LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
ECONOMIC DEVELOPMENT, ENVIRONMENT & TOURISM

Climate Support Programme (CSP) – Climate Change Adaptation Strategies

Adaptation Strategies for Limpopo Province

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

environmental affairs
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REPUBLIC OF SOUTH AFRICA

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1. Executive Summary

South Africa has begun to experience the impacts of climate change, and is becoming increasingly aware of future impacts that it must prepare for.[1] The country 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] All of South Africa's provinces, including Limpopo, are likely to witness changes brought about by future climate change. In fact, recent climate change science from within the country indicates that the region within which Limpopo province is located could face could face a potential increase in temperatures by as much as 2°C by 2035, by 1-2°C between 2040 and 2060 (or even 2-5°C in the high-end scenarios), and by 3-6°C between 2080 and 2100 (or as much as 4-7°C in the high-end scenarios). Thus, Limpopo faces a warmer, and potentially hotter future. In terms of rainfall, available science is less definitive; while some models project decreased rainfall over Limpopo in the long term, these rainfall projections remain within the realm of present-day variability.[3] However, at the same time other models suggest that there may be future increases in rainfall in the region, exemplifying the uncertainty in model projections for this region of Southern Africa within the existing body of knowledge.

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,[4] implying a drier future even in the presence of greater rainfall and heavy rainfall events.[5]

In recognition of the need to be better prepared for such climate change impacts and uncertainty, Limpopo province has taken laudable steps towards building its climate change resilience. A key initial step was the preparation of the Limpopo Green Economy Plan.[6] The present report builds on the strong foundation of the Green Economy Plan by assessing climate change vulnerability of major sectors and thereafter identifying high-level strategies that could reduce vulnerability by strengthening the ability to respond and cope well, i.e. by building adaptive capacity. This report captures a set of initial adaptation strategies for each of the key sectors in Limpopo that exhibit high climate change vulnerability (based on the findings of a vulnerability assessment) or sectors that are critical to the province's economy. The identification of sectors and overall project approach and methodology were validated with stakeholders and experts in a workshop in Limpopo province in March 2015, and the strategies were presented to and reformulated by stakeholders in a second such workshop in the province in May 2015. Thus, stakeholders within the province endorsed (and in many cases proposed) the strategies enumerated here.

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:

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

[5] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

[6] LEDET, Provincial Government of Limpopo, "Limpopo Green Economy Plan: Including Provincial Climate Change Response," une 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf

Agriculture

I. Create a Climate Smart Agriculture programme to help develop or promote the use of specific seed or plant varieties in specific locations.
II. Enhance ongoing efforts involving Conservation Agriculture.
III. Initiate a dedicated climate change adaptation programme for cattle ranching / livestock rearing in the province.
IV. Fund and implement a comprehensive climate change awareness and skills-building programme within the province.

Livelihoods and Settlements – Rural and Urban

I. Devote resources to identifying and providing training on alternate sources of livelihood for different regions and communities within Limpopo.
II. Create and strengthen support business development mechanisms for smallholder farmers.
III. Redouble efforts to improve overall socio-economic security and wellbeing.
IV. Enhance efforts to reduce flood risk to rural and urban communities.

Ecosystems – Terrestrial and Aquatic

I. Develop a specialized climate change management programme to focus on protection of Limpopo'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 Limpopo Biodiversity Conservation Plan.
III. Formally establish and draw resources to a scientific research project to better understand the loss of bird species-richness in the South African Limpopo Basin.
IV. Develop a focused climate change adaptation response plan and implementation programme targeting the province's wetlands and water pans.

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.
IV. Strengthen existing Catchment Management efforts.

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 Limpopo on health impacts of climate change.
III. Fund and implement a comprehensive public health and climate change awareness and adaptive capacity building programme.
IV. Redouble efforts to improve overall socio-economic status and health indices.

Over and above the aforementioned strategies, two overarching themes emerged through discussions with experts in the provincial workshops. One was the need for strong and improved governance to underpin the design, delivery, and future evolution of these strategies. The second was the need for strong, resilient, climate robust infrastructure to support all sectors. Discussions within the workshops emphasized that both governance and infrastructure are cross-cutting elements, inherent to every aspect of Limpopo's socio-economic and political functioning. Both are essential to the ability of sectors like agriculture, water, energy, and transport to respond to and cope well with impacts of climate change (regardless of the relative levels of vulnerability of these sectors vis-à-vis one another).

Thus, along with a recommendation that the strategies listed in this report be developed into an implementation plan by the relevant sectors in Limpopo (so that they can be mainstreamed into provincial policy), this report also urges the provincial government of Limpopo and several key national Departments to invest more resources and political commitment in strengthening existing governance mechanisms, putting in place any necessary additional institutional structures or coordinating forums focused on climate change adaptation, and – on the infrastructure side – to approach future decisions about a wide range of infrastructure as decisions that have implications for strengthened climate change resilience in Limpopo and beyond.

2. Introduction and Key Concepts in Climate Vulnerability

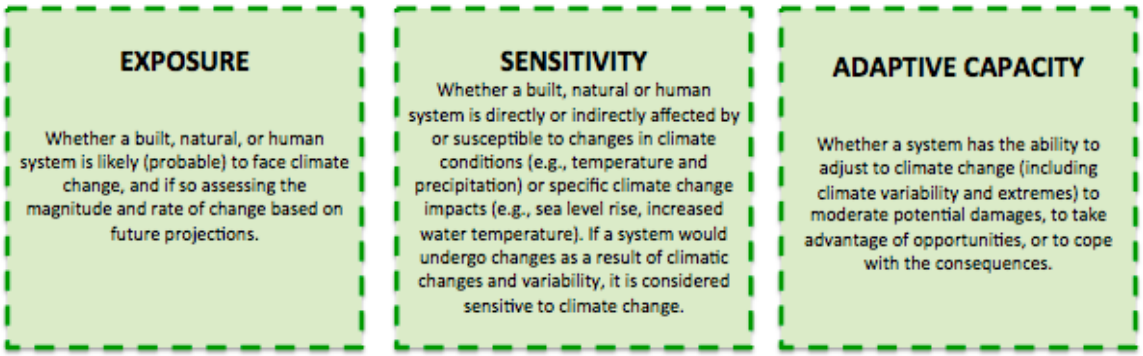
2.1. Assessing Climate Change Vulnerability

As climate change impacts become increasingly apparent in Limpopo, 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***."[7] (Emphasis added.)

Thus there are some critical constituent elements of climate change vulnerability, each of which has a discrete relationship with the other variables. These elements are defined differently by different sources, but at their core they can be identified as follows (largely as the IPCC does):

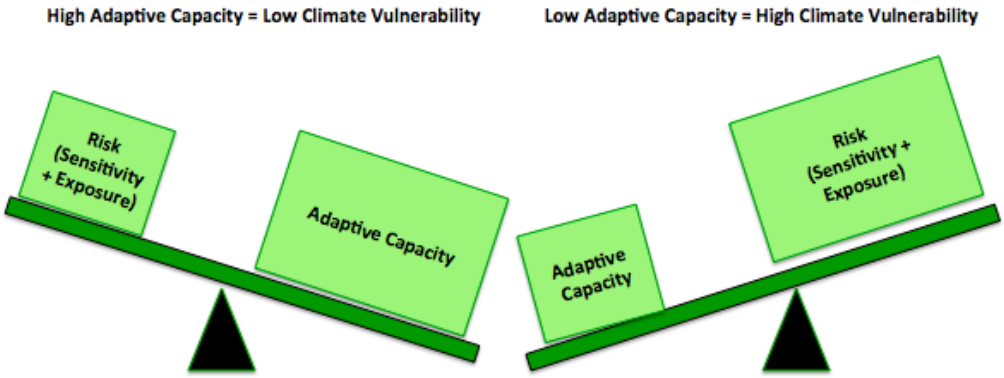


In simple terms, exposure is the extent to which a given system will be subject to or come into contact with a climate change impact – in this case, increased temperatures and changes in rainfall patterns. Sensitivity, then, is the extent to which a given system can be affected by a particular climate change impact. Sensitivity is based on inherent qualities and characteristics of an entity or system, and is an internal feature. In this case, the biophysical characteristics 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."

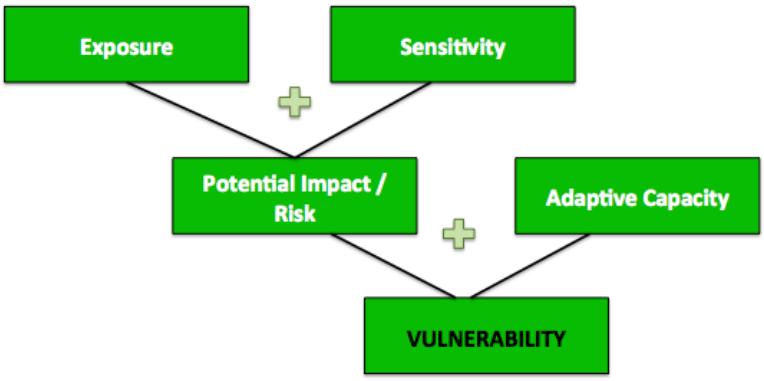
[7] Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (2007), Report of Working Group II on Impacts, Adaptation, and Vulnerability, (Section 2.4) http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=8

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,[8] the greater the adaptive capacity, the lower the vulnerability, and the lower the adaptive capacity, the greater the vulnerability.



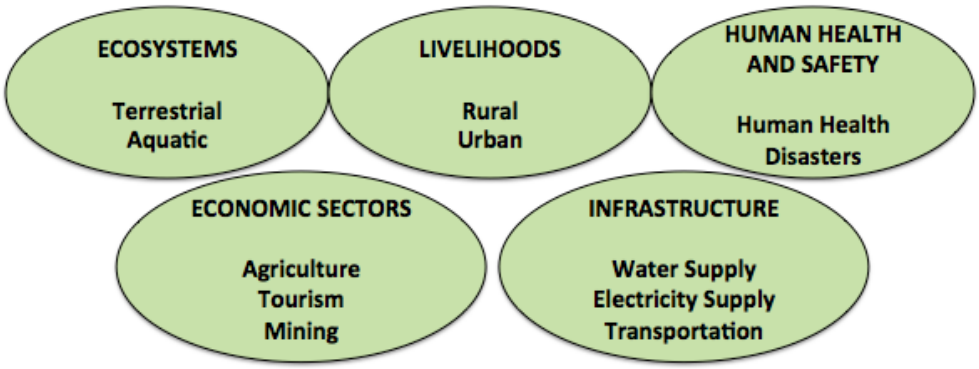
Thus, this project arrived at the determination of vulnerability of various sectors in Limpopo through the process that is typical of most climate change vulnerability assessments:



[8] 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/

2.2. 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 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:



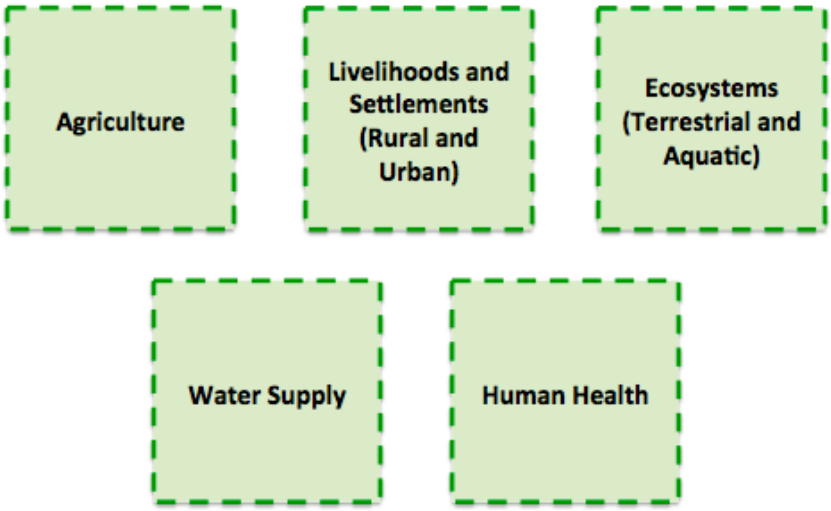
Phase one also involved seeking and integrating stakeholder input from experts and relevant sector officials in each of the three provinces, through provincial workshops in Limpopo, Mpumalanga, and North West.

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.

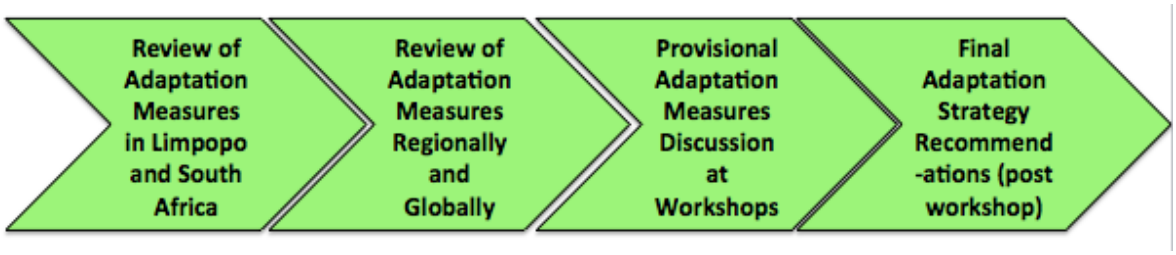
As agreed upon at the project inception stage, phase two of the project hones in on these priority sub-sectors, so as to allow more focused work on the development of adaptation strategies for the province. In response to stakeholder interest, the list of target-sectors was expanded from solely those 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 urban livelihoods and settlements are less vulnerable to climate change than rural livelihoods and settlements, the urban segment has been included in this report as a focus for adaptation strategies, in deference to stakeholders in Limpopo who indicated that urban livelihoods and settlements should not be neglected.

By the same token, a sector that was originally identified as vulnerable (Disaster Management) does not have strategies attached to it in this report because stakeholders in Limpopo articulated a strong preference for treating disaster management as a cross-cutting theme across sectors, and indicated that specific adaptation strategies should not be developed for this thematic area since it is not an actual sector.

Thus for Limpopo, the final sectors that were chosen for Adaptation Strategies are:



Phase two (two months) involves the identification of adaptation measures that can build adaptive capacity in the relevant sectors, 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 Limpopo 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 Limpopo; and input and refinement by stakeholders and sector experts in a provincial workshop. Strategies have been developed based on this foundation, and with an understanding of governance processes and institutional frameworks in Limpopo in relation to climate change adaptation.



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 Limpopo province after the conclusion of the current project, informed by the present report.

3. Priority Sectors for Adaptation Strategies in Limpopo Province

The Long Term Adaptation Scenarios (LTAS) project suggests that the region within which Limpopo province is located is could face a potential increase in temperatures by as much as 2°C by 2035, by 1-2°C between 2040 and 2060 (or even 2-5°C in the high-end scenarios), and by 3-6°C between 2080 and 2100 (or as much as 4-7°C in the high-end scenarios). LTAS projects decreased rainfall over Limpopo in the long term, but rainfall projections in the LTAS project remain within the realm of present-day variability (i.e. they do not show a statistically significant departure from current patterns).[9] Other studies suggest that there may be future increases in rainfall in the region, attesting to the uncertainty in model projections for this region of Southern Africa within the existing body of knowledge. 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,[10] implying a drier future even in the presence of greater rainfall and heavy rainfall events.[11]

An investigation into climate change vulnerability in Limpopo province has highlighted specific sectors that are particularly vulnerable. Adaptation measures are suggested for each of these sectors.

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."[12] Even though the timeframe identified and the scope of this project is through the year 2035, and the recommendations have been framed with a view to their 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.

[9] 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
[10] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010
http://www.rvatlas.org/download/sarva_atlas.pdf
[11] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013
http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf
[12] 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

3.1. Agriculture

3.1.1. Agriculture in Limpopo

Limpopo is the breadbasket and agricultural engine of South Africa, accounting for nearly 60% of all fruit, vegetables, maize, wheat, and cotton. Livestock farming is also a significant contributor to the province's agriculture sector. It is the source of 65% of the country's papayas, 36% of its tea, 25% of its citrus fruit, bananas, and litchis, 60% of its avocados, 60% of its tomatoes (40% by one company alone), and 35% of its oranges. It produces 285,000 tons of potatoes annually.[13] An estimated 33% of households in Limpopo are considered agricultural households, and the province is home to 16% of South Africa's agricultural households.[14] Despite this, the agriculture sector contributed only three percent to the province's annual average Gross Domestic Product (GDP) in 2012.[15] Nevertheless, as noted in the Limpopo Green Economy Plan, agriculture is a key sector for the province because it is a source of food security, a contributor to exports, and an economic multiplier for the people of Limpopo through income and employment.[16]

3.1.2. 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.[17]

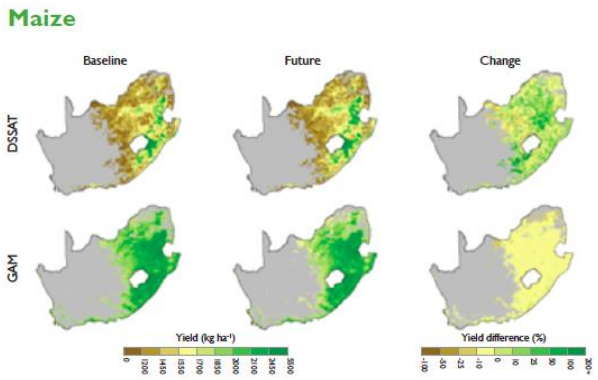


Figure 1: Median Change in Crop Yield for Rain-fed Maize

The accompanying figure is one illustration (based on two distinct models) of how yields of Maize (one of Limpopo'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).[18]

[13] GoLimpopo.Com, "Limpopo Facts Overview," last accessed May 2015. http://www.golimpopo.com/facts-overview
[14] Statistics South Africa, "A Giant Step in Agriculture Statistics," August 2013. http://www.statssa.gov.za/?p=1447
[15] Glen Steyn and Associates, "Provincial Statistical Indicators 2014," http://www.glensteyn.co.za/page/provincial-statistical-indicators-2014
[16] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf
[17] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf
[18] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

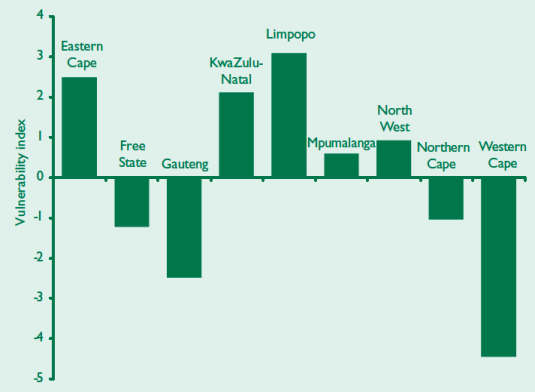


Figure 2: Climate Vulnerability of Agriculture - Ranking in South Africa by Province (Source: IFPRI)

There is also concern for Limpopo's citrus fruit; the temperature may become too warm for lemon cultivation, for instance.[19]

An assessment by the International Food Policy Research Institute (IFPRI) identified Limpopo as one of South Africa's most sensitive provinces in terms of the susceptibility of the agriculture sector to climate change, mainly due to the high proportion of small-holder farmers. As indicated in the figure to the left, along with agriculture in KwaZulu-Natal and the Eastern Cape, this sector in Limpopo is expected to suffer the largest impacts of climate change and variability.[20]

3.1.3. Agricultural Adaptation in Limpopo and South Africa

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 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,[21] to obviate duplication of the list in this present report, whose aim is rather to identify a strategy for the province going forward.

The Limpopo Green Economy Plan similarly recommends a review of invasive species legislation, water efficiency in agriculture, the use of appropriate crops, the creation of a seed bank, companion agriculture (amongst other initiatives less salient to climate change adaptation).[22] Limpopo already has efforts underway on Conservation Agriculture (CA) under the SoilCare and LandCare programmes (in partnership between DAFF and FAO), starting with training and awareness building sessions, and evolving into longer term projects.[23]

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

[19] Ulrike Gebhardt, "Citrus 'Superfruits' Thriving Despite Climate Change," July 2, 2013. http://www.dw.de/citrus-superfruits-thriving-despite-climate-change/a-16921898

[20] 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

[21] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013 http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

[22] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf

[23] Pearson Mnkeni and Charlen Mutengwa, Food, Agriculture Natural Resources Policy Analysis Network, "A Comprehensive Scoping Assessment Study of Climate Smart Agriculture Policies in South Africa," April 2013. http://www.fanrpan.org/documents/d01761/South%20Africa_Comprehensive_Scoping_Assessment_of_CSA_Policies.pdf

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.[24] 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 soil 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.[25]
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 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.[26]

A survey of farmers in Limpopo 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. For instance, fifty percent of farmers identify crop diversification as a preferred adaptation strategy. However, fewer farmers are amenable to changing current farming practices; only 15.7% were open to different planting dates, only 35% were open to planting new varieties, and 39% were open to planting different crops. Moreover, 99% of farmers surveyed were against shorter growing periods, 98% against moving to a different site, and 99% were averse to moving from farming to livestock. Sixty six percent identified increased irrigation as a suitable adaptation measure.[27] This is indicative of the challenges involved in convincing farmers to make significant changes in a system they have become used to for decades, or even generations. In the same study, farmers also identified certain barriers to adaptation – namely, lack of information, lack of government support, lack of education and skill.[28]

[24] 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
[25] 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
[26] 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
[27] Phokele Maponya and Synvester Mpandeli, "Perception of Farmers on Climate Change and Adaptation in Limpopo Province in South Africa, J Hum Ecol, 42(3): 283-288 (2013). http://www.krepublishers.com/02-Journals/JHE/JHE-42-0-000-13-Web/JHE-42-3-000-13-Abst-PDF/JHE-42-3-283-13-2381-Maponya-P/JHE-42-3-283-13-2381-Maponya-P-Tx[9].pmd.pdf
[28] Phokele Maponya and Synvester Mpandeli, "Perception of Farmers on Climate Change and Adaptation in Limpopo Province in South Africa, J Hum Ecol, 42(3): 283-288 (2013). http://www.krepublishers.com/02-Journals/JHE/JHE-42-0-000-13-Web/JHE-42-3-000-13-Abst-PDF/JHE-42-3-283-13-2381-Maponya-P/JHE-42-3-283-13-2381-Maponya-P-Tx[9].pmd.pdf

3.1.4. Agricultural Adaptation Lessons and Best Practices from Elsewhere

Globally as well as across Africa, there is growing momentum behind "Climate Smart Agriculture."[29] 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.[30] 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.[31]

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.[32] Thereafter, 26 African countries have collectively launched the 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.[33] 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.[34]

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.[35] Traditional "Kihamba" agro-forestry techniques in Tanzania are helping raise incomes by an estimates 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.[36]

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 Limpopo.

3.1.5. Climate Adaptation Measures for Agriculture in Limpopo - Recommendations

There is still a dearth of province-specific scientific literature on climate change impacts on the agricultural sector and on locally relevant climate change adaptation practices. While there is awareness of Climate Smart Agriculture and agricultural climate resilience more generally amongst responsible

[29] The Climate Smart Agriculture Partnership, http://www.fao.org/climate-smart-agriculture/en/
[30] Climate Smart Agriculture, "About Climate Smart Agriculture," http://www.fao.org/climate-smart-agriculture/72610/en/
[31] Food and Agricultural Organisation (FAO), "Climate Smart Agriculture for Development," http://www.fao.org/climatechange/climatesmart/en/
[32] 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
[33] 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
[34] Africa CSA http://africacsa.org/#founding-members
[35] 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
[36] FAO, "Success Stories on Climate Smart Agriculture," 2014. http://www.fao.org/3/a-i3817e.pdf

institutions, officials, and even some farmers within Limpopo, available literature points to the province being at early stages of engaging with and operationalizing such efforts.

The recommendations that follow are closely linked to the concepts of Climate Smart Agriculture, but the specifics of these adaptation strategies have been suggested by stakeholders in Limpopo bearing in mind overall sustainability of the agriculture sector as well. The original adaptation strategies were presented to stakeholders in a provincial workshop in May 2015 and the experts present there reformulated and modified the recommended strategies into the following:

V. **Create a Climate Smart Agriculture programme to help develop or promote the use of specific seed or plant varieties in specific locations:** There is a fair amount of agro-climatic diversity even within Limpopo province. Thus, an applied research program that spurs the development or adoption of specific varieties of climate-resilient seeds or plants should aim to identify different varieties for different parts of the province. This should take into account different soil types, different staple food and dietary patterns, and other such local constraints and preferences. Such a program should involve field trials and other on-the-ground initiatives and train farmers to use these new, locally suited varieties.

VI. **Enhance ongoing efforts involving Conservation Agriculture:** the province is already engaged in great depth with Conservation Agriculture. These activities should be given a boost and such programs expanded and provided greater resources. Sub-programs should be developed and expanded to focus on key components such as mulching, agroforestry, livestock, mixed farming, nutrient conservation, water conservation etc.). These programs should involve a research component to generate much more locally relevant data, and the 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. But the programs would also involve skills building and knowledge transfer activities to train farmers and build on-farm capacity.

VII. **Initiate a dedicated climate change adaptation programme for cattle ranching / livestock rearing in the province:** A multi-year, province-specific programme should be launched to help livestock farmers and cattle ranchers adapt to changing climatic conditions. Given the predominance of cattle farming in the province, this is a key area for intervention. Such a campaign would include the production of greater research conducted within the province, with results relevant to the local industry, but also include applied research on adaptation measures. It would involve education and training sessions, funding for on-farm adaptation measures, and ongoing assistance to ensure that farmers are maximizing the benefits of the adaptation responses utilized.

VIII. **Fund and implement a comprehensive climate change awareness and skills-building programme within the province:** such an awareness-building programme would be broad based and far-reaching in nature. Its design would include new curriculum (or additions to curriculum) in schools and colleges (in both basic and higher education), to teach students earlier about climate change impacts on agriculture as well as adaptation measures. It would also involve the generation of knowledge materials that could be widely disseminated, especially at key events

such as Earth Day, World Environment Day, Arbor Day etc. The programme would also include awareness generation through the use of radio and television and other media, to increase public knowledge of climate change's impacts on agriculture and potential adaptation responses. The programme would not be tailored only towards the public, but would also target farmers themselves, and would involve educational outreach about the impacts of climate change on the specific crops grown in specific areas; it would engage farmers on various practices that can strengthen climate resilience (in an effort to lower their resistance to change) on their own land, and train them on best practices (to enhance their ability to reap successful results from adaptation measures).

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 and 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), Limpopo Department of Agriculture (LDA), Department of Water and Sanitation (DWS), and Department of Education.

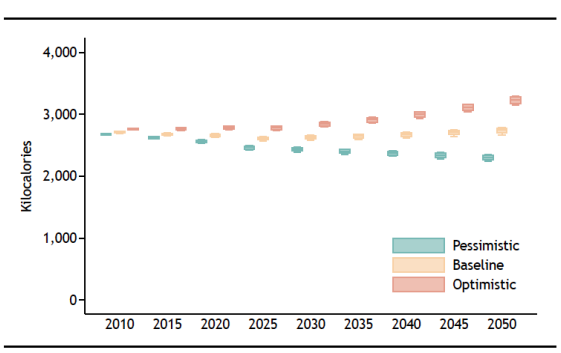
3.2. Livelihoods and Settlements – Rural and Urban

3.2.1. Livelihoods and Settlements in Limpopo

The relatively high vulnerability of rural livelihoods – predominantly based on agriculture and livestock – is a matter of significance for Limpopo province, which is home to South Africa's largest land area with rural inhabitants, mostly relying on natural resources for subsistence. Of all of South Africa's provinces, Limpopo had the lowest per capita income (annual), as recorded in the 2011 census.[37] While the urban population in Limpopo is relatively small compared to the rural population, stakeholders at the provincial workshop in May 2015 noted that in the future, with more rural-urban migration, the balance would shift, and emphasized that the adaptation strategies in this report should also apply to the urban setting.

3.2.2. 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.[38]



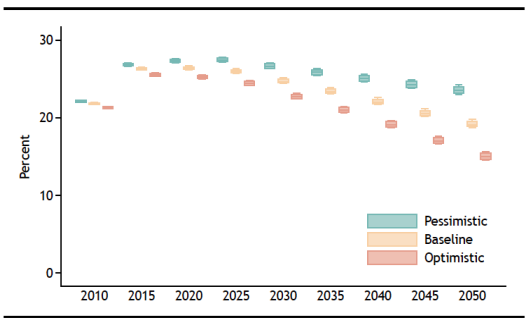


Figure 3a: Kilocalories per capita in South Africa in multiple income and climate scenarios (2010-2050); and **Figure 3b:** Share of malnourished children under five years of age in South Africa in multiple income and climate scenarios (2010-2050). (Source: IFPRI).

Impacts from climate variability, such a drought, are already a problem for livelihoods in Limpopo and are likely to become more pronounced with climate change. For instance, one study found that food security in Limpopo is negatively impacted by drought, resulting in food scarcity, and that farmers have already had to sell their livestock to cope with reduced availability and higher prices of livestock feed during drought.[39] While the impact of this is greatest in rural areas, ripple effects would be felt in urban areas, which source their food from rural regions of the province.

[37] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[38] 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
[39] Phokele Maponya and Sylvester Mpandeli, "Impact of Drought on Food Scarcity in Limpopo Province, South Africa,"

In general, resource-poor settings such as Limpopo are at a greater disadvantage in coping with the effects of climate change and adapting to changing conditions. Limpopo's climate vulnerability in 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.[40]

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. Limpopo, together with KwaZulu-Natal and the Eastern Cape, accounts for 76% of all rural dwelling children. Additionally, 78.7% of children in Limpopo are estimated to live below the poverty line.[41] The age distribution of Limpopo's population is also shifting towards older age groups: in 2001, 52.2% of the provincial population was 19 years old or younger, while in 2011, this group dropped to 45.6%. At the same time, the population aged from 20 to 64 years comprised 42.1% of the total in 2001, but increased to 48.2% of the total in 2011. Now there are also more people aged 65 years older, from 5.7% of the total in 2001 to 6.3% of the total in 2011.[42] In 2011, Limpopo had the highest proportion of elderly people who classify as poor, at 77%.[43] These trends are also likely to continue, implying an increase in the number and share of Limpopo's population that is more vulnerable to climate change impacts, particularly livelihoods (since they are often a dependent population not generating their own livelihoods).

Limpopo also has amongst the highest rates of out-migration of all of South Africa's provinces,[44] which is often indicative of the more able-bodied individuals (with higher abilities to cope with change) leaving the province and a disproportionate share of those remaining in the province being those will relatively lower adaptive capacity.

3.2.3. Rural and Urban Livelihoods Adaptation in Limpopo and South Africa

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

Literature indicated that some farmers in Limpopo province have been experimenting with climate adaptation measures such as modifying their planting dates, increasing their irrigation potential, and changing the amount of land used for cultivation.[45] One study in Limpopo (in Vhembe district) found that some farmers in the area do already use adaptive strategies to make agriculture more resilient to climate change and variability. For instance, they have already turned to drought-resistant varieties, crop

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African Journal of Agricultural Research Vol. 7(37), pp. 5270-5277, 25 September, 2012. http://www.academicjournals.org/article/article1380886085_Maponya%20%20and%20Mpandeli.pdf

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

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

[42] Glen Steyn and Associates, " Provincial Statistical Indicators, 2014." http://www.glensteyn.co.za/page/provincial-statistical-indicators-2014

[43] 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

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

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

diversification, planting more water-efficient crops or crops that require less water on the whole, adjusting fertilizer input, using rainwater harvesting techniques, and even monitoring local weather indicators.[46] Significantly, another study found that merely providing farmers information about drought does not strengthen their resilience to it, and has no positive correlation to the farmers experiencing food scarcity.[47] This implies that along with improving access to credible climate change and variability information, there is a need for more rigorous and involved training for farmers on how to use the available information optimally.

There are also several one-off examples in Limpopo to turn to for lessons on how small holder farmers are creating sustainable livelihoods for themselves – for instance, improved yields demonstrated by Mercy Sithagu of Sithagu Farms;[48] self-learning through community solidarity based farming associations in Nwadjahane and Khomele;[49] and diversification and value-addition demonstrated by the biodiesel non-profit Mapfura-Makhura Incubator.[50]

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.[51] It also makes note of the need to overcome apartheid-era spatial planning challenges through land redistribution without compromising on food security and agricultural production.

For urban settlements, increased temperatures in built areas (i.e. the Urban Heat Island Effect) are likely to be a key impact on both settlements and livelihoods (since heat affects labor productivity and health). This is particularly a concern for informal settlements and shacks in peri-urban areas, where there are limited resources and people travel longer distances in heat. While there isn't much documented information about green design, green roofs, and other climate adaptation measures in urban areas in Limpopo, there are indications that some innovative work has been gaining traction in relation to school buildings and the momentum is likely continuing with green design elements of commercial and government buildings.[52]

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[46] Sylvester Mpandeli, "Managing Climate Risks Using Seasonal Forecast Information in Vhembe District in Limpopo Province," Journal of Sustainable Development , Vol. 7, No. 5 , October 2014. https://www.questia.com/library/journal/1P3-3443567481/managing-climate-risks-using-seasonal-climate-forecast

[47] Phokele Maponya and Sylvester Mpandeli, "Impact of Drought on Food Scarcity in Limpopo Province, South Africa," African Journal of Agricultural Research Vol. 7(37), pp. 5270-5277, 25 September, 2012. http://www.academicjournals.org/article/article1380886085_Maponya%20%20and%20Mpandeli.pdf

[48] Tarryn Genis, "South African Farming Entrepreneur Builds Sustainable Livelihood," *The Guardian,* 2012. http://www.theguardian.com/sustainable-business/south-africa-farming-entrepreneur

[49] Osbahr, H., C. Twyman, W. N. Adger, and D. S. G. Thomas. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society* **15**(2): 27 http://www.ecologyandsociety.org/vol15/iss2/art27/

[50] Agnes Musyoki, UNRISD, "The Emerging Policy for Green Economy and Social Development in Limpopo, South Africa," June 2012. http://www.fes-globalization.org/geneva/documents/8%20UNRISD%20Musyoki.pdf

[51] 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

[52] Holcim Foundation, "A Big Tick from Educationalists and Green Architects," July 15, 2013. http://www.holcimfoundation.org/Article/a-big-tick-from-educationalists-and-green-architects

3.2.4. 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 Limpopo 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."[53] 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.[54]

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;[55] 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;[56] and Malawi's Climate Adaptation for Rural Livelihoods and Agriculture (CARLA) project,[57] which is partially underway but has begun offering key implementation lessons about capacity building and training.[58]

[53] DDInternational, "Western Odisha Rural Livelihoods Project," http://ddinternational.org.uk/viewProject?project=4
[54] 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
[55] Inter Agency Standing Committee (IASC), "Addressing the Humanitarian Challenges of Climate Change – Regional and National Perspectives: Case Studies on Climate Change Adaptation," 2009.
[56] Inter Agency Standing Committee (IASC), "Addressing the Humanitarian Challenges of Climate Change – Regional and National Perspectives: Case Studies on Climate Change Adaptation," 2009.
[57] 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
[58] 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

3.2.5. Climate Adaptation Measures for Livelihoods and Settlements in Limpopo - Recommendations

Since the majority of livelihoods in Limpopo 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. Limpopo must actively explore how to provide alternative means of livelihoods to its people, divorced from agriculture. Furthermore, stakeholders in Limpopo province also underscored the need for adaptation strategies that address physical safety, i.e. flood risk. The recommendations below are those that were put forward to stakeholders in the provincial workshop in May 2015, were evaluated by those in attendance and revised and reframed as follows:

V. **Devote resources to identifying and providing training on alternate sources of livelihood for different regions and communities within Limpopo**. 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 Limpopo, 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' uptake 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 co-designed and co-implemented by the communities in collaboration with external and government experts. Given the small share of agriculture in Limpopo's GDP, the introduction and adoption of alternative means of livelihoods may bring more value-addition into the provincial economy and generate more income for the communities and the province as a whole, while also potentially arresting the out-migration (which is motivated by a search for opportunities outside the province).

VI. **Create and strengthen support business development mechanisms for smallholder farmers**. The province of Limpopo, 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 Limpopo (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.

VII. **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 Limpopo province, adaptive 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 Limpopo 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.

VIII. **Enhance efforts to reduce flood risk to rural and urban communities:** Physical safety of both rural and urban settlements should be improved by reducing and managing flood risk. Limpopo has been prone to flooding in several recent years, and climate change is likely to exacerbate the treat. Better land use management needs to be implemented, taking current as well as future flood risk into account. This should be supplemented with an education and training program to help build capacity in communities to respond to floods; this can include training in the use of sandbags or building levees. More Early Warning Systems should be put in place, but the systems could be technological as well as based on indigenous approaches and people's networks. Municipalities need to invest in more effective and higher capacity storm water draining systems; these can reduce the impact of floods.

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 with DAFF and the Department of Rural Development and Land Reform (DRDLR) for the first three adaptation strategies suggested above, and with DWS and the Department of Public Works (DPW) for the fourth. Close inter department coordination is key to effective implementation and results for these strategies. Funding could be secured from development partner, but would also be sought from the national treasury.

3.3. Terrestrial and Aquatic Ecosystems

3.3.1. Terrestrial and Aquatic Ecosystems in Limpopo

Ecosystems in Limpopo, both terrestrial and aquatic, are highly 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 Limpopo's ecosystems. Preserving Limpopo's ecosystems in the face of climate change pressures is key, especially in light of the Limpopo Green Economy Plan's emphasis on utilizing unexploited biodiversity resources in the province for green tourism and payments for ecosystem services.[59]

According to the South African National Biodiversity Institute, Limpopo Province already has one critically endangered ecosystem (Woodbush granite grassland), five endangered ecosystems (Blouberg forest, Malmani karstlands, Mapungubwe/Greefswald riverine forest, Sekhukhune mountain lands, and Sekhukhune bushveld), and four vulnerable ecosystems (Legogote sour bushveld, Lowveld riverine forest, Springbokvlakte thornveld, and Tzaneen sour bushveld).[60]

3.3.2. Vulnerability to Climate Change

Most of Limpopo falls within the Savanna biome, and the Savanna ecosystem has a fairly high resilience to climate variability and change. Thus it is considered less vulnerable than many other ecosystems.[61] Grasslands are less prevalent in Limpopo but the grassland zone that does exist (primarily in the southern/central parts of the province) are 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. 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.[62]

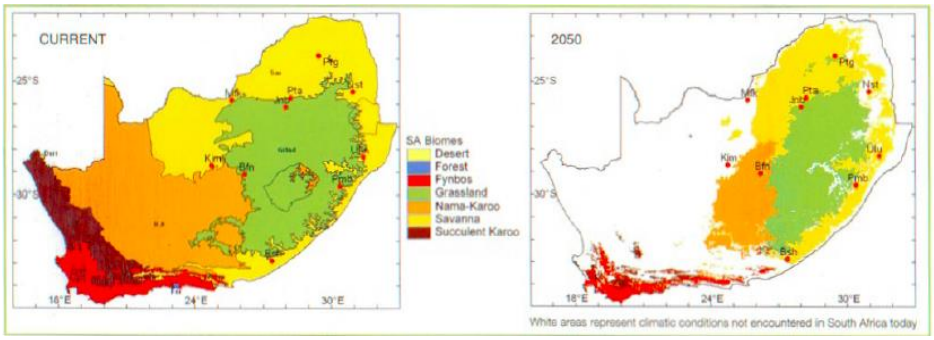

Figure 4: Biomes of South Africa as Mapped in 2000 and Projected in 2050 (Source: SANBI, The Heat is On)

[59] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. http://www.thehda.co.za/uploads/images/HDA_Limpopo_Report_lr.pdf
[60] South African National Biodiversity Institute, "Summary of Listed Ecosystems by Province," http://bgis.sanbi.org/ecosystems/Summary_%20listed_ecosystems_province.pdf
[61] CSIR, Risk and Vulnerability Atlas, "Information Portal K2C," http://www.rvatlas.org/k2c/information/conservation.php
[62] South African National Biodiversity Institute, "The Heat is On," 2008 http://www.sanbi.org/sites/default/files/documents/documents/theheatison.pdf

However, there is also growing evidence to suggest that the Savanna biome itself may face negative impacts from climate change, as a result of encroachment by bush and woody tree vegetation.[63] This type of forest encroachment (or forest colonization), is more likely in a wetter climate scenario, with more rain; while Limpopo is likely to see an increase in rainfall volume and more heavy rainfall events, rising temperatures and evaporation are also likely to lead to an overall drier climate in the region, leaving it unclear whether Limpopo's savannas may be encroached on by forest ecosystems.[64] 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).[65]

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 Limpopo basin 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.[66] Invasive species are also a concern for aquatic ecosystems in Limpopo province.

According to findings from the LTAS project, Limpopo is in the zone within Northeast South Africa (mainly the Limpopo river basin), which is likely to experience a "substantial risk" for loss of bird species richness.[67]

3.3.3. Ecosystem Adaptation in Limpopo and South Africa

Limpopo's Green Economy Plan identifies key priority areas for action on biodiversity and ecosystem management. These include the Limpopo Biodiversity Conservation Plan, valuation of natural resources, the up-scaling of existing programs under the "working for" umbrella (with a focus on removing alien plants and maintaining the veld), production of final products and beneficiation from natural resources, tree planting etc.[68]

The Limpopo Biodiversity Conservation Plan is a systematic guidance for conservation in Limpopo province, comprising maps of Critical Biodiversity Areas (CBAs) and land-use guidelines. Through this comprehensive process, nearly 40% of the province has now been identified as CBAs, with another 22% classified as Ecological Support Areas.[69] While the plan was created taking into account climate change

[63] 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

[64] 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

[65] 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

[66] 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

[67] Department of Environmental Affairs, Long Term Adaptation Scenarios, "Biodiversity," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltasbiodiversity-tech-report2013high-res.pdf

[68] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf

[69] SANBI, "Limpopo Conversation Plan V.2," Technical Report, 2013. http://bgis.sanbi.org/limpopo/LCPv2_technicalReport_hires.pdf

(for instance through the integration of "Ecosystem Based Adaptation" areas that specifically support climate change resilience, and targets for conservation in the EBAs), the plan cannot be viewed as a climate change adaptation plan for ecosystems in Limpopo province.

A helpful tool that is available to Limpopo 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.[70] 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.[71]

3.3.4. 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.[72]

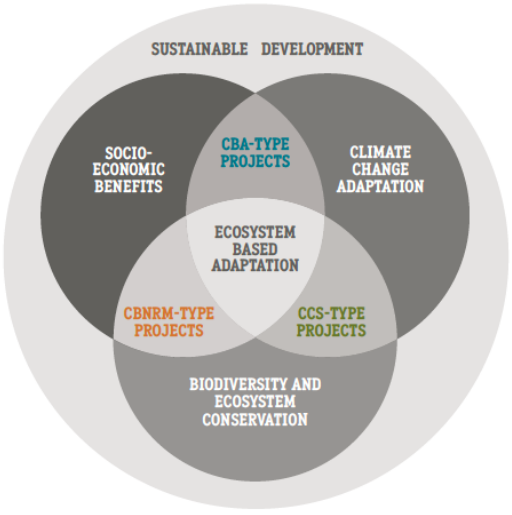

Figure 5: Ecosystem Based Adaptation

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 Arnhem),[73] the government of Colombia's

[70] SANBI, Biodiversity GIS, "Municipal LUDS," http://bgis.sanbi.org/municipalities/choose-muni.asp?prov=LIM
[71] 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
[72] SANBI, "Biodiversity, Climate Change, and Sustainable Development," http://www.sanbi.org/sites/default/files/documents/documents/biodiversity-climate-change-and-sustainable-development_0.pdf
[73] IUCN, "Ecosystem Based Adaptation – A Natural Response to Climate Change," 2009. https://cmsdata.iucn.org/downloads/iucn_eba_brochure.pdf

efforts to work with local communities to build climate resilience through the protection of thousands of hectares of tropical ecosystems rich in medicinal plants,[74] debt-for-nature swaps funded by France that involve local communities in Madagascar and Cameroon,[75] grassland protection and restoration in China by the Gansu and Xinjiang Pastoral Development Project,[76] and sustainable pasture management in Mongolia to protect grasslands as well as livelihoods of local herders.[77] 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.[78]

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.[79]

3.3.5. Climate Adaptation Measures for Ecosystems in Limpopo - Recommendations

Across South Africa and Limpopo, 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 (terrestrial and aquatic); 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:

V. **Develop a specialized climate change management programme to focus on protection of Limpopo'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 Limpopo, 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, and human livelihoods impacts of these changes, as well as what can be done to reduce or better manage the change. Thus Limpopo 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).

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[74] UNFCCC, "Ecosystem Based Adaptation," 2012 Calendar. https://unfccc.int/files/adaptation/application/pdf/nwp_cal_2012.pdf
[75] 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
[76] 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
[77] 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
[78] 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
[79] 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

VI. **Identify and integrate specific climate-change related priorities and metrics when next revising the Limpopo Biodiversity Conservation Plan:** given the role of the Limpopo Biodiversity Conservation 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, the latest-available research on climate change management in grassland and savanna 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 Limpopo's two primary ecosystems.

VII. **Formally establish and draw resources to a scientific research project to better understand the loss of bird species-richness in the South African Limpopo Basin**: The LTAS project is unequivocal about the loss of bird species richness in the Limpopo basin in Northeast South Africa, resulting from climate change. However, publically available literature does not reflect a wealth of information on this topic, suggesting that there is a need for filling the gaps with greater research. Across the world, there is a notable constituency of persons and institutions that are dedicated to the protection and well-being of birds, and would be strong allies for an effort to strengthen research on which birds are most at risk in the area, and what potential adaptation measures and conservation interventions could provide them support. Thus it may be viable to establish a programme focusing on the impacts of climate change on avian life in the relevant region, partnering with groups such as BirdLife International, Audubon, and other bird conservancies.

VIII. **Develop a focused climate change adaptation response plan and implementation programme targeting the province's wetlands and water pans:** Aquatic and freshwater ecosystems are often neglected in favor of terrestrial ecosystems (including flora and fauna). Publicly available literature does not demonstrate that a lot of attention has been given to studying the impacts of climate change on wetlands and water pans in Limpopo province, and the resulting impacts on surrounding ecosystems from changes to wetlands. Wetlands are key locales for biodiversity and play a critical role in ecosystem functioning as well as the provision of ecosystem services. Thus, to better understand the implications for Limpopo and to build resilience, a dedicated programme should be launched to closely study the impacts of climate change in the province, and to implement pilot adaptation measures based on best practices in wetland conservation.

Strategies I, III, and IV (suggested above) involve programmes that 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). If ongoing, continuous implementation is challenging due to limited resources, the programs should be run for at least two to three years in a pilot phase and then re-evaluated for longer-term continuation. For these programmes, the primary implementation responsibility would fall on DEA, in close collaboration with the Limpopo Department of Economic Development, Environment, and Tourism (LEDET). For Strategy II, LEDET would be the lead implementation entity (specifically, the Biodiversity Directorate). The national Treasury would be the primary source of funding, but development partners and international conservation groups such as IUCN (and Birdlife International or Audubon for Strategy III) could be approached for assistance.

3.4. Water Supply

3.4.1. Water Supply in Limpopo

Limpopo predominantly depends on surface water resources, and has relatively limited groundwater aquifers due to the geological nature of the province (despite this, groundwater is a significant source of water for domestic use in rural areas). According to the 2011 census, only 52.3% of Limpopo's population had access to piped water supply within their own dwelling or yard (and 14% of the population has no access to piped water at all).[80] Nearly a quarter million people and an estimated 300 schools had no access to any formal water infrastructure, as of 2010.[81] Irrigation accounts for an estimated 53% of water use in Limpopo, while rural water services account for less than five percent of available water resources (the mining and power sector account for eight percent each).[82]

Nearly all of Limpopo'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).[83] Similarly, the Limpopo Green Economy Plan notes that of Limpopo's 19 Water Management Areas, five already experience water shortages, and that several more could face shortages by 2025.[84]

At the basin level (not just Limpopo province), within South Africa the waters of the Limpopo river are used mainly for agricultural use (62%), followed by industrial use (21%), and then domestic use (17%).[85]

3.4.2. Vulnerability to Climate Change

Studies indicate that in most climate change scenarios projected for the Limpopo river basin in South Africa, future water supply availability by 2050 will "worsen considerably."[86] For a province that is heavily agrarian (with significant irrigation needs), as well as a province where nearly 48% of the population did not have access to piped water within their own dwelling or yard (in 2011), the prospects of increased water stress are significant.

For the Northeastern region of South Africa (including Limpopo), climate change is likely to pose the following risks to the water sector:[87]

- 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;

[80] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[81] Limpopo Department of Public Works, "Strategic Plan 2010-2015," http://www.dpw.limpopo.gov.za/docs/publications/StrategicPlan2010-2015.pdf
[82] Limpopo Water Sector Strategy and Five Year Plan (2006). https://www.dwaf.gov.za/Masibambane/documents/strategies/pwsp/lp/limpopo-strategy.pdf
[83] 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
[84] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf
[85] Berhanu F Alemau, FARNPAN, "Limpopo River Basin Focal Project – Water Availability and Access," 2008. http://www.fanrpan.org/documents/d00554/LBFP_water_availability_literature_Jul2008.pdf
[86] Tingju Zhu and Claudia Ringler, IFPRI, "Climate Change Impacts on Water Availability and Use in the Limpopo River Basin," Water 2012, 4, 63-84; doi:10.3390/w4010063
[87] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf

- 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, and 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.[88]

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.[89]

3.4.3. Water Supply Adaptation in Limpopo and South Africa

Experts suggest that future climate change related water stress in the Limpopo basin in South Africa can be potentially mitigated by improved water infrastructure and management, although it will be difficult to compensate for all the adverse impacts.[90]

The Limpopo Green Economy Plan identifies several priorities for water resources management moving forward, including: facilitating water security by creating awareness; greater water use efficiency in the mining sector; alternative water storage; water recycling; improved reticulation; water harvesting; reduced household consumption; catchment management; and regulation of swimming pools.[91]

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.[92]

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;

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[88] 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

[89] 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

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

[91] Limpopo Provincial Government, "Limpopo Green Economy Plan," June 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economyplan.pdf

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

(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.[93]

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, 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).[94]

3.4.4. 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.

Canada's Adaptation to Climate Team (ACT)'s policy roadmap for decision makers on climate change adaptation is instructive for water governance.[95] 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.[96] 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 tube-wells; 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).[97]

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[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), Long Term Adaptation Scenarios, "Water," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltaswater-tech-report2013high-res.pdf

[95] 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

[96] 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

[97] 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

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.[98]

3.4.5. Climate Adaptation Measures for Water Supply in Limpopo - 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 Limpopo 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.

V. **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, Limpopo should establish a governance framework or mechanism (such as a 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.

VI. **Ensure that proposed water related infrastructure projects explicitly integrate climate change resilience into their planning and design stages.** Limpopo 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 Limpopo (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 Limpopo 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

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

modified by climate change. The role of strong and effective infrastructure in the water sector cannot be overstated. Thus, efforts to maintain and repair infrastructure should also be ramped up, and an adaptation plan should be developed to address how Limpopo intends to safeguard and maintain its water infrastructure in the face of more climatic stressors like droughts, heavy rains, and floods.

VII. **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. Limpopo province has a lot of ground to cover in terms to providing people adequate access to safe and reliable drinking water for domestic consumption, cooking, bathing etc. 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, Limpopo should set or strengthen targets for provision of universal access (in line with national targets or even more ambitious) and quantitative, measurable metrics for performance and efficiency (such as the reduction of conveyance losses from leaks). These should be annually evaluated and recalibrated based on progress made. One of the performance metrics suggested by stakeholders is the number of water engineers and technical staff in the eater sector trained to understand the impacts of climate change on this sector, so that they can be better prepared.

VIII. **Strengthen existing Catchment Management efforts:** Adaptation to climate change in the water sector must go beyond water infrastructure and institutional arrangements, to the source of the water itself. Thus, there is a need to enhance Catchment Management activities already underway in the province. Specifically, efforts should be made to stem and reduce deforestation in catchment areas (as well as degradation). Attention should also be given to the removal of alien invasive species in catchments.

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.

3.5. Human Health

3.5.1. Human Health in Limpopo

Limpopo's population has lower life expectancy – 54 years – than the national (57 years) and global average (71 years).[99] In terms of rural health capacity (including number of practitioners and healthcare facilities in relation to the disease burden, as well as general indicators such as lack of access to piped water or toilet facilities etc.), one study identifies Greater Sekhukhune district as one of the ten most "deprived" districts in South Africa.[100] According to one estimate, poor rural households in some Limpopo districts spend as much as 80 percent of their monthly income on health expenditure (predominantly transportation costs to seek healthcare).[101]

One of the biggest healthcare challenges in the province is the continued prevalence of HIV/AIDS, which has taken a considerable toll on the working-age population of Limpopo. In contrast, the province is performing much better in combating tuberculosis (TB), and is estimated to have the second best cure rate in the country.[102] However, neither HIV/AIDS nor TB is linked to climatic factors and thus climate change has no implications for their prevalence. In this context, it is Limpopo's second, third, fourth, fifth, and sixth leading causes of death that could potentially be exacerbated by climate change: hypertensive heart disease, diarrhea, lower respiratory infection, stroke, and ischemic heart disease respectively.[103]

Most significantly, Limpopo is a region of moderate to high malaria risk (especially the eastern regions of the province),[104] and climate change has significant implications for the spread of malaria as well as other similar vector-borne diseases. Malaria outbreaks in Limpopo are not uncommon, as was seen recently in the summer of 2014.[105]

3.5.2. Vulnerability to Climate Change

Populations in Limpopo 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, Limpopo is also more sensitive, relative to some other provinces. Temperatures in Limpopo, especially the interiors, are likely to be warmer than some of South Africa's coastal regions. Additionally, due to the number of informal settlements (inadequate shelter) and the demographic trend of older populations (more elderly as a proportion of the population), the province is particularly susceptible to heat related health impacts such as heat stroke, dehydration, diarrheal disease, and mortality and morbidity from chronic disease

[99] DBSA, "Limpopo Profile Summary Report," 2012. http://www.dbsa.org/EN/DBSA-Operations/Proj/Documents/Summary%20of%20Limpopo%20Province.pdf
[100] Rural Health Advocacy Project, "Fact Sheet Rural Health – November 2013," http://www.health-e.org.za/wp-content/uploads/2014/02/Updated-Rural-Fact-Sheet-27-Nov-2013.pdf
[101] Rural Health Advocacy Project, "Fact Sheet Rural Health – November 2013," http://www.health-e.org.za/wp-content/uploads/2014/02/Updated-Rural-Fact-Sheet-27-Nov-2013.pdf
[102] Health Systems Trust, "Limpopo Province," http://www.hst.org.za/uploads/files/secB_lp.pdf
[103] Debbie Bradshaw et al., South African National Burden of Disease Study, "Estimates of Provincial Mortality: Limpopo Province," 2000. http://www.mrc.ac.za/bod/limpopo.pdf
[104] SA Venues, "Malaria Risk Areas in South Africa," http://www.sa-venues.com/malaria-risk-areas.htm
[105] eNCA, "Malaria Outbreak in Limpopo," March 29, 2014. http://www.enca.com/south-africa/malaria-outbreak-limpopo

(respiratory and cardiac, in particular) that is exacerbated by thermal stress on the body (from the body having to work harder physiologically to maintain thermal equilibrium).

One of the few studies to have specifically looked at the impact of climate change on human health in Limpopo focused on the effects on children. The study found that climatic factors such as increasing temperatures affected the incidence of several diseases amongst children in Limpopo province, including diarrhea, respiratory disease, asthma, and malaria, and that climatic factors could be responsible for as much as 37% of the total disease burden.[106]

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.[107]

3.5.3. Human Health Adaptation in Limpopo and South Africa

The only significant study to address climate change in the health sector in Limpopo is one that was focused on children. However, many of the study's recommendations are applicable to the health sector across the board in terms of building adaptive capacity and stronger responses to climate related health concerns. Some of these recommendations include: an awareness raising and educational campaign, to inform families of the risks to health from high temperatures and changing vector habitats; improving overall socio-economic status of households in Limpopo, to ensure better nutrition and level of health; reduction of populations living in poorly-serviced high density rural settlements; improved sanitation and waste collection services by the municipality, including in informal settlements; and reduction of deforestation and preservation of tree cover for shade (and to reduce the risk of erosion and flooding), amongst others.[108]

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.

[106] Adeboyejo Aina Thompson et al., "Impact of Climate Change on Children's Health in Limpopo Province, South Africa," Int J Environ Res Public Health. 2012 Mar; 9(3): 831–854. Published online 2012 Mar 8. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3367281/
[107] Long Term Adaptation Scenarios, SANBI, "Health," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltashuman-health-tech-report2013high-res.pdf
[108] Adeboyejo Aina Thompson et al., "Impact of Climate Change on Children's Health in Limpopo Province, South Africa," Int J Environ Res Public Health. 2012 Mar; 9(3): 831–854. Published online 2012 Mar 8. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3367281/

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.[109]

3.5.4. 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.[110] 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.[111] 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.

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.[112] 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).[113]

A host of other resources also exist, showcasing best practices and lessons learned, for health care professionals and health sector policymakers[114] concerned with increasing adaptive capacity or resilience to climate change.[115] 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

[109] Long Term Adaptation Scenarios, SANBI, "Health," 2013. http://www.sanbi.org/sites/default/files/documents/documents/ltashuman-health-tech-report2013high-res.pdf
[110] The Lancet, Editorial, "Managing the Health Effects of Climate Change," May 13, 2009. http://www.thelancet.com/commissions/climate-change
[111] 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
[112] 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
[113] 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
[114] Anthony McMichael, NCCARF, "Human Health," 2009. https://www.nccarf.edu.au/sites/default/files/attached_files_publications/NCCARF%20health%20brochure_S.pdf
[115] 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

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.[116]

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,[117] the Climate and Health Council,[118] and Physicians for Social Responsibility.[119]

3.5.5. Climate Adaptation Measures for Human Health in Limpopo - 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 Limpopo 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.

V. **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. Limpopo 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.

VI. **Secure, dedicate, and allocate substantial funding for better climate-related health surveillance and monitoring in the province and to carry out studies within Limpopo on health impacts of climate change.** Within South Africa and especially within Limpopo province, there is still a dearth of locally-relevant medical and public health literature that can inform decision makers about specific threats within Limpopo, 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).

VII. **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

[116] 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
[117] Healthcare Without Harm https://noharm.org
[118] The Climate and Health Council http://www.climateandhealth.org
[119] Physicians for Social Responsibility http://www.psr.org/environment-and-health/climate-change/

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 Limpopo. 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 Limpopo.

VIII. **Redouble efforts to improve overall socio-economic status and health indices:** As is the case with livelihoods, vulnerability of the health sector to the impacts of climate change would be reduced by enhancing overall levels of population health. Healthier communities have more adaptive capacity and are more resilient to risks such as heat waves or lowered water quality (due to higher immune status). Nutritional status must be elevated and under-nutrition or malnutrition minimized. Thus, even from a health sector climate change adaptation perspective, socio-economic factors must be taken into account and the overall well being of Limpopo's residents must be improved. This calls for greater successes in the implementation of existing economic development programmes, greater access to essential services like water supply and electricity, and more capacity in the health sector (more health care providers, shorter distances to seek assistance etc.). Sanitation in particular must be a priority, and Limpopo must extend coverage of population with access to adequate sanitation. Better systems should be put in place for waste disposal and collection from informal settlements and shacks. Thus at the broadest level possible the province must integrate climate change into its existing socio economic and health plans and policies, so as to ensure climate mainstreaming within broader development programmes and initiatives. The achievement of these, in turn, will make the health of Limpopo's people stronger and better prepared to cope with health stressors driven by climate change.

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.

4. Conclusion

It is critical that the recommended adaptation strategies in this report not become relegated to archival documentation but that they are 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), 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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