands Game Reserve and other nature tourism destination. Next to Gauteng, the Western Cape, Mpumalanga often attracts the third highest number of international tourists to South Africa (although this changes from year to year). It is estimated that the tourism industry contributes between 5 and 10 billion Rand a year to the province's economy (i.e. it accounts for between 3.4 – 6.4% of Mpumalanga's economy).[83]

2.5.2. Vulnerability to Climate Change

Given the predominance of nature-based tourism in Mpumalanga, climate change is a particularly serious concern for this sector. Climate change is already altering the natural world, modifying the habitat range of animals and the growing range of plants, introducing alien invasive species into regions previously not suited climatically, decreasing the numbers of some less resilient species that are unable to cope with rising temperatures and changing precipitation patterns.

In a study conducted to assess the potential impact of climate change on the Kruger-to-Canyons biosphere reserve, CSIR estimated that the region is likely to experience the following: an increase in maximum temperature by 0.5 °C – 3.5 °C per annum, an increase in minimum temperature by 0.6 °C – 2.2 °C per annum, and an increase in average temperature by 0.3 °C – 1.5 °C per annum. In terms of changes in rainfall, the area is expected to receive more rain, by 85-303 mm per annum, with especially large increases along the escarpment. Due to higher temperatures, future evaporation is also expected to increase. The study noted that a shift in climate could lead to a change in ecosystem goods and services for the area, with implications for social and economic stability in the region.[84]

2.5.3. Tourism Adaptation in Mpumalanga and South Africa

South Africa's tourism department has been proactive in studying and working to be better prepared for the impacts of climate change. The first step towards adaptation is to understand what the impacts are likely to be, in order to know what and how much to prepare for. At the national level, South Africa has already conducted a vulnerability and impact assessment of climate change on the tourism sector.[85]

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[83] Mpumalanga Department of Finance, "Role of Tourism in Mpumalanga Economy," May 2010. http://finance.mpu.gov.za/documents/ea.Role.of.Tourism.in.Mpumalanga.Economy.pdf

[84] Claire Davis, "Risk and Vulnerability Planning in the Kruger to Canyons Biosphere Reserve," http://researchspace.csir.co.za/dspace/bitstream/10204/4274/2/Davis_2010_P.pdf

[85] Department of Tourism, "Baseline Assessment: Vulnerability and Impact of Climate Change on Major Tourism Attractions and Activities," 2011. http://www.tourism.gov.za/CurrentProjects/ResponsibleTourism/Responsible%20Tourism/Baseline%20Assessment.pdf

The national government has also issued a National Tourism and Climate Change Response Programme and Plan of Action. However, this does not contain specific strategies for the tourism industry to adopt, and primarily highlights the need for such strategies to be devised.[86]

2.5.4. Tourism Adaptation Lessons and Best Practices from Elsewhere

Adaptation measures for the tourism sector often implicate other sectors. For instance, climate adaptation to preserve national parks would involve adaptation measures for ecosystems. Climate change adaptation measures in coastal areas such as beaches and coastal towns (for instance, the building of sea walls or embankments), requires the involvement of other entities such as local governments or the Public Works department. In areas where public transportation (such as train tracks) are affected by sea level rise and thus impairs the tourism sector, it is the transport sector that must undertake the adaptation measure. Nevertheless, there are climate adaptation strategies that the tourism sector itself may be able to adopt.

As enumerated in UNEP's valuable resource, "Climate Change Adaptation and Mitigation in the Tourism Sector,"[87] adaptation responses by the tourism sector could be technical, managerial, policy, research, education, or behavioral in nature.

Some examples of tourism sector climate change adaptation include sea walls that have been built in Mozambique, changes in building codes and zoning permits in Fiji, the construction of new dams and water supply infrastructure in areas facing water shortages in Thailand, the production of artificial snow at ski resorts in the USA and UK, increased air conditioning at beach resorts in the Caribbean to cope with higher temperatures, and spraying cool water onto ocean surface waters to reduce water temperatures (to prevent or reduce coral bleaching).[88]

2.5.5. Climate Adaptation Measures for Tourism in Mpumalanga - Recommendations

I. **Formally establish and draw resources to a scientific research project to better understand the impact of ecosystem and biodiversity changes on the tourism sector in Mpumalanga**: Given how closely tied the tourism sector in Mpumalanga is to the province's ecosystems, a recognition that ecosystems are vulnerable to climate change must also bring with it a better understanding of what this means for the tourism sector, in order to devise appropriate adaptation strategies for the tourism sector.

II. **Identify suitable buffers around protected areas so as not to negatively impact on tourism on reserves:** These buffers should be considered in any land-use change applications.

III. **Identify most sensitive or vulnerable tourist sites and site-specific adaptation measures**: Mpumalanga's tourism industry should conduct a climate change vulnerability assessment for the ten or twenty most visited tourist destinations in Mpumalanga, and ascertain what the climatic threats are to those specific sites or to the types of activities conducted there. Once there is a better understanding of where the biggest threats are, specific adaptation

[86] Department of Tourism, South Africa, "Draft National Tourism and Climate Change Action Plan," 2011. http://www.tourism.gov.za/AboutNDT/Branches1/Knowledge/Documents/TourismClimateChangePlan-January2011.pdf
[87] UNEP, "Climate Change Adaptation and Mitigation in the Tourism Sector," 2008. http://www.unep.fr/shared/publications/pdf/DTIx1047xPA-ClimateChange.pdf
[88] UNEP, "Climate Change Adaptation and Mitigation in the Tourism Sector," 2008. http://www.unep.fr/shared/publications/pdf/DTIx1047xPA-ClimateChange.pdf

strategies can be identified in a way that make them applicable to those particular sites. For instance, if the study finds that large mammals in Kruger park are at the risk of elevated heat stress from rising temperatures, then Kruger could consider building more shelter areas for the animals, or installing spraying systems in strategic locations etc.

The lead entity responsible for implementing these strategies would be the provincial department of Tourism, with support from the national department. The national treasury could be a potential funding source, but financial support could also be sought from international conservation-oriented donors and institutions such as IUCN. The strategies could be operationalized within a year.

2.6. Water Supply

2.6.1. Water Supply in Mpumalanga

According to the 2011 census, 71% of Mpumalanga's population had access to piped water supply within their own dwelling or yard (and 12.6% of the population has no access to piped water at all).[89] Nearly all of Mpumalanga's Municipal Water Services Authorities (WSAs) were deemed as highly or very highly vulnerable, according to the Department of Water Affairs, in 2013 (on a general, non-climate basis).[90]

Irrigation and afforestation account for a remarkable 84% of water use in the Komati basin, and over half of water use in the Limpopo, Crocodile, Luvhuvu and Olifants catchments. However, there are competing uses of water in Mpumalanga, given that the province produces 75% of South Africa's electricity, and is home to 80% of all coal mines in the country.[91]

2.6.2. Vulnerability to Climate Change

For the Northeastern region of South Africa (including Mpumalanga), climate change is likely to pose the following risks to the water sector:[92]

- Decreased availability of water in rivers as a result of the net effect of increased temperatures and increased evaporation, combined with shifts in the timing and amount of rainfall;
- Changes in the timing of high and low flows due to changes in rainfall patterns;
- A higher incidence of floods as heavy rainfall events increase;
- Increased risk of water pollution and decreased water quality, arising from erosion and high rainfall events (which elevate the amount of nutrient runoff, sediments, dissolved organic carbon) and increased temperatures (which promote algal blooms).

Greater rainfall intensity in this region is expected to increase scouring in rivers and sedimentation in dams, which has implications for water treatment and supply infrastructure.[93]

Projections suggest that even without the exacerbating influence of climate change, South Africa will "exceed the limits of economically viable land-based water resources by 2050," making this sector highly vulnerable to climate stressors.[94]

[89] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[90] Department of Water Affairs, "Strategic Overview of the Water Sector in South Africa, 2013," http://nepadwatercoe.org/wp-content/uploads/Strategic-Overview-of-the-Water-Sector-in-South-Africa-2013.pdf
[91] Dr. S. Coleman Nyathi, "An Economic Vision for Mpumalanga – Implications for the Water Sector," https://www.dwaf.gov.za/sfra/Articles/Mpumalanga%20Indaba/nyati.pdf
[92] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf
[93] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf
[94] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf

2.6.3. Water Supply Adaptation in Mpumalanga and South Africa

Very little appears to have been done within Mpumalanga in terms of addressing climate change impacts to the water sector. Available literature does not demonstrate many active plans and strategies that explicitly discuss climate change adaptation needs for water supply in Mpumalanga (for instance, the draft Mpumalanga Provincial Water Sector Plan strategic outline makes no mention of climate change nor does the Reconciliation Strategy for the Olifants).[95]

At the national level, the South Africa Risk and Vulnerability Atlas points to Integrated Water Resource Management (IWRM) as a framework for improving socio-economic welfare of people dependent on water resources without compromising the sustainability of ecosystems. It also emphasizes that water adaptation in South Africa requires more investment in information, stronger institutions, and man-made water adaptation infrastructure.[96]

The National Climate Change Response Strategy White Paper recommends a host of adaptation approaches for the water sector: (i) integrating climate change in planning processes across various relevant sectors; (ii) sustaining state of the art research on water and climate change; (iii) transboundary water management with a regional perspective; (iv) investing in water conservation and demand management, and the best catchment management; (v) exploring new or un-used sources of water such as groundwater, desalination, and treated re-usable effluents; (vi) increasing community water resilience; (vii) providing human, legal, regulatory, institutional, governance, and financial resources to cope with climate change in the water sector; and (viii) undertaking focused monitoring and research.[97]

The LTAS water sector report outlines adaptation responses across several areas, ranging from institutional approaches to hard infrastructure and service delivery, i.e. water resources management (which includes Water quality management, water resources infrastructure, and water services). In particular, it underscores the need to integrate adaptation into water resources planning frameworks in South Africa, and incorporate climate change adaptation into reconciliation studies. It also reaffirms measures highlighted in the water sector climate change adaptation strategy, including water governance; infrastructure development, operation, and maintenance; and water management (which incorporates resource management and protection; gathering and storing of better reported water data; water planning; water allocation and authorization; optimization of dam and groundwater management and operation; water conservation and demand management; and disaster management).[98]

2.6.4. Water Supply Adaptation Lessons and Best Practices from Elsewhere

There is a wealth of information on water sector adaptation measures and best practices from various corners of the globe. What is less clear, given the complexity of water resources and water supply systems, is the extent to which the range of measures adopted have been successful and to what degree. Nevertheless, there are lessons to draw from the activities taking place in this sector the world over.

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[95] Department of Water Affairs and Forestry and Mpumalanga Provincial Government, "Mpumalanga Provincial Water Sector Plan," 2006. https://www.dwaf.gov.za/masibambane/documents/strategies/pwsp/mp/mpu-strategic.pdf

[96] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010 http://www.rvatlas.org/download/sarva_atlas.pdf

[97] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf

[98] South African National Biodiversity Institute (SANBI), Long Term Adaptation Scenarios, "Water," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltaswater-tech-report2013high-res.pdf

Canada's Adaptation to Climate Team (ACT)'s policy roadmap for decision makers on climate change adaptation is instructive for water governance.[99] Burkina Faso's experience with the United Nations' national adaptation planning process is a demonstration of how well established institutional arrangements can foster early strategic thinking about medium and long term adaptation strategies.[100] The United Nations' Environment Programme (UNEP) has resources on eleven key water technologies that aid adaptation, with illustrative information on where they've been used successfully to build adaptive capacity, including developing countries like India (the technologies include boreholes and tubewells; desalination; household drinking water treatment and storage; protected wells; leakage management and detection systems for piped water; post-construction support for community-managed water supplies; rainwater collection; rainwater harvesting; water reclamation and re-use; and water safety plans).[101]

The Alliance for Global Water Adaptation (AGWA) is a helpful network and resource on the integration of climate change adaptation approaches into water infrastructure development, with projects around the world to draw insights from.[102]

2.6.5. Climate Adaptation Measures for Water Supply in Mpumalanga - Recommendations

Given the critical nature of water resources to human and economic wellbeing, there has been considerable work done on developing water-sector climate change adaptation strategies at the global, regional, and national levels. Relative to some other sectors, this is a sector that is well studied and receives a fair amount of attention from governments, development agencies and international institutions. Thus there is a rich body of knowledge to draw from for water sector planners and practitioners when evolving climate change adaptation strategies for Mpumalanga province. Some common themes reappear frequently across much of this literature, emphasizing the type of adaptation measures or approaches that are recognized widely as being integral to building resilience in the water sector: water management or governance, water infrastructure, and water service delivery. Thus, the recommendations here are also a reflection of those tenets, familiar to all in the water sector in South Africa, but with a need to now operationalize them in a province-specific manner.

IV. **Establish a cross-sectoral, inter-departmental governance framework to help integrate and mainstream climate change adaptation into all water related operations.** Water is a cross-cutting issue such that optimal management – whether in the present of for the future, taking into account climate change – cannot be done in isolation by one department. In order to ensure that climate change adaptation is integrated in all major water resource decisions and is reflected in actual implementation, there needs to be coordination between those responsible for agriculture and irrigation, for industry, for public works and domestic water supply and sanitation, for disaster management, forestry and land use, and public health. Thus, at the province level, Mpumalanga should establish a governance framework or mechanism (such as a

[99] Bon Sandford et al., "Briefing Paper for Decision Makers: Climate Change Adaptation and Water Governance," 2011. http://www.gwp.org/Global/ToolBox/References/Climate%20change%20adaptation%20and%20water%20governance%20(ACT-SFU,%202011).pdf

[100] UNFCCC, LDC Expert Group, "Best Practices and Lessons Learnt in Addressing Adaptation in the Least Developed Countries Through the National Adaptation Program of Action Process." 2011. http://www.gwp.org/Global/ToolBox/References/Best%20practices%20and%20lessons%20learned%20in%20addressing%20adaptation%20in%20the%20least%20developed%20countries%20(UNFCCC,%202011).pdf

[101] Mark Elliott et al., UNEP, "Technologies for Climate Change Adaptation – The Water Sector," April 2011. http://www.gwp.org/Global/ToolBox/References/Technologies%20and%20Practices%20for%20Climate%20Change%20Adaptation%20in%20the%20Water%20Sector%20(UNEP,%202011).pdf

[102] Alliance for Global Water Adaptation, http://alliance4water.org

standing committee or advisory board) with membership reflecting decision makers across all relevant sectors, with a specific mandate to think about and suggest how climate change adaptation can be integrated into various existing water related processes, policies, instruments, and programmes, in a holistic and well-coordinated way to ensure sectoral alignment.

V. **Ensure that proposed water related infrastructure projects explicitly integrate climate change resilience into their planning and design stages.** Mpumalanga is already a water-stressed environment, and increasing variability with climate change is expected to exacerbate the situation. Even as there may be more heavy rainfall events, there will likely be a rise in evaporation, creating greater challenges for water availability for all users. There are several plans and proposals underway to develop water-related infrastructure for Mpumalanga (such as water storage for supply, advanced water treatment plants, or flood risk reduction structures etc.), and more are likely to emerge as development pressures in the province increase. Any such proposed project must integrate climate change considerations into the entire project development process, including in the design, planning, pre-feasibility and feasibility stages, to ensure that such infrastructure projects are effective in a non-stationary environment that be modified by climate change.

VI. **Raise performance and efficiency of water service delivery for domestic use, with aggressive quantitative targets.** A key determinant of overall human vulnerability is access to basic services. While Mpumalanga is far better situated in terms of water supply compared to other South African provinces, there is a lot of progress to be made in terms to providing people adequate access to safe and reliable drinking water for domestic consumption, cooking, bathing etc. within their own dwelling unit, and also for sanitation. Until such time that the population universally enjoys water security, strengthening climate change resilience through other adaptation measures in this or other sectors will be significantly more challenging. Thus, Mpumalanga should set or strengthen targets for provision of universal water and sanitation access (in line with national targets or even more ambitious) and quantitative, measurable metrics for performance and efficiency. These should be annually evaluated and recalibrated based on progress made.

All the strategies articulated above could be developed (or further strengthened, building on existing efforts) in a one-year timeframe and then implemented on an ongoing, continuous basis (with periodic review and evaluation and recalibration as needed). These strategies should all be integrated into the municipal Integrated Development Plans (IDPs). Responsibility for implementation would rest with the Department of Water and Sanitation (DWS). However, very close coordination and cooperative governance approaches would be required, involving DEA, DAFF, DRDLR, DPW, the Department of Mineral Resources (DMR) and the Department of Cooperative Governance and Traditional Affairs (CoGTA). The national Treasury would be the main source of funding, with allocations in Departmental budgets.

2.7. Human Health

2.7.1. Human Health in Mpumalanga

Mpumalanga's health sector has received unfavorable evaluations in recent years. It is an under capacitated sector facing a relatively high disease burden (in comparison to some other provinces in South Africa). According to the South African Human Rights Commission, hospitals in the province have major shortcomings, and that public health in the province might be facing a state of collapse.[103] Even authorities in Mpumalanga have acknowledged this.[104] HIV/AIDS has taken a significant toll in Mpumalanga, but cardiovascular and respiratory health issues also pose a serious challenge.[105]

2.7.2. Vulnerability to Climate Change

Populations in Mpumalanga are vulnerable to the impacts of climate change, at least partly as a result of overall low health indices and diminished adaptive capacity. This is a result of the disease burden from HIV/AIDS, and tuberculosis, as well as poor nutritional status.

In terms of vulnerability to climate change related health impacts, Mpumalanga is a high-risk area for communicable and insect-borne diseases. It already has a very high prevalence of Malaria, relative to other provinces in South Africa. It has also been identified as vulnerable to climate change in relation to the growth of diarrheal disease, and respiratory diseases. Being situated in a high rainfall area, but with inadequate sanitation and healthcare facilities, Mpumalanga is likely to see a rise in its climate-change related disease burden.[106]

Temperatures in Mpumalanga are projected to increase with climate change, and this is likely to spark a rise in heat related health impacts such as heat stroke, dehydration, diarrheal disease, and mortality and morbidity from chronic disease (respiratory and cardiac, in particular) that are exacerbated by thermal stress on the body (from the body having to work harder physiologically to maintain thermal equilibrium).

Adaptive capacity in Mpumalanga in the health care sector is considered abysmally low. Even without the added pressure of climate change, hospitals in the province have been criticized as being amongst the most hazardous and ill-functioning in South Africa.[107] Even the South African Human Rights Commission expressed grave concern over the state of the province's healthcare facilities.[108] Thus, the province is currently ill-equipped to adapt to the health impacts from climate change.

[103] eNCA, " Mpumalanga Hospitals in Dire State," December 22, 2013. http://www.enca.com/south-africa/mpumalanga-hospitals-dire-state-sahrc
[104] Times Live, "Mpumalanga Hospitals Placed in Intensive Care," June 26, 2014 http://www.timeslive.co.za/thetimes/2014/06/26/mpumalanga-hospitals-placed-in-intensive-care
[105] Debbie Bradshaw et al., "South African National Burden of Disease Study: Mpumalanga Province," 2000. http://www.sahealthinfo.org/bod/mpumalanga.pdf
[106] UNICEF, "Exploring the Impact of Climate Change on Children in South Africa," 2011. http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf
[107] Times Live, "Hospitals in Mpumalanga Placed in Intensive Care," June 2014. http://www.timeslive.co.za/thetimes/2014/06/26/mpumalanga-hospitals-placed-in-intensive-care
[108] ENCA, "Mpumalanga Hospitals in Dire State: SAHRC," December 2013. http://www.enca.com/south-africa/mpumalanga-hospitals-dire-state-sahrc

Overall, at the national level, the Department of Health's National Climate Change and Health Adaptation Plan defines nine areas of health risk that are likely to be impacted by climate change: heat stress; vector-borne diseases; malaria; food insecurity, hunger, and malnutrition; natural disasters; air pollution; communicable diseases (like cholera); non-communicable diseases; mental health; and occupational health.[109]

2.7.3. Human Health Adaptation in Mpumalanga and South Africa

Several studies have focused on the link between climate change and malaria in Mpumalanga. Some of these have also suggested that better understanding the relationship between climate and malaria transmission is key to better malaria control and healthcare adaptation to climate change.[110] However, evidence has been scant to show that the health sector in Mpumalanga is already taking climate change into account in its strategy against malaria or other vector-borne diseases.

South Africa's National Climate Change Response Strategy White Paper highlights several adaptation responses for the health sector. These include the following: (i) reducing air pollution and diminishing other contributors to respiratory disease; (ii) improving food security and nutritional status; (iii) developing and rolling out public awareness campaigns on the health risks of heat and to inculcate avoidance behaviors; (iv) designing and implementing heat-health action plans, including improved climate-sensitive disease surveillance; (v) strengthening information base through research; (vi) improving health-data capturing such that it can be linked into multiple-risk systems like the SARVA database; (vii) improving the malaria control strategy to reduce its bio-safety hazards (from DDT); and (viii) strengthening awareness about malaria and cholera outbreaks.

In addition to these, the LTAS project identifies other key interventions necessary for the health sector, including more vulnerability assessments; enhanced monitoring and surveillance; improved access to data; multi-sectoral collaboration; and strengthening individual and social adaptive capacity overall.[111]

2.7.4. Human Health Adaptation Lessons and Best Practices from Elsewhere

Prestigious medical and health journal The Lancet has identified climate change as potentially being the biggest public health threat of the twenty first century.[112] The Intergovernmental Panel on Climate Change (IPCC) has also highlighted human health as one of the key areas of climate change impact, and emphasized the need for climate change adaptation in the health sector.[113] The IPCC's discussion of adaptation in the healthcare sector includes early warning systems, seasonal forecast systems, public education and awareness campaigns, improvement in national and international disease surveillance, the use of earth observation systems (remote sensing satellite data and Geographic Information Systems), and better training of health care professionals with regard to the effects of climate change.

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[109] Long Term Adaptation Scenarios, SANBI, "Health," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltashuman-health-tech-report2013high-res.pdf

[110] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3292497/ and http://mg.co.za/article/2014-04-10-climate-change-clouds-sas-plans-to-eradicate-malaria

[111] Long Term Adaptation Scenarios, SANBI, "Health," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltashuman-health-tech-report2013high-res.pdf

[112] The Lancet, Editorial, "Managing the Health Effects of Climate Change," May 13, 2009. http://www.thelancet.com/commissions/climate-change

[113] IPCC, Fourth Assessment Report, Report of Working Group II on Impacts, Adaptation, and Vulnerability, "Human Health," Chapter 8, 2007. https://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch8.html

The World Health Organisation (WHO) has started providing guidance to countries on how to include adaptation measures for the health sector in the process of developing National Adaptation Plans (as part of a country's submissions to the UNFCCC). The WHO's guidance urges countries to have national level climate change health adaptation strategies and to put in place adequate institutional arrangements to address climate change in the health sector.[114] The European Union is also working to increase climate change adaptation in the health sector. In its draft strategy document on adaptation to climate change impacts on human, plant, and animal health, the EU emphasizes awareness raising and communication, better inter-governmental and inter-agency cooperation, cross-sectoral policies, and the use of preparedness and risk management systems such as the EU's 'Climate, Environment, and Health Action Plan and Information System (CEHAPIS).[115]

A host of other resources also exist, showcasing best practices and lessons learned, for health care professionals and health sector policymakers[116] concerned with increasing adaptive capacity or resilience to climate change.[117] The majority of these include recurring themes such as improving the ability of surveillance systems to detect trends triggered by climate change, making infectious disease surveillance systems especially comprehensive, implementing heat early warning systems, increasing public awareness of the health impacts of climate change, and enhancing knowledge and training of health care professionals to equip them to better anticipate and address climate change related health impacts.[118]

Increasingly, coalitions and associations of medical practitioners and other health care professionals are also joining forces to urge adaptation and resilience-building in the health sector, as a response to climate change. These organizations can be useful resources to their counterparts in South Africa. A few examples include Healthcare Without Harm,[119] the Climate and Health Council,[120] and Physicians for Social Responsibility.[121]

2.7.5. Climate Adaptation Measures for Human Health in Mpumalanga - Recommendations

Globally the health sector has received an increasing amount of attention in recent years, in the context of climate change impacts to human health and the development of adaptation responses to ameliorate and manage such impacts. In South Africa, however, there is comparatively less literature on this subject, due to fewer health sector studies that specifically take a climate change perspective. While the field is certainly growing and is better understood every passing day, there is still a pressing need for credible, peer reviewed literature from within South Africa and from within Mpumalanga province to shed light on various aspects of the public health threats from climate change. Thus, the following recommendations are made with a view to strengthening this body of evidence and building capacity in the health sector to cope better with expected impacts from climate change.

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[114] WHO, "WHO Guidance to Protect Health from Climate Change Through Health Adaptation Planning," 2014. http://apps.who.int/iris/bitstream/10665/137383/1/9789241508001_eng.pdf?ua=1

[115] European Commission, "Adaptation to Climate Change Impacts on Human, Animal, and Plant Health," Commission Staff Working Document, 2013. http://ec.europa.eu/clima/policies/adaptation/what/docs/swd_2013_136_en.pdf

[116] Anthony McMichael, NCCARF, "Human Health," 2009. https://www.nccarf.edu.au/sites/default/files/attached_files_publications/NCCARF%20health%20brochure_S.pdf

[117] Emma Back, CDKN, "Managing Climate Extremes and Disasters in the Health Sector," 2012. http://cdkn.org/wp-content/uploads/2012/10/SREX-lessons-for-health-sector.pdf

[118] Jonathan Samet, Resources for the Future, "Public Health: Adapting to Climate Change," March 2010. http://www.rff.org/RFF/Documents/RFF-IB-10-06.pdf

[119] Healthcare Without Harm https://noharm.org

[120] The Climate and Health Council http://www.climateandhealth.org

[121] Physicians for Social Responsibility http://www.psr.org/environment-and-health/climate-change/

IV. **Formally join, participate in, and leverage capacity and information from global climate change health networks and knowledge-sharing platforms.** Globally, there is an extraordinary wealth of information on climate change impacts on the health sector. Mpumalanga can benefit from this rich evidence base by establishing partnerships and collaborations with some of the leading institutions working in this space (universities and medical research organizations), as well as networks of practitioners who are actively implementing climate change adaptation strategies in the health sector in similar settings.

V. **Secure, dedicate, and allocate substantial funding for better climate-related health surveillance and monitoring in the province and to carry out studies within Mpumalanga on health impacts of climate change.** Within South Africa and Mpumalanga province, there is still a dearth of locally-relevant medical and public health literature that can inform decision makers about specific threats within Mpumalanga, and the best measures to tackle the specific risks. This type of evidence base can be built and strengthened by both improving disease surveillance and monitoring systems (and to make them more attuned to climate-sensitive diseases), and by funding more research that investigates climate related health impacts and trends in the province (this research will, in turn, benefit from the enhanced monitoring and data-collection).

VI. **Fund and implement a comprehensive public health and climate change awareness and adaptive capacity building programme,** with a particular focus on heat-health and vector-borne diseases, water-borne diseases, respiratory health, and with a special focus on vulnerable populations like children and the elderly. While there is a large range of health impacts that are likely to be influenced and exacerbated by climate change, adaptive capacity can be strengthened fairly quickly in the short term by focusing on some of the more well-understood diseases and health impacts that are of greater relevance in a setting like Mpumalanga. Even as the healthcare sector's own capacity must be raised to respond better to climate-related health impacts, there are significant gains to be made be empowering people (especially women and families) to monitor their own health and take adaptive measures to reduce their risk in simple ways. Thus, an educational and capacity-building campaign would be of benefit in Mpumalanga.

Each of the aforementioned initiatives could be developed (or further strengthened, building on existing efforts) in a one-year timeframe and then implemented on an ongoing, continuous basis (with periodic review and evaluation and recalibration as needed). These strategies should all be integrated into the municipal Integrated Development Plans (IDPs). Responsibility for implementation would rest the Department of Health, but in coordination with LEDET, DWS, DEA, and the Department of Education (DoE). Funding could be secured from development partners and international institutions (given a large potential pool of health sector grants and aid), but would also be sought from the national treasury.

2.8. Disaster Management

2.8.1. Disasters in Mpumalanga Province

Mpumalanga has experienced a range of natural disasters in recent times, from floods to veldfires to drought. Each of these disaster types is impacted by climatic conditions, and thus a changing climate has significant implications for the frequency and intensity of such events in the province. During January to August 2007, fires in Mpumalanga affected forestry plantations, damaging almost one-tenth of the province's entire plantation area. Over 70% of Mpumalanga province is classified as being at veldfire risk.[122] The province also experiences fire outbreaks in 2012, in both the Highveld and lowveld.[123]In 2014, Mpumalanga suffered from severe floods, which killed an estimated 12 people and caused 535 million Rand in damage.[124] In 2015, however, the province has been drought-stricken, like much of South Africa.

2.8.2. Vulnerability to Climate Change

A range of climate change reports for South Africa, including the South African Risk and Vulnerability Atlas (SARVA) and the Climate Change Handbook for Northeastern South Africa, all suggest that certain categories of natural disasters are expected to worsen with climate change across the country, including the region where Mpumalanga province is located (north-central South Africa).

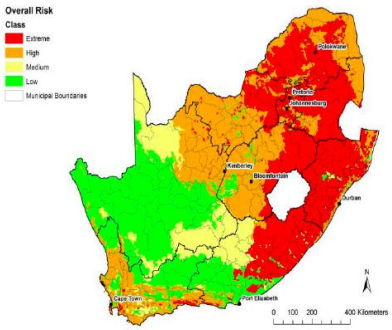

Figure 9: Veldfire risk classification of the country (CoGTA, 2012)

A study by the national department of Cooperative Governance and Traditional Affairs mapped out areas of existing risk to veldfires. It is evident that while all of Mpumalanga province is at risk, the interior of the province is particularly at high risk (see figure below).[125] With climate change, as temperatures and evaporation rates increase across the province (as is expected), the hot and dry conditions are likely to worsen the risk of veld fire.

According to findings of the LTAS project, Mpumalanga is the second-most at-risk province for flood-related damage to power line crossings, in the face of increased floods resulting from climate change.[126]

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[122] GG Forsyth et al., "National Veldfire Risk Assessment," March 2010. http://www.nda.agric.za/doaDev/sideMenu/ForestryWeb/webapp/Documents/Veldfire_Risk_Report_v11.pdf

[123] News24, "High Risk of Veldfires in Mpumalanga," August 8, 2012. http://www.news24.com/SouthAfrica/News/High-risk-of-veldfires-in-Mpumalanga-20120808

[124] SAPA, IoLNews, "Mpumalanga Flood Damage Costs R535 million," April 2, 2014. http://www.iol.co.za/news/south-africa/mpumalanga/mpumalanga-flood-damage-costs-r535m-1.1670199

[125] SALGA, Sabelo Gwala, "Disaster Risk Reduction: A Multi Stakeholder Approach to Targeted Intervention in Selected Municipalities," March 2013. http://www.salga.org.za/app/webroot/assets/files/Research_Results/Disaster%20Risk%20Reduction%20-%20March%202013%20-%20Publication.pdf

[126] SANBI, "Climate Change Adaptation: Perspectives for Disaster Risk Reduction and Management in South Africa," 2013. https://www.environment.gov.za/sites/default/files/reports/ltasphase2_perspectivesfordisastermanagementinSA.pdf

2.8.3. Disaster Management Adaptation in Mpumalanga and South Africa

In terms of existing disaster management frameworks and structure, Mpumalanga's capacity has been growing, especially with the establishment of the Ehlanzeni Disaster Management Center. According to an assessment by the South African Local Government Association (SALGA), the following Disaster Management related bodies in Mpumalanga province are all in place and functioning: the disaster risk management centre, the disaster risk management advisory forum, an inter-departmental disaster risk management committee, a volunteer disaster management unit, and a disaster risk management plan is also in place as part of the province's IDP. Amongst these, it assessed that the inter-departmental disaster risk management committee and the advisory forum were operating less effectively than the others, in a relative scale. Additionally, a case study of Mbombela Municipality by SALGA revealed that despite all the right institutional structures in place, actual fire-fighting capacity was low, both in terms of numbers and in terms of availability of adequate, functional equipment.[127]

Based on a literature review and engagement with stakeholders at two provincial workshops, there isn't enough evidence to suggest that existing disaster management structures and policy frameworks and regulations at the provincial level have actively and explicitly integrated climate change. The department and officials are well aware of the additional risks posed by climate change and thus are implicitly prepared for the increase in climate related disasters. However, this needs to be made explicit and climate change needs to be mainstreamed in provincial disaster management efforts so that an increase in resources and skills training can be assured in the face of growing threats.

The national level LTAS project produced a number of recommendations for climate change adaptation in the disaster risk management sector. These include: continuous monitoring; establishment and increased deployment of flood and drought early warning systems; improved land care, catchment management, and water-sensitive urban design; enforcement of existing zoning practices to reduce the number of vulnerable people in flood-risk areas; maintenance and correct operation of existing infrastructure; integrated design and planning to take into account climate risk and change uncertainty; and improved safety-nets and income diversification for particularly vulnerable populations.[128]

South Africa's National Climate Change Response Strategy also laid out several recommendations for adaptation to climate change, in relation to the disaster management sector. It urges that South Africa: continue to develop and improve early warning systems for weather and climate (especially severe weather) events and pest infestation events and to ensure that these warnings reach potentially affected populations timeously; seek to collaborate with neighbouring states to share early warning systems with regional applications and benefits; continue to promote the development of risk and vulnerability service centers at universities, which will in turn support resource-constrained municipalities; facilitate increased use of seasonal climate forecasts amongst

[127] SALGA, Sabelo Gwala, "Disaster Risk Reduction: A Multi Stakeholder Approach to Targeted Intervention in Selected Municipalities," March 2013. http://www.salga.org.za/app/webroot/assets/files/Research_Results/Disaster%20Risk%20Reduction%20-%20March%202013%20-%20Publication.pdf

[128] SANBI, "Climate Change Adaptation: Perspectives for Disaster Risk Reduction and Management in South Africa," 2013. https://www.environment.gov.za/sites/default/files/reports/ltasphase2_perspectivesfordisastermanagementinSA.pdf

key stakeholders, such as in the water and agriculture sectors; maintain, update, and enhance the SARVA as a tool that provinces and municipalities may use to inform climate change adaptation planning; cooperate with social networks such as community organisations, non governmental organisations (NGOs), women and farmers organisations, and the Adaptation Network to help raise awareness, transfer technology, and build capacity; and develop mechanisms for the poor to recover after disasters, including micro-insurance.[129]

2.8.4. Disaster Management Adaptation Lessons and Best Practices from Elsewhere

Internationally, a great deal of work is underway to integrate and mainstream climate change into disaster risk reduction and disaster management instruments and institutions. At the broadest level, the Hyogo Framework for Action calls on all nation states to "promote the integration of risk reduction associated with existing climate variability and future climate change," and makes multiple references to climate change as an exacerbating factor for disaster risk in the coming years.[130] The International Federation of Red Cross and Red Crescent Societies have established the Red Cross Red Crescent Climate Center, to help humanitarian communities in responding to climate change related disasters and to facilitate better preparation for such disasters as they increase in frequency or intensity. They have published several useful guides to help the disaster management community build capacity to respond to climate change risks,[131] including a "Guide to Mainstreaming Disaster Risk Reduction and Climate Change Adaptation,"[132] which provides guidance for mainstreaming in several sectors such as healthcare, water sanitation and hygiene, migration, human settlements, livelihoods and food security, and natural resource management. The Intergovernmental Panel on Climate Change (IPCC) specifically addressed, in the Special Report in Extreme Weather (SREX), the need for disaster management to adapt to a changing climate. Amongst other things, it noted that management strategies that focus on reduction of everyday (or chronic) risk (as opposed to solely extreme events) help reduce both disaster risk and improve the ability to respond to extreme events; greatly improved and strengthened disaster risk management and adaptation will be needed as part of the development process; and community participation in planning, decentralized decision making, and the use of local community knowledge and capacity will be critical.[133]

For practitioners of disaster management and for policymakers engaged in disaster management planning and regulation, there are a host of resources providing exposure to best practices. These include the Global Facility for Disaster Reduction and Recovery's "Understanding Risk: Best Practices in Disaster Risk Assessment,"[134] which (inter alia) describes the use of open data and crowdsourcing the help disaster risk reduction and response, the implementation of community-based risk assessments, and the use of satellite earth observations to support disaster management. The

[129] South African National Biodiversity Institute (SANBI) and Department of Environmental Affairs, "National Climate Change Response White Paper," (2011). http://www.sanbi.org/sites/default/files/documents/documents/national-climate-change-response-white-paper.pdf
[130] United Nations International Strategy for Disaster Reduction, "Hyogo Framework for Action," 2007. http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf
[131] IFRC, "Aggravating Factors: Climate Change," http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/aggravating-factors/climate-change/
[132] IFRC, "A Guide to Mainstreaming Disaster Risk Reduction and Climate Change Adaptation," 2013. http://www.ifrc.org/PageFiles/40786/DRR%20and%20CCA%20Mainstreaming%20Guide_final_26%20Mar_low%20res.pdf
[133] IPCC, SREX, Allan Lavell and Michael Oppenheimer, "Climate Change: New Dimensions in Disaster Risk, Exposure, Vulnerability, and Resilience," 2012. http://www.ipcc.ch/pdf/special-reports/srex/SREX-Chap1_FINAL.pdf
[134] The World Bank, "Understanding Risk: Best Practices in Disaster Risk Assessment – Proceedings from the 2012 UR Forum," 2012. http://www.gfdrr.org/sites/gfdrr/files/publication/UR_Proceedings_120912_reduced.pdf

Australian National Climate Change Adaptation Research Facility recommends the introduction of collaborative funding (across national, provincial, local, and community levels) for groups to work together to tackle disaster risk in various areas; the use of local community resilience grants; and embedding researchers with disaster response and management teams so as to produce better studies and observations of areas for intervention.[135] The Catalyst Project's "Best Practices Notebook for Disaster Risk Reduction and Climate Change Adaptation" provides insights into institutional and organizational change to help mainstream climate change into disaster risk reduction policymaking; ecosystem-based disaster risk reduction; and management of climate change disaster risks in urban areas.[136] The World Bank has also published a guide for disaster management practitioners trying to integrate climate change, titled "Understanding Risk in an Evolving World: Emerging Best Practices in Natural Disaster Risk Assessment," which (amongst other things) highlights the use of open data for building resilience; the use of Geographic Information Systems (GIS); Government-to-Government risk assessment capacity building; a framework for modelling future urban disaster risk; and global probabilistic risk assessment modelling.[137]

2.8.5. Climate Adaptation Measures for Disasters in Mpumalanga - Recommendations

There is a need for both greater actionable information on climate-related disasters in Mpumalanga, as well as a need for strengthening existing capacity to respond to disasters (a need that will increase with climate change making disasters such as floods and fires more frequent and intense). Thus some key recommendations for Mpumalanga are as follows:

IV. **Secure, dedicate, and allocate funding for research on specific climate-related disaster risks for Mpumalanga, based on climate change scenarios, including identifying geographic hotspots for each major disaster type.**

V. **Develop and implement public awareness and training programmes based on this evidence base to educate people about climate change related disaster risks and responses.**

VI. **Strengthen overall disaster prevention, disaster management, and disaster response in the province through broad-based capacity building of first responders and relevant officials.**

In terms of responsibilities, all departments are responsible themselves for including issues of climate change into their own plans. Departments should seek increases in their budgets to allow for better disaster management and planning, with the inclusion of climate change as a criterion. If department budgets are exhausted, additional funding could be sought from the Disaster Management Center. Implementation of these strategies should take place within a year.

[135] Michael Howes et al., NCCARF, "Rethinking Disaster Management and Climate Change Adaptation," 2013. http://www.climateaccess.org/sites/default/files/Howes%20et%20al_Rethinking%20disaster%20risk%20management.pdf

[136] Matt Hare et al., "A Best Practices Notebook for Disaster Risk Reduction and Climate Change Adaptation: Guidance and Insights for Policy and Practice from the Catalyst Project," 2013. http://www.catalyst-project.eu/doc/CATALYST_D65_Best_Practices_Policy_Notebook.pdf

[137] The World Bank, Global Facility for Disaster Reduction and Recovery, "Understanding Risk in an Evolving World: Emerging Best Practices in Natural Disaster Risk Assessment," 2014. http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/japan/pdf/101414_event/Understanding_Risk-Web_Version-rev_1.8.0.pdf

2.9. Extractives (Mining)

2.9.1. Mining in the Mpumalanga Province

The extractives sector (mining and minerals) contributes just under a fifth of Mpumalanga's total economy, and was responsible for 0.7% of the province's GDP annual growth in 2010. Mining is a critical pillar of the province's economy, with the main minerals being coal, gold, and nickel, with some platinum.

While the sector is not directly impacted by changes in temperature and rainfall in the way that ecosystems and agriculture are, the sector's water dependency and the effect of heat on working conditions makes this sector susceptible to climate change as well.

2.9.2. Vulnerability to Climate Change

Understanding future water availability in Mpumalanga is challenging because climate models do not currently provide clarity on whether the region will experience a rise in rainfall volumes or a reduction in rainfall. Even with a moderate increase in rainfall, however, higher temperatures and evapotranspiration suggest that the region will face a drier future.

Water stress and scarcity is a risk and a source of vulnerability to the mining sector in South Africa and the Mpumalanga, given the mining industry's heavy consumption of water for commercial activity (water is required for several industrial processes within mines and for treating ores etc.). Across South Africa, the mining sector uses three percent of all water withdrawn in the country (more than all other industries and commercial users put together).[138] In an average platinum plant, for instance, 36% of the water footprint lies in evaporation from the mineral processing unit, and 19% from the tailings storage facility.[139] By 2030, South Africa is likely to face a 17% gap between available water and projected demand.[140]

Not only is water scarcity a risk for the mining industry because of potentially lower water availability for its own operations, it is also a risk because in conditions of water stress or scarcity, this may result in regulatory risks or restrictions on certain aspects of its operations. For instance, many mines "dewater" dolomite aquifers in order to safely conduct mining below a certain depth; in a situation of growing water scarcity, such practices may be limited in the public interest. In the same vein, water scarcity from climate change could result in further environmental standards for the mining industry, to ensure that it does not negatively impact the water quality of limited freshwater through its discharge of mining wastes like overburden, waste rock, slime and other effluents.

A situation where the region experiences an increase in rainfall comes with risks of its own. More rainfall, especially heavy rainfall events and increased surface runoff, would likely exacerbate the problem of Acid Rock Drainage (ARD) or Acid Mine Drainage (AMD). Flash floods and heavy water runoff can also cause scour in mining areas, an additional risk to the industry's operations.[141]

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[138] EL Haggard, CM Sheridan, and KG Harding, "Quantification of Water Usage at a South African Platinum Plant," 2015. http://www.wrc.org.za/Lists/Knowledge%20Hub%20Items/Attachments/11180/SE410214%20abstract.pdf

[139] N. Ranchod et al., "Assessing the Blue Water Footprint of an Opencast Platinum Mine in South Africa," *Water South Africa* Vol. 41, No. 2 (2015) http://www.ajol.info/index.php/wsa/article/view/115261

[140] Linda Dailey Paulson, "South African Coal Industry Examines Water Footprint," RWL Later, February 2, 2015. http://www.rwlwater.com/south-african-coal-industry-examines-water-footprint/

[141] Climate Change Business Journal, "Climate Change and the Mining Industry," Environmental Business International, 2013. http://www.climatechangebusiness.com/Mining_Industry_and_the_Climate_Change

The mining industry is also vulnerable to climate change impacts in terms of working conditions of mine labour. Rising temperatures may pose health hazards and reduce labour productivity, and worsen air quality conditions within mines.[142]

2.9.3. Extractives Sector Adaptation in Mpumalanga Province and South Africa

The mining industry in South Africa has already been taking several initiatives to improve its environmental performance, including water conservation and treatment. The South African mining industry has started looking at mine water re-use as a serious and viable option.[143]

On the policy side, the government developed an Integrated Water Quality Management Strategy for the Vaal river system (alongside a comprehensive reconciliation study), which extends into Mpumalanga. A study on the Potential Savings Through Water Conservation and Water Demand Management in the Upper and Middle Vaal Water Management Areas was also conducted.[144] At a national level, the second National Water Resources Strategy of 2013 placed a strong emphasis on treatment (including desalination) of mine water and on reducing the problem of AMD (including by modifying the conditions on mining licenses).[145]

The Department of Energy and CSIR's Sustainable Development Through Mining programme tackles a host of environmental issues, including wastewater treatment and mitigation of AMD.[146]

2.9.4. Extractives Sector Adaptation Lessons and Best Practices from Elsewhere

Within the mining industry globally, there is growing awareness and understanding of the risks that climate change poses. BSR (a global corporate social responsibility consulting firm) surveyed risks and opportunities to leading mining companies worldwide and identified adaptation practices that fell into two categories: value protection (ensuring resilience of physical assets and planning responses to maintain business and usual operations) and value creation (devising solutions that contribute to the ability to pursue new revenue-generating opportunities and help suppliers, stakeholders, and customers adapt to climate change).[147]

According to BSR, under the value protection category, companies like Vale and Gold Fields have already established internal management systems and strategies to address climate change; Anglo-American, Exxaro, Vale, and Newmont have engaged in on-site scientific assessments and modelling to estimate physical risk to their assets; HudBay Minerals and Norsk Hydro have formally modified their existing risk identification and management protocols to include climate change; Anglo-American, Exxaro, and Gold Fields have integrated climate change related risk and mitigation into decision making processes during the entire project cycle; Kumba Iron Ore, Alumina, Kinross, and Norsk Hydro have strengthened or made more robust some of their site, project, and facility designs to be more structurally resilient to climate

[142] T. Kjellstrom et al., "Climate Change and Occupational Health: A South African Perspective," *South African Medical Journal* (August 2014) http://www.scielo.org.za/scielo.php?pid=S0256-95742014000800033&script=sci_arttext
[143] James Fotouhi, "Unearthing Mining Water Technology Innovation," WaterWorld Vol. 29, Issues 6 http://www.waterworld.com/articles/wwi/print/volume-29/issue-6/technology-case-studies/unearthing-mining-water-technology-innovation.html
[144] Department of Water Affairs, "Position Statement on Vaal River System and Acid Mine Drainage," November 2010. https://www.dwa.gov.za/Projects/AMDFSLTS/Documents/Vaal%20River%20System%20&%20AMD%20Version%203.pdf
[145] Desalination and Water Re-use Business News, "South Africa to Focus on Desalination and Water Re-use," July 2013. http://www.desalination.biz/news/news_story.asp?id=7152
[146] Sustainable Development Through Mining http://www.sdmining.co.za
[147] Julia Nelson and Ryan Schuchard, BSR, "Adapting to Climate Change: A Guide for the Mining Industry," http://www.bsr.org/reports/BSR_Climate_Adaptation_Issue_Brief_Mining.pdf

change; Teck, Cameco, Goldfields, Harmony Gold and Vale have developed emergency procedures and contingency plans that incorporate climate change; Norsk Hydro, Anglo-American, Newcrest, Exxaro, and Iluka Resources have significantly improved their water management systems.[148]

In terms of value creation, BSR reports that Gold Fields has responded to potential changes in future market conditions (resulting from climate change and environmental stresses) by expanding the portfolio of commodities; Gold Fields and Anglo-American are both developing and testing technology to help operations continue in potentially harsher climatic conditions; Barrick, Rio Tinto, Exxaro, Sesa Goa, Gold Fields, and Vale are investing in renewable energy and alternative fuels; and Gold Fields has pioneered waste recycling programs that could also bring in revenue from carbon credits.[149]

Best practices are also detailed in the International Council of Mines and Minerals' (ICMM's) publication, "Adapting to a Changing Climate: Implications for the Mining and Metals Industry."[150] The report recommends an adaptation framework within which the mining industry could develop and implement a large range of measures (many of which are detailed in the publication). The framework comprises: awareness, engagement and objective-setting; risk and opportunity assessment; monitoring, evaluation, and reporting; adaptation planning; adaptation actions; and partnership and collaboration. The range of adaptation measures described include those pertaining to protecting physical assets and facilities, changing management and strategic processes internally, engaging with climate change processes at the international and national level to be a part of decision-making; conducting risk assessments; diversifying business models and a number of other options.[151]

2.9.5. Climate Adaptation Measures for Extractives in Mpumalanga - Recommendations

There is a need for more in-depth and province-specific studies in Mpumalanga regarding the implications of a changing climate for its mining industry. The following strategies could provide a strong foundation for further work by the industry and the provincial government, including in collaboration:

I. **Establish a long-term climate change and health programme for the mining sector in the province:** the government should work with the industry and mining unions to better assess and prepare for increasing heat stress and temperature-related health threats that those working in the mining industry will be exposed to, as well as other health concerns such as potentially higher dust levels from dryer conditions. Such a long-term program would involve better monitoring and reporting of worker health, and also promote adaptation measures at the individual and business level (including better hydration, improved ventilation, heat stress early warning protocols etc.). It should be noted that it may be likely that best practices are already being implemented, but if so these could be formalized and monitored across the board.

   The Department of Mineral Resources (DMR) should be the lead implementing entity for this strategy, and operationalize this in coordination with the Department of Labor (DoL), Department of Health (DoH), mining companies, the Chamber of Mines, and mine worker unions. Final implementation of such a programme would rest with the individual mines themselves. This

[148] Julia Nelson and Ryan Schuchard, BSR, "Adapting to Climate Change: A Guide for the Mining Industry," http://www.bsr.org/reports/BSR_Climate_Adaptation_Issue_Brief_Mining.pdf
[149] Julia Nelson and Ryan Schuchard, BSR, "Adapting to Climate Change: A Guide for the Mining Industry," http://www.bsr.org/reports/BSR_Climate_Adaptation_Issue_Brief_Mining.pdf
[150] ICMM, "Adapting to a Changing Climate: Implications for the Mining and Metals Industry," http://www.icmm.com/page/92086/adapting-to-a-changing-climate-implications-for-the-mining-and-metals-industry
[151] ICMM, "Adapting to a Changing Climate: Implications for the Mining and Metals Industry," March 2013, http://www.icmm.com/document/5173

strategy can be operationalized within a year, and thereafter there should be continuous implementation as this should be an ongoing programme. Funding for the strategy can be sought from DMR as well as mining companies' Corporate Social Responsibility budgets.

II. **Organize an annual conference or symposium in the province focused on the mining industry's response to climate change:** the industry, in collaboration with the government, should convene annually or biannually to focus attention and resources on the impacts of climate change and approaches to adaptation and risk-reduction. Bringing in experts from other regions would help with knowledge-transfer and expose the industry to best practices that have been successful elsewhere in building resilience to climate change.

The Department of Mineral Resources (DMR) should be the lead implementing entity for this strategy, and operationalize this in coordination with the Department of Environmental Affairs (DEA), mining companies, and the Chamber of Mines. The conference need not be restricted to one province, it could be a national level conference with participation by all provinces and local governments. However, if conducted at a Provincial level the lead entity should be Mpumalanga Department of Economic Development, Environment, and Tourism. This strategy can be operationalized within a year, and thereafter there should be continuous implementation as this should be an annual event. Funding for the event can be sought from DMR as well as mining companies' Corporate Social Responsibility budgets.

III. **Fund a province-specific assessment of water related climate change risk to the mining industry in Mpumalanga:** given the central role of the mining sector in the provincial economy, the government should allocate resources for a comprehensive climate change risk assessment focused on water, in relation to the mining industry in the province. Improved knowledge of risks will enable the industry and policymakers to evolve more tailored adaptation actions in the future.

The Department of Water and Sanitation would be an appropriate lead entity for this strategy, in close collaboration with DMR as well as DEA, and the mining companies. At the provincial level, DEDET and other relevant local entities would drive the strategy implementation. The assessment could be kicked off within a year, aiming for results within another year's timeframe. Funding for this initiative could come from DWS or from DEDET.

3. CONCLUSION

It is critical that the recommended adaptation strategies in this report not become relegated to archival documentation but that they be translated into implementable and actionable adaptation plans.

For the strategies to be converted into ground reality, it is imperative that the relevant departments for each sector within the province take cognizance of the recommended strategies, and integrate the strategies into their annual planning and budgetary processes. Departments are best placed to assess the yearly and long-term expenditure required for the application of such strategies, and have a detailed understanding of their funding streams. Thus, sector-experts within the departments should be given the responsibility of preparing detailed implementation plans for the relevant strategies, identifying timelines, coordination mechanisms, monitoring and evaluation mechanisms, metrics to gauge the implementation and progress of the strategy, and the required financial and human resources.

In addition, the national Department of Environmental Affairs (DEA), the Department of Agriculture, Forestry and Fisheries (DAFF), the Department of Human Settlements (DHS), the Department of Water and Sanitation (DWS), the Department of Mineral Resources (DMR), the Department of Rural Development and Land Reform (DRDLR), the Department of Health, the Department of Mineral Resources (DMR), and the Department of Tourism are urged to take note of the sector-by-sector strategies recommended for the province. National Departments can investigate potential ways of supporting the development of implementation plans in the corresponding sector at the provincial level, and work with the National Treasury to assist the allocation of funds for the implementation of the corresponding sector strategies.

Similarly, Local Municipalities within the province are also urged to take cognisance of the recommended strategies and identify ways to integrate the strategies into their next Integrated Development Plans (potentially with assistance and guidance from SALGA).

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