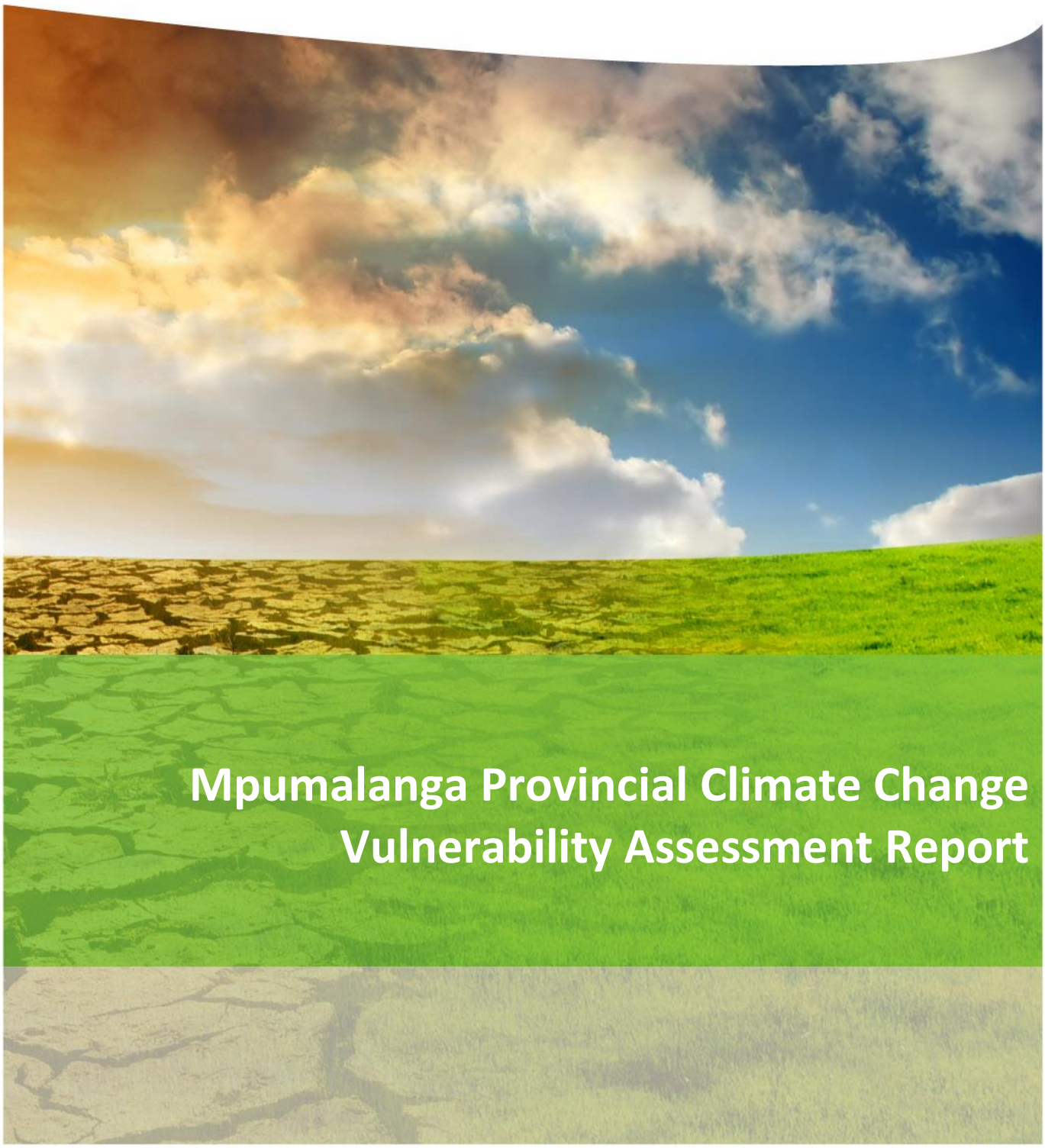
agriculture, rural development, land & environmental affairs
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA



Mpumalanga Provincial Climate Change Vulnerability Assessment Report

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Executive Summary

Mpumalanga province is already experiencing impacts linked to climate change, and available climate science indicates that these impacts are likely to increase and intensify in coming decades. The main forms in which climate change is impacting the province (and South Africa as a whole) is through a rise in temperature and changes in water availability and timing. Changes in temperature, rainfall, and atmospheric carbon concentrations directly affect agriculture and forestry, two critical sectors in Mpumalanga, and indirectly impact all other sectors. Efforts are already underway in the province to better understand the nature and extent of the current and future impacts, and to help the province better prepare for climate change.

While climate change is a global phenomenon and has impacts across the continent, region, country, and province as a whole, certain sectors within the province are more vulnerable to the changes due to their nature – specifically, due to their sensitivity or level of response to climate change, and to their current ability to cope with changes, i.e. their adaptive capacity. In terms of exposure to climate change, credible, publicly available climate science allows for an understanding of climate change indicators (temperature and rainfall trends) at the level of the province. Climate modelling of a higher resolution, e.g. at the Municipality or District Municipality Level, is fraught with uncertainty and diminished levels of confidence. Hence this assessment has relied on exposure data and projections at a province-wide scale for the purpose of ascertaining climate vulnerability of key sectors in Mpumalanga province. However, it must be noted that as high-resolution climate modelling improves and becomes more accessible, it will likely be possible to identify varied exposure across different regions within Mpumalanga.

Building an efficient and effective climate adaptation strategy for Mpumalanga province involves a key initial step, that includes (i) to identify key sectors, (ii) to conduct the climate risks and vulnerability assessment, and (iii) to identify adaptation priorities and their key focus areas.

Combining climate change sensitivity and exposure of each key sector allows for a picture of climate risk (potential impacts) to develop. When coupled with the sector's adaptive capacity in the province, this allows a differentiated picture of sectoral climate change vulnerability to emerge. **The current assessment reveals that the sectors in Mpumalanga province displaying greater climate change vulnerability, in relative terms, are agriculture, forestry, rural and urban livelihoods and settlements, tourism terrestrial and aquatic ecosystems, water supply, and (more so in the long term) public health and safety, plus disaster management.** This assessment is captured in Chapter Four of this report.

For Mpumalanga, the elevated vulnerability of these sectors is a significant matter. Mpumalanga is South Africa's second largest producer of citrus fruit, and thus citrus cultivation is a major component of the agriculture sector in the province. The province also produces sub-tropical fruit including mangoes, avocadoes, litchis, bananas, papayas, granadillas, and guavas. Mbombela alone accounts for a third of the country's orange exports.[1] Other crops grown in Mpumalanga include sugarcane, potatoes, sweet potatoes, tomatoes, carrots, pumpkins, and beans. Maize and sorghum are the winter staple crops, while

[1] South Africa Info, "Mpumalanga Province, South Africa," last accessed May 2015. http://www.southafrica.info/about/geography/mpumalanga.htm#.VUxc30saWs0

wheat is grown in the summer.[2] An estimated 18% of people in Mpumalanga are employed in the agriculture sector, with forestry being the main occupation.[3] The agriculture sector contributes an estimated six percent to the province's annual average Gross Domestic Product (GDP).[4]

The relatively high vulnerability of rural livelihoods – predominantly based on agriculture and livestock – is also a matter of significance for Mpumalanga province. An estimated 50% of people in Mpumalanga live in conditions of poverty, and over 60% of the population resides in rural areas.[5] Of all of South Africa's provinces, Mpumalanga had the fifth lowest per annual average household income, as recorded in the 2011 census.[6] In 2011, seven percent of Mpumalanga's population lived in shacks that were not in backyards, while four percent lived in shacks in backyards (and another four percent lived in "traditional dwellings").[7] Resource-poor settings such as this are at a greater disadvantage in coping with the effects of climate change and adapting to changing conditions.

Ecosystems in Mpumalanga, both terrestrial and aquatic, are highly vulnerable to climate change impacts, particularly in the longer term. Both terrestrial and aquatic ecosystems in Mpumalanga are vulnerable to climate change impacts, particularly in the longer term. Given the large number of people who depend on natural resources for their livelihoods, this is a threat both to human populations as well as the biodiversity of Mpumalanga's ecosystems. Preserving Mpumalanga's ecosystems in the face of climate change pressures is key, especially in light of the fact that Mpumalanga's tourism industry is extremely dependent on the health and robustness of the province's natural resources, its animal life, and its ecological systems. Grasslands in particular 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.[8] Similarly, aquatic ecosystems in an already water-stressed province are likely to be negatively impacted by warmer temperatures and greater evaporation rates. Wetlands are particularly vulnerable.

Vulnerability in the water sector is a matter of great concern. According to the 2011 census, 71% of Mpumalanga's population had access to piped water supply within their own dwelling or yard (and 12.6% of the population has no access to piped water at all).[9] Nearly all of Mpumalanga's Municipal Water Services Authorities (WSAs) were deemed as highly or very highly vulnerable, according to the Department of Water Affairs, in 2013 (on a general, non-climate basis).[10] Irrigation and afforestation account for a remarkable 84% of water use in the Komati basin, and over half of water use in the

[2] Match Deck, "Mpumalanga Offers Agric Opportunities in SA," June 26, 2012. http://www.matchdeck.com/article/425-mpumalanga-offers-agric-opportunities-in-sa#/index
[3] Agriseta, "Sector Analysis – Agriculture," June 2010. http://www.agriseta.co.za/downloads/news/AGRISETA_Sector_Analysis_290610-version_2.pdf
[4] Agriseta, "Sector Analysis – Agriculture," June 2010. http://www.agriseta.co.za/downloads/news/AGRISETA_Sector_Analysis_290610-version_2.pdf
[5] Mpumalanga Provincial Government, "Mpumalanga Economic Profile," September 2009. http://www.mpumalanga.gov.za/dedt/economic%20profile/Mpu_Econ_Vol5_01_Jul_2010.pdf
[6] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[7] Housing Development Agency, "Mpumalanga – Informal Settlements Status," 2013. http://www.thehda.co.za/uploads/images/HDA_Mpumalanga_Report_lr.pdf
[8] South African National Biodiversity Institute, "The Heat is On," 2008 http://www.sanbi.org/sites/default/files/documents/documents/theheatison.pdf
[9] South Africa Statistics, "Census 2011," published 2012. http://www.statssa.gov.za/publications/P03014/P030142011.pdf
[10] 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

Limpopo, Crocodile, Luvhuvu and Olifants catchments. However, there are competing uses of water in Mpumalanga, given that the province produces 75% of South Africa's electricity, and is home to 80% of all coal mines in the country.[11]

Populations in Mpumalanga are vulnerable to the health impacts of climate change, at least partly as a result of overall low health indices and diminished adaptive capacity. This is a result of the disease burden from HIV/AIDS, and tuberculosis, as well as poor nutritional status. In terms of vulnerability to climate change related health impacts, Mpumalanga is a high-risk area for communicable and insect-borne diseases. It already has a very high prevalence of Malaria, relative to other provinces in South Africa. It has also been identified as vulnerable to climate change in relation to the growth of diarrheal disease, and respiratory diseases. Being situated in a high rainfall area, but with inadequate sanitation and healthcare facilities, Mpumalanga is likely to see a rise in its climate-change related disease burden.[12]

There is a dearth of studies and reports in the health sector in Mpumalanga province (and South Africa as a whole) regarding the projected impacts of climate change. However, based on the province's overall levels of human vulnerability and on insights from climate change-health literature around Africa and the globe, this project also identifies human health and safety as an area of vulnerability in the longer term, along with disaster management (which faces an increasing burden such as an elevated risk of veldfires and potentially more flood events) as Mpumalanga's climate undergoes change.

The priority sectors described here, having emerged out of the research conducted for this climate vulnerability assessment report, will become the focus of the next stage of the project – the development of adaptation strategies based on best practices and consultation with stakeholders in Mpumalanga province.

[11] Dr. S. Coleman Nyathi, "An Economic Vision for Mpumalanga – Implications for the Water Sector," https://www.dwaf.gov.za/sfra/Articles/Mpumalanga%20Indaba/nyati.pdf
[12] UNICEF, "Exploring the Impact of Climate Change on Children in South Africa," 2011. http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf

1. Introduction and Background

This report is the product of the initial stage of secondary research and stakeholder engagement in the Province of Mpumalanga. The project was aimed at developing climate change adaptation strategies at the province level. The objective of the five-month project, which was funded by GIZ and facilitated by the National Department of Environmental Affairs, is to develop a province-specific climate change adaptation strategy. The focus was on developing adaptive interventions for high-vulnerability sectors in the province in order to address current and projected impacts of climate change. Thus the project culminated in a climate change adaptation strategy report for Mpumalanga province, developed in the second phase (whose results are in a separate report). However, to inform the development of such strategies and to first identify focus areas for action, the first phase of the project produced this sectoral climate change vulnerability assessment for Mpumalanga province.

1.1. Project Objectives

The primary objective of the five-month project was two-fold: 1. The first objective was to conduct vulnerability assessment in order to identify sectors that are at risk and highly vulnerability to climate change in Mpumalanga province; 2. The second objective was to develop a province-specific climate change adaptation strategy for the province. The final product is a document that identifies and discusses adaptive measures to the current and projected impacts of climate change. The focus of this report is on assessing vulnerability in selected sectors in Mpumalanga. The adaptation strategy process subsequently built on the results of the vulnerability report as part of second phase of the project.

The ultimate goal of the project is to create a shared knowledge-base for key stakeholders in Mpumalanga province on both the impacts the province faces from climate change as well as adaptation strategies that could protect Mpumalanga's natural capital, livelihoods of local communities, and the resources underpinning economic activity in climate-vulnerable sectors of importance to the province.

An allied objective, important to the funding agency, was to strengthen governance capacity in the province to understand the content and processes involved in vulnerability assessments and strategy-building, such that the provincial government gains the ability to itself engage in these processes in the years ahead at different levels, e.g. to conduct future municipal level or industry level or species level climate change vulnerability assessments.

1.2. Project Methodology

The methodology and approach adopted to perform this vulnerability assessment builds on the existing framework that incorporates key climate change concepts. These include sensitivity, exposure, climate risk, vulnerability and adaptive capacity. In this regard this assessment report is also aligned to the guidelines provided by the South Africa's National Climate Change Response

White Paper and the Intergovernmental Panel on Climate Change Fourth and Fifth Assessment Reports (AR4 and 5, 2007, 2014). In light of this therefore, climate change vulnerability is defined as:

"The degree to which a system is susceptible to, and 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".

With this definition in mind, the key elements of the method for this vulnerability assessment includes identifying, assessing and discussion the following key components:

- **Sensitivity:** This element focuses on assessing whether a built, natural or human system is directly or indirectly affected by or susceptible to changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., sea level rise, increased water temperature). Sensitivity relates to the internal features (qualities and characteristics) of a system and the extent to which they are resilient to the changes. For the purpose of this assessment, if a system undergoes changes as a result of climatic change and variability, it is considered sensitive.

- **Exposure**: This element of the methodology assesses whether a built, natural, or human system is likely (probable) to undergo negative impacts as result of climate change. If such exposure is likely, the assessment then explores the magnitude and rate of change based on future climate change projections. The exposure assessment is expected to yield a clear understanding of the extent to which a given system will be subject to climate change impact in the near future. In the case of Mpumalanga province, the negative exposure of the water services sector for example, is likely to have negative impact on energy generation and the meeting of basic water needs.

- **Adaptive Capacity:** Once both sensitivity and exposure of a particular system are clearly understood, the assessment then focuses on the ability and /or capacity of the relevant built, natural and human system to adapt to variability and extreme changes in climate with minimum disruption and / or minimum additional costs to users of such a system. Depending on the type of system being assessed, adaptive capacity is often estimated based on proven historical ability to cope with the expected changes, and through consideration of a futuristic view via proxies such as levels of education and income. In the case of Mpumalanga, issues such as policies, strategies and programs, including resources such as funding and human capital are likely to form part of the adaptive capacity.

Within the three elements of the methodology described above, climate change risk is understood as combination of hazardous exposure and climate sensitivity. The concept of vulnerability in the context of this assessment is understood as the result of the interaction between the observed

(high) risk and the extent to which the system is able to adapt. This broad approach is consistent with current practice within the South African.

The table below provides a list of the selected sectors and sub-sectors that this vulnerability assessment focuses on as per the project terms of reference:

Table 1: List of key sectors and sub-sectors for Mpumalanga

SECTOR	SUB SECTOR
Ecosystems	Aquatic (rivers, lakes, wetlands)
	Terrestrial (biodiversity, forests, invasive species)
Livelihoods	Rural
	Urban
Economic Activity	Agriculture / Farming (including Forestry)
	Tourism
	Extractives
Infrastructure and Utilities	Water Supply
	Energy Supply
	Transportation
Public Health and Safety	Human Health (diseases etc.)
	Extreme Weather / Disasters (wild fires, floods, drought)

For each of the variables in the function, i.e. sensitivity, exposure, and adaptive capacity, values were assigned (low / medium / high) depending on the findings of the assessment. The focus is on the short term (2015-2020) and long term (2020-2040 or mid-century) periods, based on what existing secondary climate literature and intelligence-gathering in the provinces indicate.

Literature reviewed

A series of documents were reviewed as part of this process. For the Vulnerability Assessments the report has relied heavily on the findings of the Long Term Adaptation Scenarios (LTAS) project, including the sector reports from Phase One and Phase Two. The commissioning of new climate modeling was beyond the scope of this project. However, since the LTAS project resulted in the generation of a wealth of climate model downscaling and the results are recent, high quality, and representative, the same findings have been incorporated into this assessment. Additionally, this report is supplemented with evidence from the IPCC's AR5, from relevant studies carried out by CSIR (such as the Climate Change Handbook for Northeastern South Africa), from the South African Risk and Vulnerability Atlas (SARVA), and other publicly accessible, credible, peer-reviewed published studies on climate change in South Africa and southern Africa more broadly.

This report has consolidated and reviewed available province-specific climate change impact studies that the provincial governments were able to provide us access to. Similarly, it has examined existing, publicly accessible vulnerability assessments of the key sectors at the national level –

including agriculture, water and sanitation, health, rural development, biodiversity and human settlements. The preliminary data search demonstrated that high quality studies relating to the provinces are somewhat scant in the public domain. Thus, where necessary due to lesser available province-specific reports and analysis, the report has relied on extrapolations of credible, peer-reviewed materials. Furthermore, this report has supplemented the literature review with on-the-ground data gathering in the form of two stakeholder workshops.

1.3. Content of this Report

Presented in this report is a high-level vulnerability assessment based on an existing base of climate change data, literature reviews and scholarly studies. This report was used as a discussion document to gain further inputs from a range of stakeholders in the provinces and from the Department of Environmental Affairs in the **Vulnerability Workshop** that was held on **23rd March 2015.**

This current report is distinct from the final Adaptation Strategies Report for Mpumalanga province. The Adaptation Strategies Report is a subsequent report and the culmination of the overall Climate Support Project.

2. Climate change science and uncertainty

2.1. Dealing with Uncertainty in Climate Change Science

Climate science is a complex field, involving a large number of variables that influence how the earth's atmospheric system functions and reacts. In other words, despite the fact that a great deal is known about the climate system and the types of impacts that climate change can result in, there are still some uncertainties that prevent us from knowing with one hundred percent certainty the impacts that will take place, including timelines, and specific locations. This assertion applies to most international studies, including those conducted in South Africa, and in Mpumalanga Province in particular. However, not having one hundred percent certainty is no reason to ignore what climate science is able to tell us.

A large amount is known about what the causes climate change and what its effects are likely to be in Mpumalanga. With careful consideration, this provides ample evidence to guide decision makers about what must be done to respond to the challenge. Indeed, it is helpful for policy makers to understand uncertainties and probabilities involved so that they can take these into account when using scientific input to inform decisions. For instance, those who allocate water resources to agriculture use in Mpumalanga could ignore water requirements for energy generation in the Inkomati if uncertainty is understated. For these reasons, uncertainty plays a key role in informing water policy issues in in the Inkomati. Clearly there are a number of critical sectors that rely on availability of adequate water in Mpumalanga, including conservation, support for emerging and subsistence farmers and water for domestic use. Understanding climate uncertainty in the case of Mpumalanga is important in order to facilitate the development of strategies to ensure sectors identified in Table 3 above are able to adapt.

This chapter provides a snapshot of the current and future climate nationally, and more importantly, it provides a provincial snapshot of current and future climate.

2.2. Current and Future Climate – A National Level Snapshot[13]

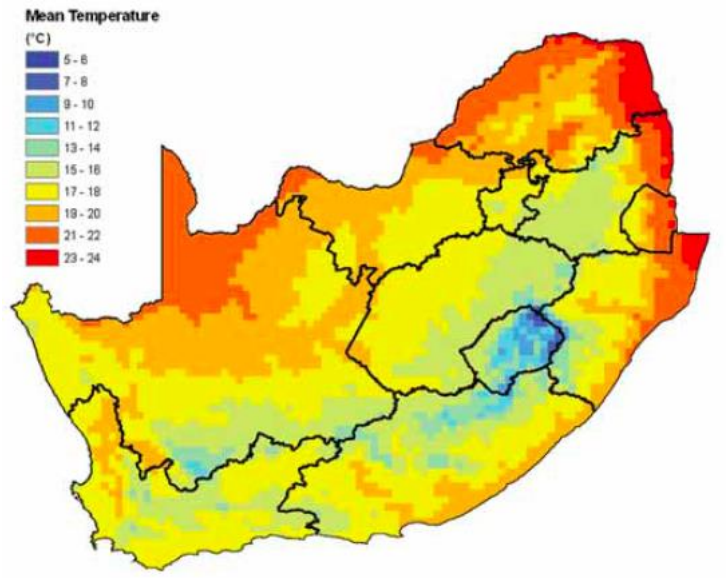
South Africa has a warm climate, and much of the country experiences average annual temperatures of above 17°C. The southern and eastern escarpments are the regions with the lowest temperatures, due to the decrease in temperature with altitude. The warmest areas are the coastal areas of KwaZulu-Natal, the Lowveld of KwaZulu-Natal and Mpumalanga, the Limpopo valley and the interior regions of the Northern Cape. The oceans surrounding South Africa have a moderating influence on the temperatures along coastal areas. The warm Agulhas current makes the east coast significantly warmer than the west coast, where the cold Benguela current and upwelling result in lower temperatures.

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

Table 2: South Africa's Seasonal Climate Characteristics

SEASONAL CLIMATE CHARACTERISTICS			
Summer (December-January-February)	Autumn (March-April-May)	Winter (June-July-August)	Spring (September-October-November)
This is the most important rainfall season for the central and northern interior of South Africa. Heat-induced thunderstorms frequent the South African interior, being most abundant over the eastern escarpment and Highveld areas.	Rainfall decreases rapidly over the eastern interior of South Africa during this time. This is, however, an important rainfall season for the western interior of South Africa (especially the Northern Cape and Eastern Cape interiors). The Cape interior regions receive significant amounts of rainfall during autumn from cloud bands that occur to the west of the most well-pronounced regions of subsidence.	Weather is characterised by sunny days, clear skies and cold nights. Frost is common especially over the higher altitude parts of South Africa. Cold front systems bring rain to the south-western Cape and the Cape south coast. On occasion this cold front intrudes northwards and brings "cold snaps", and in extreme cases causes snowfall to occur over the Free State and the Highveld regions of Gauteng and Mpumalanga.	Spring is characterised by the onset of rainfall over the interior regions of South Africa, with the first of the significant falls of rain typically occurring over KwaZulu-Natal before spreading deeper into the interior. A weather system that may bring snow and heavy falls of rain to the South African interior during spring, is the cut-off low. These weather systems may occur at any time of the year, but are most common during spring and autumn.

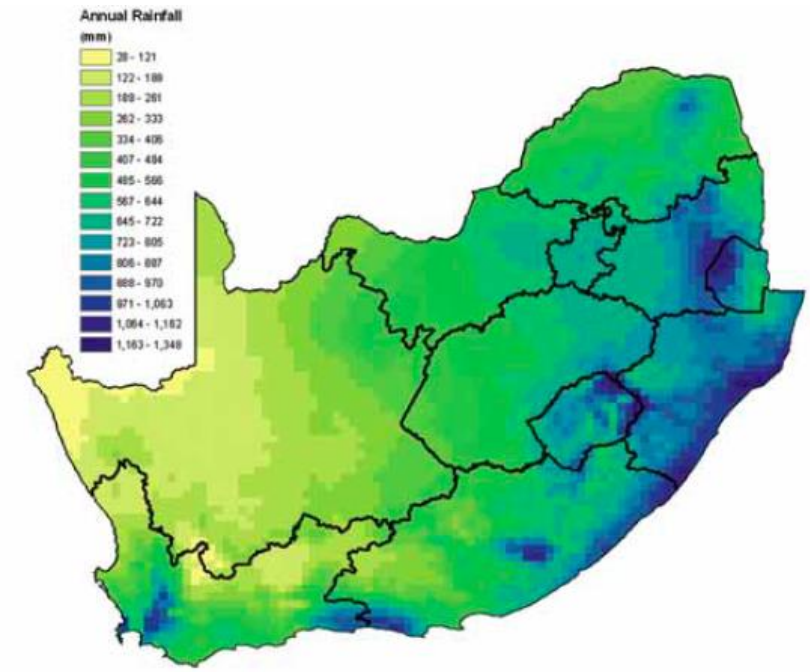
Source: Northeastern climate vulnerability handbook (page 6[14])



Map 1: Historic Average Annual Temperature (Celsius) over South Africa, Historic Average (1961-1990). Source: SARVA[15] In climate science, baselines are typically historic averages over periods considered as being prior to the impacts of anthropogenic climate change (temperatures since the 1980s and 1990s are often regarded as anomalous to historic average, and already showing a distinct increasing trend, and thus are not used for the purposes of indicating historic baselines).

[14] http://www.indigo-dc.org/documents/K2C%20Handbook.pdf
[15] Department of Science and Technology, *South African Risk and Vulnerability Atlas* http://www.rvatlas.org/download/sarva_atlas.pdf

Rainfall over South Africa is highly variable in space, and there exists a west-east gradient in rainfall totals. The west coast and western interior are arid to semi-arid areas. Rainfall totals are high over and to the east of the eastern escarpment of South Africa.



Map 2: Average Annual Rainfall Totals (mm) over South Africa, Historic Average (1961-1990). Source: SARVA[16] In climate science, baselines are typically historic averages over periods considered as being prior to the impacts of anthropogenic climate change (temperatures since the 1980s and 1990s are often regarded as anomalous to historic average, and already showing a distinct increasing trend, and thus are not used for the purposes of indicating historic baselines).

Climate modelling conducted for the South African Risk and Vulnerability Atlas (SARVA) indicates some broad future trends at the country-scale. The model projects an increase in the median temperature of more than 3°C over the central and northern interior regions of South Africa by 2100. Over the coastal regions of the country, a somewhat smaller increase (about 2°C) is projected. The largest increase in median temperature is projected to occur over the central interior of South Africa, exceeding a value of 4°C during autumn and winter. Generally, the largest temperature increases are projected for autumn and winter, with the summer and spring changes being somewhat smaller.

Over the same time period (by 2100) most of the summer rainfall region of South Africa is projected to become drier in spring and autumn as a result of the more frequent formation of mid-level high-pressure systems over this region. An increase in the median rainfall is projected over eastern South Africa for winter and spring, with a projected decrease over northeastern South Africa during summer. Statistical downscaling results indicate that the median duration of dry spells for the mid-21st century may be expected to increase along the western and northern margins of South Africa

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

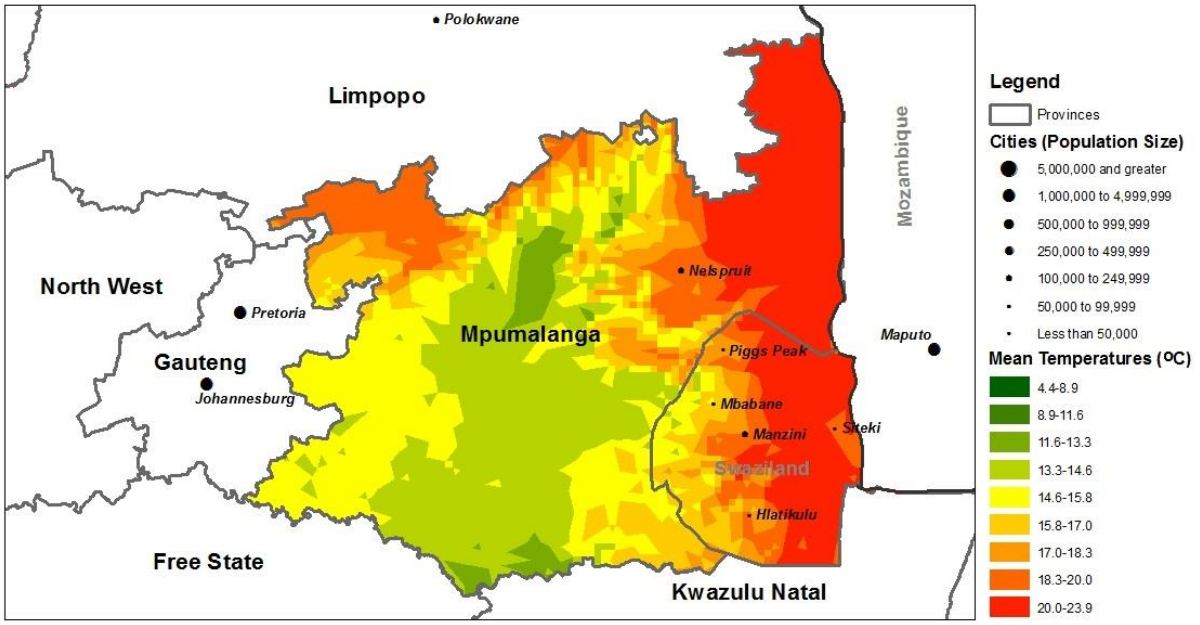
between spring and autumn, compared to 1961-1990.

Downscaled climate change modelling of the change in the annual number of consecutive dry days undertaken for SARVA suggests that in the near term (2021 – 2050) there will be an increased drying and associated risk of drought in the western and north eastern parts of the country, becoming more pronounced in the long term (2071 – 2100). What is critical to note, however, is that the model projections also indicate a large range of probabilities, which is significant and suggests that in some parts of the country (particularly the southern and eastern cape) the direction of change is not certain, and may alter over the near term and long term.

2.3. Current and Future Climate – A Mpumalanga Level Snapshot

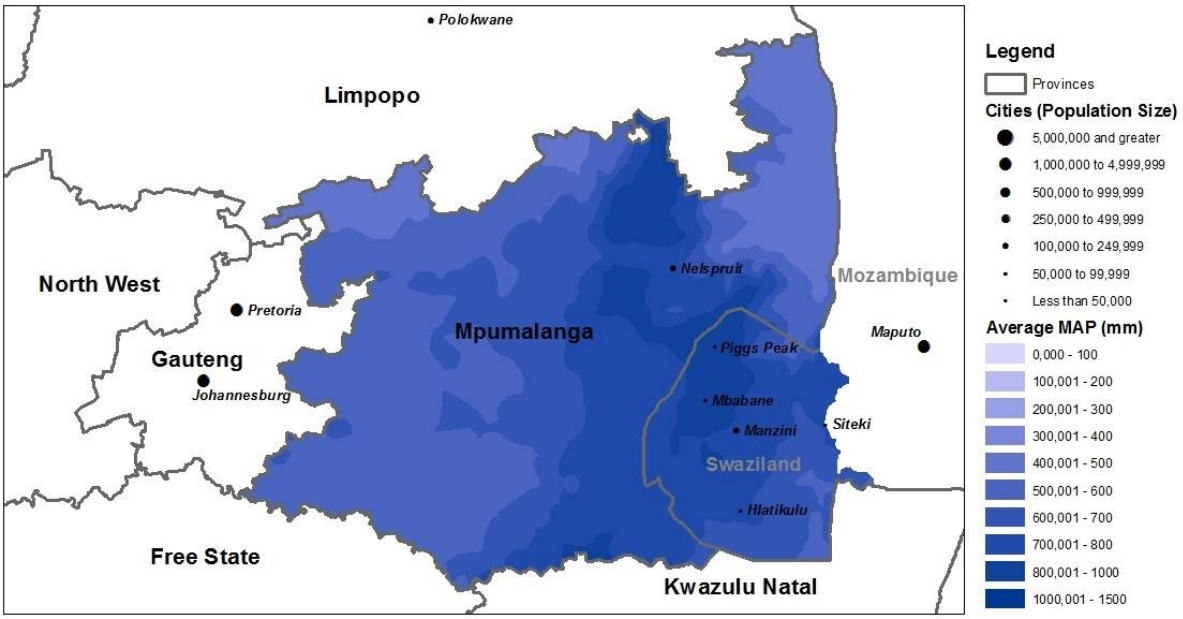
The maps below capture the present-day temperature and rainfall profile of Mpumalanga province.

Mean annual temperatures tend to be highest in the north-west and north-east regions of the province.



Map 3: Mpumalanga Mean Annual Temperature in Degrees Celsius (Data Source: WorldClimate 2015)

Mean Annual Precipitation tends to increase towards the eastern regions of the province.



Map 4: Mpumalanga Mean Annual Precipitation in millimetres (Data Source: WorldClimate 2015)

These temperature and rainfall pictures are likely to change in the future. The findings of the Long Term Adaptation Scenarios (LTAS) project suggests that the region within which Mpumalanga province is located is likely to face potential increases in temperature in three possible ways: by as much as 2°C by year 2035, by 1-3°C between years 2040 and 2060 (or even 1-4°C in the high-end scenarios), and by 3-5°C between 2080 and 2100 (or as much as 4-6.5°C in the high-end scenarios). These are all outside the range of present-day variability. LTAS projects decreased rainfall over Mpumalanga in the long term, with the decrease ranging from mild to a very significant pattern of drying, based on the model and scenario used.[17] Other studies[18] suggest[19] that there may be future increases in the total volume of rainfall in the region (especially around the escarpment), attesting to the uncertainty in model projections for this region of Southern Africa within the existing body of knowledge. Such studies indicate that winter rainfall, in particular, is going to increase, but that total frequency of rainfall events is unlikely to alter significantly (indicating an increase in heavy rainfall events).[20] 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.[21] While fewer studies suggest a dryer future for Mpumalanga than they do for its neighbour Limpopo, the chances are that the province is likely to experience a drier future even in the presence of greater and heavy rainfall events.[22]

[17] 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
[18] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010.
[19] UNICEF, "Exploring the Impact of Climate Change on Children in South Africa," 2011.
http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf
[20] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010.
http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf
[21] Department of Science and Technology, "South African Risk and Vulnerability Atlas," 2010
http://www.rvatlas.org/download/sarva_atlas.pdf
[22] Long Term Adaptation Scenarios, "Agriculture and Forestry," 2013
http://www.sanbi.org/sites/default/files/documents/documents/ltasagriculture-and-forestry-tech-report2013high-res.pdf

Chapter 4 below provides a detailed discussion on the current and future climate vulnerability and risk in Mpumalanga.

2.4. Uncertainty Involving Climate Impacts in South Africa

The major climate features that dominate South Africa are shown in Figure 1 below. These climate features have a geographic influence on different parts of the country, as well as being drivers of climate variability.

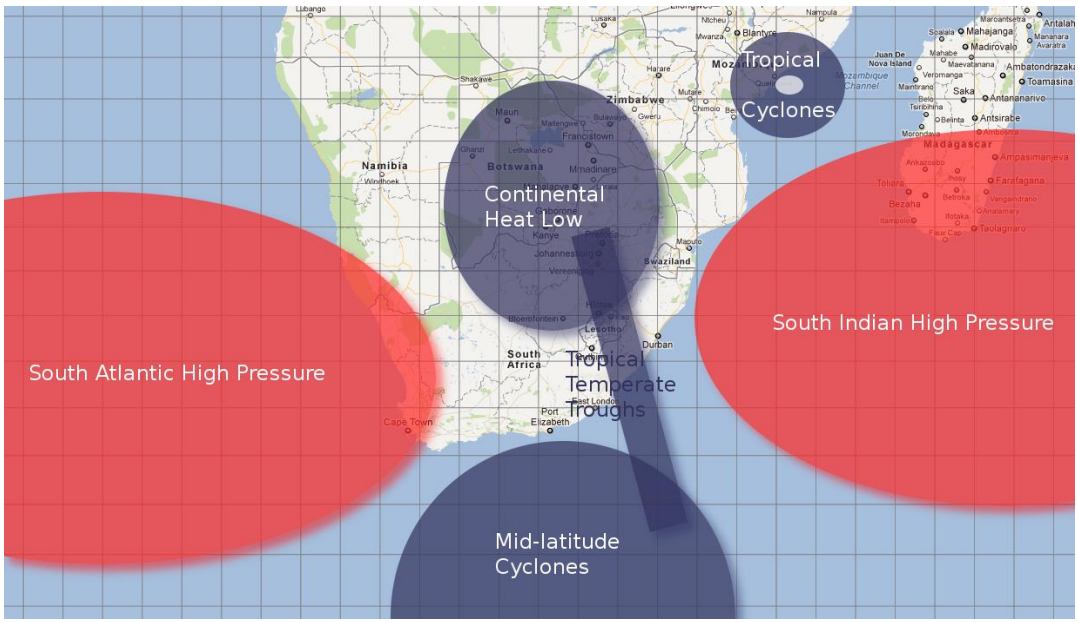


Figure 1: Major Climate Systems influencing South Africa[23]

The interaction of these climate features with seasonal solar and temperature variation drive the seasonal and inter-year precipitation patterns across the country.

The most commonly used method for determining the impacts of climate change is to use General Circulation Models (GCMs), which allow the simulation of most of the key features of climate on a global scale. GCMs use a very high spatial resolution (typically 250 km^2 grids or units). At this scale GCMs are less accurate in their projections, particularly about rainfall, which is influenced by several localized factors including physical relief. Therefore, to assess local or provincial impacts from climate scale, outputs from the GCMs are often downscaled to an appropriate resolution. The process of downscaling involves the interpretation of results from GCM models in relation to local climate factors and dynamics. **Note:** the scope of the current project does not permit commissioning of a large scale GCM downscaling. However, Chapter 4 of this report provides current and future climate change/ vulnerability scenarios based on credible, peer reviewed climate science as captured within South Africa's Long Term Adaptation Strategies (LTAS) program.

[23] Pegasys Strategy and Development, Internal Background Document for LTAS Water Sector Report

The LTAS project's results can be encapsulated in three main categories of findings:

1. **There is a clear increasing trend in temperatures across South Africa, and temperatures are projected to rise more in the interior regions than on the coast.**

2. **There is ambiguity about rainfall trends across South Africa, with implications for the northern provinces of South Africa that total annual rainfall could either increase over time with climate change, or it could also decrease. Depending on the type of downscaling used (statistical versus dynamical) and the specific climate scenario used for downscaling, results imply that wet season (winter) rainfall is likely to increase overall, but there is also the possibility of a decrease of precipitation (drying). There is, however, significant uncertainty in these findings and statistically there is no significant departure from current rainfall variability patterns.**

3. **Even in a potential future with higher rainfall totals, the increase in temperature suggests an increase in evaporation, thus even if rainfall increases, conditions may get drier and water availability may decrease overall (including in the Mpumalanga province region).**

Specifically, GCM downscaling for the LTAS program provided the following findings:

- Across South Africa, surface air temperature shows a general warming across the board, but most strongly in the interior regions. Warming is expected to be around 1°C increasing to around 3°C in the northern interior by the middle of the current century. By the end of the century the rate of warming is expected to be even greater, depending on the level of future greenhouse gas emissions.

- Changes in temperature will lead to changes in evaporation from soil, plants and water surfaces).

- Through 2065, annual temperature will increase by an estimated 1.5 to 2.5 °C along the coastline and by approximately 3.0 to 3.5 °C in the interior. This is largely due to the moderating influence of the ocean on temperature. Towards the end of the century, temperature change will become more rapid, with projected increases of 3.0 to 5.0 °C along on the coast and more than 6.0 °C in the interior.

- Annual variability is expected to increase in the northern parts of the country and decrease in the south.

Maximum and minimum temperatures are also important indicators of climate change, and they additionally influence evaporation rates. GCMs downscaled for LTAS indicated the following in relation to January and July maximum and minimum temperatures:

- Through 2065, January maximums are expected to increase by 2 to 3°C with an east to west gradient. July minimums are also expected to increase by 2 to 3 °C but with a more south to north gradient. Most of the country will experience an increase in the inter-annual variability

of the July minimum temperature. Towards the end of the century, January maximums are expected to increase by 4°C in the east and more than 6°C in the northwest. July minimums are expected to decrease by less than 4°C along the southwest coast and more than 6°C in the interior. The rate of change will increase markedly in the second half of the century. Variability in January maximums is expected to increase by more than 30% in the central and northern interior and decrease by up to 30% along the west coast.

In comparison to temperature trends, the precipitation projections from GCM downscaling are not as clear regarding rainfall trends. Even though there exists some uncertainty about future rainfall patterns in South Africa, some high level implications can certainly be drawn from what is known. Some of the reasons for the uncertainty are the interaction of the various forces that shape rainfall across South Africa, and the non-linear nature of the results of the interactions. Another layer of uncertainty results from different modeling approaches pointing to slightly different outcomes.

The mid-latitude cyclones cause the cold fronts that produce rain during winter in the Western and Southern Cape, while the South Atlantic High shifts southward to cause dry weather during summer in the western parts of the country. The effects of the South Atlantic High are expected to strengthen under a warming climate, thereby driving the mid-latitude cyclones southwards, with a possible reduction in winter rainfall. Generally, the number of rain days is expected to decrease in the western parts of the country, whereas localised orographic rainfall in the coastal mountains is expected to increase year round.

On the other hand, the interaction between the tropical temperate troughs, the South Indian High and the Continental Low result in moist air being channeled into the central interior and east coast during summer. This is combined with local convective rainfall along the east and south coast. Tropical cyclones occasionally affect the northeastern parts of the country in summer, whereas the high pressure anti-cyclone results in dry winters in the eastern and interior parts of the country. Total summer rainfall, number of rain days and rainfall intensity are all expected to increase under a warming climate.

While many of the models reflect the trend of wetting in the eastern parts and some drying in the west of the country, a couple of the models reflect a strong drying trend across the country. This has an important implication for the climate change predictions by shifting the range of possible climate futures to include a much dryer future across the country. While this does raise the level of uncertainty in South Africa's possible climate futures for now, what it means is that any South African climate assessment and strategy must consider a much more challenging climate scenario in order to cover all the bases and be better prepared for a broader range of potential climate outcomes.

The bottom line is that in creating adaptation strategies (in the follow-up report), the next stage of the project must develop strategies that address an environment of increasing temperature in Mpumalanga province, and take into account the possibility of a drier future, but must build into

them the likelihood of greater variability and unpredictability in rainfall, including both more heavy, intense precipitation events and longer dry spells and increased water stress.[24]

2.4.1. Types of Impacts from Changing Climate

Changes in temperature and rainfall patterns (i.e. exposure) result in a range of consequences in a climate system that impact on terrestrial, aquatic, and marine systems. Table 3 below summarizes the types of impacts that are likely to take place[25]. In the middle column of the table the type of change that is possible is captured, followed by the likely impact.

Table 3: Types of impacts linked to climate variability

CLIMATE VARIABILITY	TYPE OF CHANGE	IMPACT
Temperature Rise	Increased number of warm and very hot days, and increased daily maximum temperatures	▪ Increased evaporation impacting on the availability of surface water; ▪ Soil degradation due to increased acidity, nutrient depletion, declining microbiological diversity, lower water retention, and increased runoff; ▪ Positive or negative impacts on crops' growing seasons, yields, and growing range. Some crops – especially fruits – require a chill factor (a period of cold) in the winter to have a good harvest; ▪ Increased incidence of heat waves and associated health conditions for human and livestock health, such as heat stress. Heat especially impacts the health of the particularly old and young or those already suffering from other illness; ▪ Increase in concentration and range of pests and pathogens that are human and livestock disease vectors (carriers), such as mosquitos and ticks; ▪ Increased risk of drought conditions, and of wildfires, plus associated damage to crops, property, and infrastructure.
Change in Rainfall	Increased number of consecutive dry days	▪ Decreases in runoff and streamflow and an increased risk of drought, affecting crop production, food security, and rural livelihoods; ▪ Reduced streamflow (a particular threat for communities dependent on surface water); ▪ Loss of soil moisture affecting crops and increased risk of soil erosion due to wind; ▪ Increased risk of veld-fires and resultant threat to property, grazing, and crops;
	Increased number of wet days and/or	▪ Increased risk of floods and consequent damage to property, crops, and loss of life;

[24] CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.csir.co.za/nre/coupled_land_water_and_marine_ecosystems/pdfs/Davis_2010.pdf

[25] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013). http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

CLIMATE VARIABILITY	TYPE OF CHANGE	IMPACT
	increase in extreme (heavy) precipitation events	▪ Water logging of soil which can affect crops; ▪ Increased risk from water borne diseases, particularly after flood events; ▪ Damage to bulk infrastructure such as irrigation systems; ▪ Damage to property and crops from winds associated with violent storms; ▪ Increase in lightning events which can damage crops and cause loss of life;
	Variability or change in the timing of precipitation	▪ Rain-fed agriculture, which relies on the timing of rains for planting and harvest, is particularly at risk; ▪ Less predictability impacts the management of water resources in catchments and for large water infrastructure, with implications for water supply reliability.

While acknowledging the uncertainty associated with temperature variability and changes in rainfall patterns the impacts indicated in Table 3 above are likely to take place locally in Mpumalanga. Chapter 4 below, explores further climate change and the impacts in the context of Mpumalanga region.

(NOTE: The glossary box on the subsequent page has been constructed for the purposes of this project using input from UCAR[26], Skeptical Science[27], The Guardian[28], and the IPCC's Special Report on Emissions Scenarios (SRES) section 4.2.[29] Usage and copyright of the box and its contents rests with Pegasys Strategy and Development, South Africa, and it may be reprinted with permission from and attribution to Pegasys Strategy and Development.)

[26] University Center for Science Education, "Compare IPCC Scenarios Interactive," last accessed May 2015. http://scied.ucar.edu/compare-ipcc-scenarios-interactive
[27] Skeptical Science, "Beginner's Guide to Representative Concentration Pathways – Technical Summary," http://www.skepticalscience.com/rcp.php?t=3
[28] GP Wayne, " Now Available: A Guide to the IPCC's new RCP Emission Pathways," August 30, 2013. http://www.theguardian.com/environment/climate-consensus-97-per-cent/2013/aug/30/climate-change-rcp-handy-summary
[29] IPCC SRES, "SRES Scenario Taxonomy," http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=91

3. THE MPUMALANGA PROVINCE

3.1. Overview

- **Capital:** Mbombela
- **Languages:** 27.7% siSwati, 24.1% isiZulu, 10.4% Xitsonga, 10.1% isiNdebele
- **Population:** 4 229 300 (estimated 2014)
- **Share of SA population:** 7.8%
- **Area:** 76 495 square kilometres
- **Share of total SA area:** 6.3%

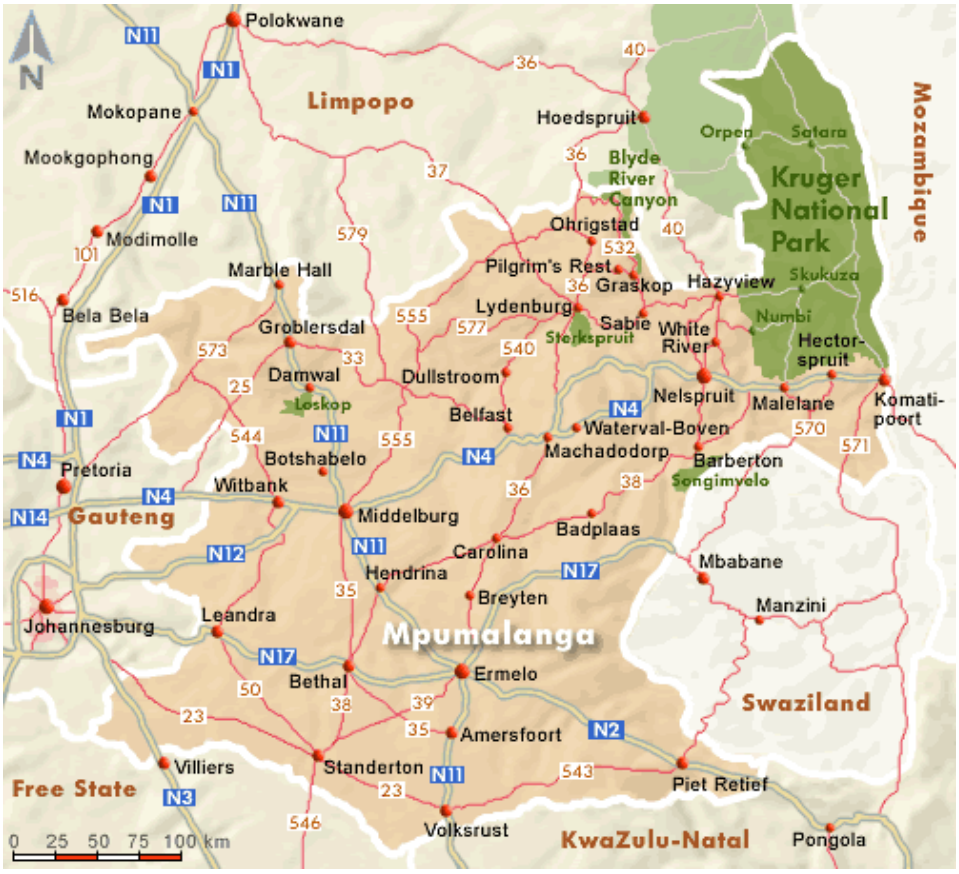


Figure 2: The province of Mpumalanga

The map above indicates the location of the province of Mpumalanga, its major towns and its primary attraction and national landmark: the Kruger National Park.

Mpumalanga is situated mainly on the high plateau grasslands of the Middleveld, and covers an area of 76,495 km^2 or 6.3% of the country. In the northeast, it has mountain peaks and ends in an escarpment. In places this escarpment plunges hundreds of metres down to the low-lying area of the Lowveld. The southern half of Kruger National Park lies in the eastern section of the province. With a total area of 76 495 square kilometres, Mpumalanga is the second-smallest province after Gauteng,

accounting for up 6.3% of South Africa's land area and with a population of over 4-million people. About a third of the people speak siSwati, the language of neighbouring Swaziland, with isiZulu, Xitsonga and isiNdebele commonly heard. Mpumalanga falls mainly within the grassland biome. The escarpment and the Lowveld form a transitional zone between this grassland area and the savannah biome. Stretches of grasslands change quickly into thickly forested ravines and waterfalls of the escarpment, and this shifts again into the sub-tropical zone of the Lowveld.

The Mpumalanga Province comprises of 3 District Municipalities and 18 local Municipalities:

Gert Sibande Municipality	Nkangala Municipality	Ehlanzeni Municipality
Albert Luthuli	Delmas	Thaba Chweu
Msukaligwa	Emalahleni	Mbombela
Mkhondo	Steve Tshwete	Umjindi
Pixley Ka seme	Highlands	Nkomazi
Lekwa	Thembisile	Bushbuckridge
Dipaleseng	Dr JS Moroka	
Govan Mbeki		

The map below captured the location of the three districts of Mpumalanga showing the location of Ehlanzeni, Nkangala and Gert Sibande Districts.

Figure 3: District Municipalities of Mpumalanga

The province is home to the Kruger National Park, South Africa's most prized tourism asset and well as key mining, agricultural and manufacturing industries. Agriculture is the largest land user, utilising approximately 68% of the province of which cultivation accounts for 15% and grazing 53% of the land cover. In total, nature reserves cover 19% and forestry plantations 9% of the Province. The remaining part of the province is used by human settlements, water bodies (dams and pans) and mines.

The Mpumalanga Province shares two international borders - with Mozambique and Swaziland and neighbours four South African provinces. International partnerships are increasingly playing a role in the provincial affairs. The province has a bi-national commission (the Komati Basin Water Authority) that oversees water issues with Swaziland and a recently signed tourism branding initiative known as Tri-lands (with Swaziland and Mozambique) are indicative of this trend[30].

3.2. Current and projected development

3.2.1. Mpumalanga's Economic Growth and Development Plan

Mpumalanga's Economic Growth and Development Plan (MEGDP, 2011) is a provincial plan that looks at a 10 year horizon. The document highlights the current economic landscape of Mpumalanga with a view to future economic growth and development. The primary objective of the MEGDP is to foster economic growth that creates jobs, reduce poverty and inequality in the Province. Therefore, there is a strong focus on job creation in the Agricultural, Manufacturing, Infrastructure and Mining sectors.

The focal point of the plan is infrastructure development as the driver for jobs. Other drivers discussed in the plan include: labour absorbing activities across the main economic sectors; opportunities in the knowledge and green economies; leveraging social capital; and rural development and regional integration.

Given the fact that climate change has a potential to impact negatively on infrastructure, it is important to use the plan as a starting point for the vulnerability assessment. Any programme aimed at developing infrastructure, whether for transport, water or purely industrial, needs to consider the uncertainty associated with climate vulnerability.

3.2.1.1. Sub-plans to support the MEGDP

In order to achieve its objectives, there are a number of sub-plans that need to be developed in parallel. These are expanded on below. The reader should take note of the fact that the provincial plan together with the sub plans discussed here under, are important in achieving government outcomes, and should therefore inform the vulnerability assessment process.

Provincial Spatial Development Plan

In relation to the economy of space, the province is looking to review its spatial development plan. This is aimed at producing positive outcomes, in particular to those who live far from basic services. Infrastructure to improve access to water, health, jobs, and rural livelihoods among others is critical in this instance. This is important, especially if the province experience increases in health related issues due to extreme climatic changes.

Provincial Infrastructure Development Plan

This plan is aimed at ensuring that by 2020, Mpumalanga's infrastructure is resilient, coordinated and contributes to economic growth and increased quality of life. The primary features of this plan

[30] South Africa Info, "Mpumalanga," http://www.southafrica.info/business/investing/opportunities/mpumalanga.htm#.VO8p7C6yHUc#ixzz3SrRQosbq

include building new roads, bridges and buildings, the maintenance of existing infrastructure, supplying bulk water infrastructure and improving infrastructure for health and sanitation. There are various committees also established to recommend what crucial infrastructure is required by the province.

Provincial Water Management Plan

One of the primary sectors considered as part of the vulnerability assessment is the water services sector. Water is the driver of large scale economic development (in particular mining and industrial, agricultural and energy generation in Mpumalanga), while at the same time it plays a critical role for domestic functioning at a household level. A clear plan in this regard is crucial since large cubic meters of water are transferred out of the Inkomati basin for strategic use to generate energy. The Provincial aims to develop a comprehensive water management plan will contain water management programs that will identify and prioritise water conservation opportunities. The plan will include clear information on water uses and allocation in the province, current water consumption and its costs and future allocation of water to improve economic growth. In the broader scheme of things the water plan should pay attention to potential climate change impacts on water in the long run. Therefore understanding the direct and indirect climate impacts on sectors that depend on water is of paramount importance. The impacts of water use and water quality should also be considered here, especially in times of drought.

Energy Distribution Plan

Mpumalanga's energy plan will prioritise working closely with the sugar industry on bagasse, the forestry industry on biomass, hydro and other forms of energy sources to supplement the power generated by Eskom are key for economic activity particularly industrialisation. However, it worth noting here that climate change is likely to have an impact on forestry, the sugar industry and hydro generation of power.

Environmental Plan

The environmental landscape in Mpumalanga is under threat, not only from expansions and development, but also from climatic impacts. The province will finalise an environmental plan which will respond to the loss of biodiversity which the province currently faces. The plan will pay particular attention on the conservation of biodiversity by ensuring that all practices whether by government or private sector/ industry take into account the conservation of biodiversity. Mpumalanga needs to build resilience into this sector urgently as tourism is dependent on having a healthy environment for both flora and fauna.

Mpumalanga Biodiversity Sector Plan

Mpumalanga Biodiversity Sector Plan informs the environmental sensitivity layer for MEGDP and provincial SDF. The Plan is intended to guide conservation and land-use decisions in support of sustainable development.

Comprehensive Rural Development Plan

This plan aims at improving the livelihood of the inhabitants in rural areas through access to basic services, infrastructure development and the creation of employment opportunities.

Reconciliation Strategy for the Olifants River Water Supply System

The Olifants reconciliation strategy developed for the Olifants Water Management Area is aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future. Especially seeing that the water demand has increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

Mbombela Municipal Area Reconciliation Study

The Mbombela Reconciliation Study covers the Municipal area that straddles the Sabie and Crocodile River catchment. The water use within the Mbombela Local Municipality (MLM) has increased rapidly over the last few years and hence both catchments are currently fully or over-allocated. The focus of the strategy looked at increasing water availability primarily for domestic and industrial use. Increased irrigation and forestry has not been included in the future planning, however, should a scheme be implemented, conjunctive use will be considered. The study showed no indications that climate change has been considered as part of the study and it has not been included in the further studies. This needs to be re-looked at going forward.

Whilst the above is not an exhaustive list, it speaks to the number of plans that have already been developed by the province and will be used as building blocks for making recommendations when it comes to the adaptation strategies for Mpumalanga.

3.3. Climate

The Lowveld region experiences mild winters and has a subtropical climate, due to its proximity to the warm Indian Ocean and latitude. The Highveld is comparatively much cooler, due to its altitude of 2300m to 1700m above sea level. The Drakensberg Escarpment receives the most precipitation, with all other areas being moderately well-watered by mostly summer thunderstorms.

The Highveld often experiences severe frost, whilst the Lowveld is mostly frost-free. Winter rainfall is rare, except for some drizzle on the escarpment. The differences in climate between the two halves of Mpumalanga are demonstrated below by the capital, Mbombela, which is in the Lowveld, and Belfast on the Highveld (data from South African Weather Service).

- ***Mbombela averages***: January maximum: 29 °C (min: 19 °C), July maximum: 23 °C (min: 6 °C), annual precipitation: 767 mm
- ***Belfast averages***: January maximum: 23 °C (min: 12 °C), June maximum: 15 °C (min: 1 °C), annual precipitation: 878 mm

Presented below is the current and future climate variability for Mpumalanga, which falls under Zone 1.

3.3.1. Current and future climate variability

3.3.1.1. Temperature

Mpumalanga sees annual temperatures range between 15 - 29°C. For the period 2015–2035, the annual temperature looks to increase by 2°C[31] which would lead to an increase in the evapo-transpiration.

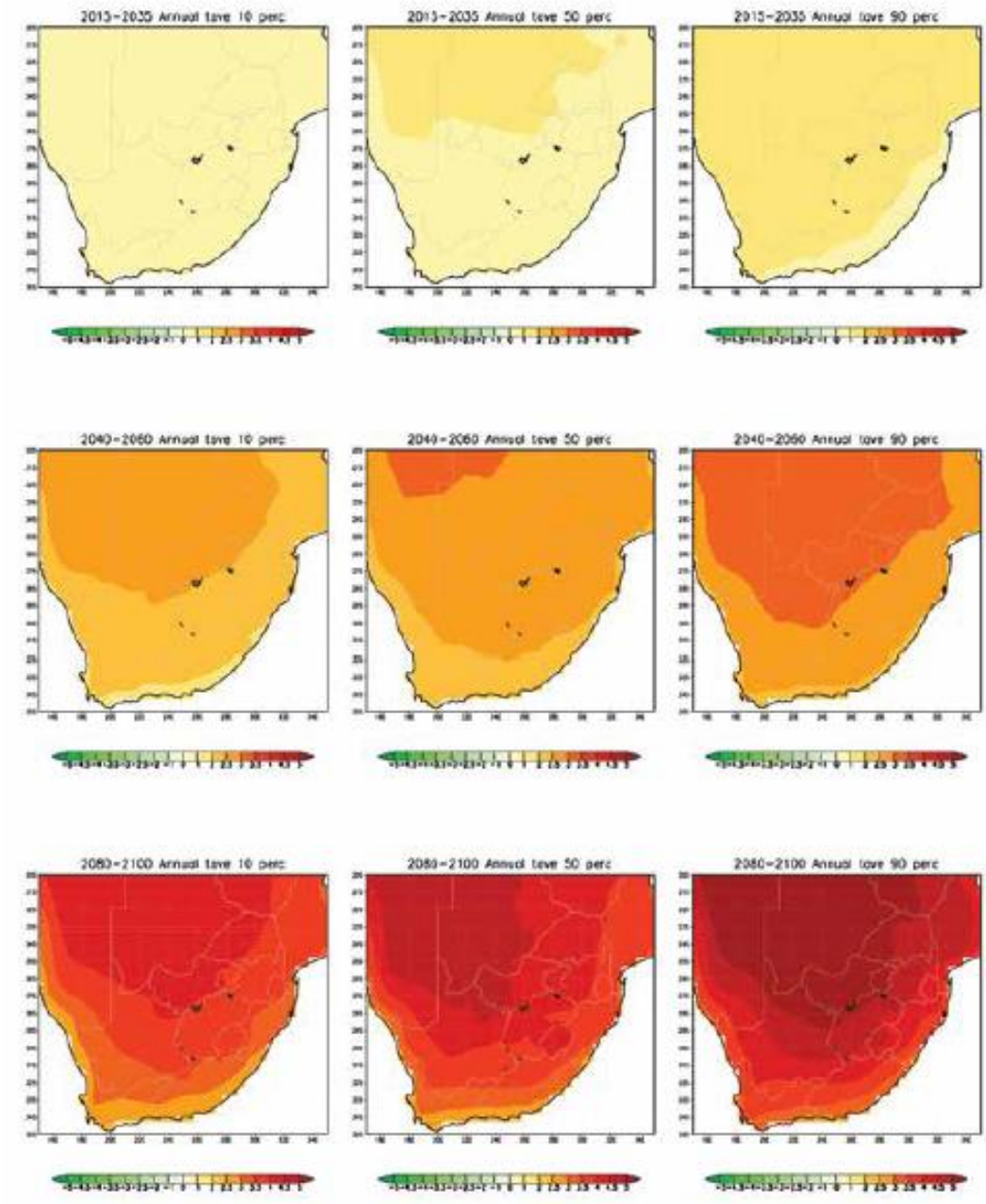


Figure 4: Projected change in the annual average temperature (°C) over South Africa, for the time periods 2015–2035, 2040–2060 and 2080–2100, relative to 1970–2005. The 10th percentile (left), median (middle) and 90th percentile (right) are shown for the ensemble of downscalings of six CGCM projections. The downscalings were performed using the regional model CCAM and are for the A2 SRES scenario[32]

[31] CLIMATE TRENDS AND SCENARIOS FOR SOUTH AFRICA LTAS Phase 1, Technical Report (no. 1 of 6)

[32] DEA (Department of Environmental Affairs). 2013.Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa

An annual average temperature for the mid-future period (2040–2060) temperature anomalies of between 1 and 3°C (2 to 5°C) and are projected to increase to 3–6°C (4–7°C) for the province for the period 2080–2100. This is a drastic increase resulting in high degrees of evapotranspiration[33].

3.3.1.2. Rainfall

The Mpumalanga area experiences summer rainfall.

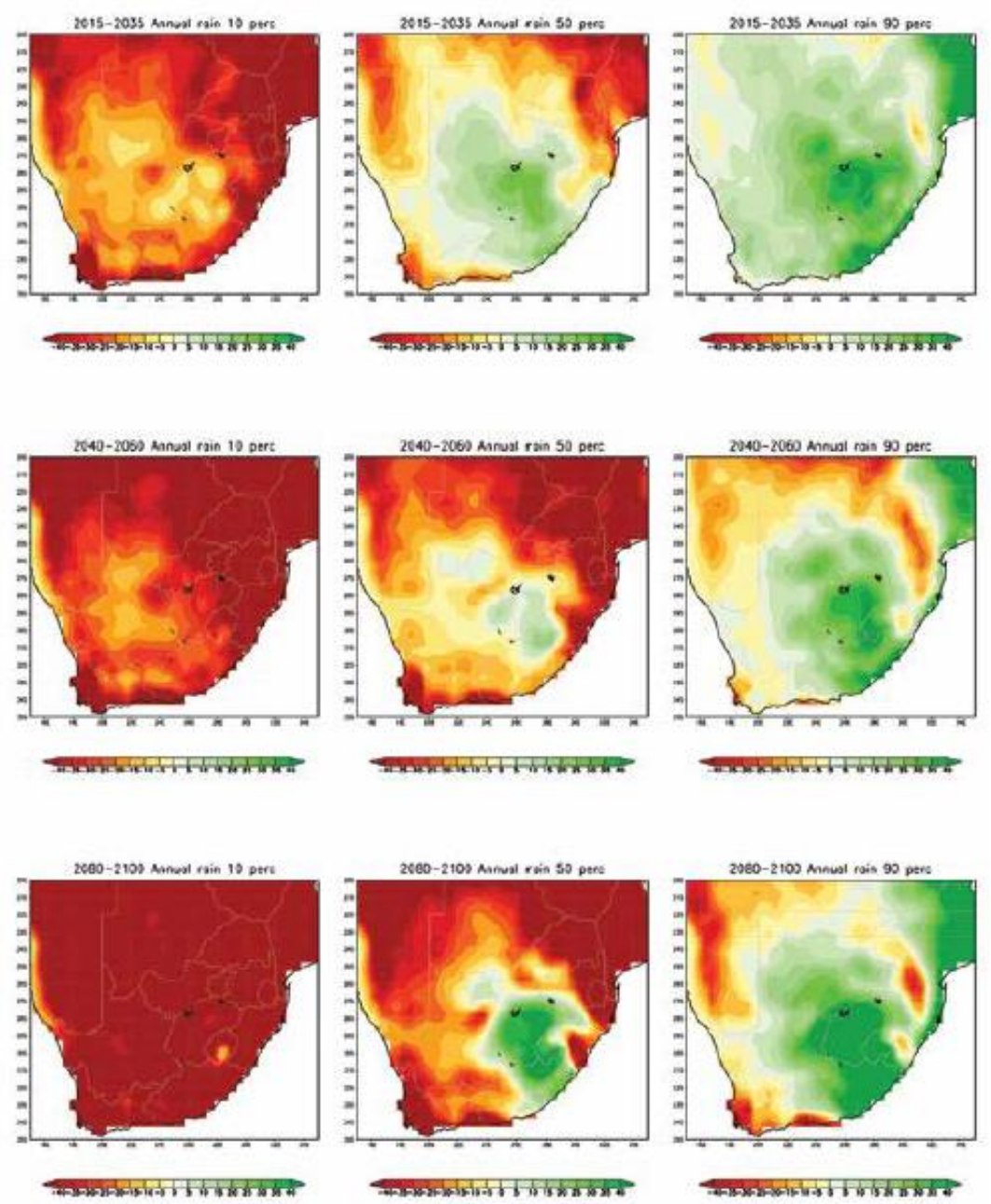


Figure 5: Projected change in the average annual rainfall (mm) over South Africa, for the time periods 2015–2035, 2040–2060 and 2080–2100, relative to 1970–2005, The downscalings were performed using the regional model CCAM and the A2 SRES scenario[34]

[33] DEA (Department of Environmental Affairs). 2013.Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa.

[34] DEA (Department of Environmental Affairs). 2013.Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa

The annual precipitation varies from less than 500 mm in the eastern Lowveld and 700 mm in the western Highveld to more than 1 100 mm in the escarpment. There are also frequent heat-induced thunderstorms over the eastern escarpment and Highveld areas which will affect the overall mean annual rainfall[35]. Whilst there may be some increases in rainfall in some parts, due to the high-temperatures, there is an increase in the evapo-transpiration which implies less water available for use. Due to seasonal shifts, there is an expected reduction in the summer rainfall over the next two decades, which will lead to heightened water stress.

Rainfall anomalies projected for the province exhibit a clear pattern of drying under the A2 scenario, which strengthens over time as predicted by the LTAS scenarios report (see figure below). The report goes on to show that there are no major shifts in the rainfall for the long term (2080-2100) and that the anomalies are within the range of present-day climate variability[36].

The table below presented the synthesised data extracted from the projection maps from the SA LTAS report. The following will assist in trying to unpack the table and its meaning:

- SON, September, October, November
- DJF: December, January, February
- MAM: March, April, May
- JJA: June, July, August

Table 4: Summary of the Ensemble Mean Projected Changes in Precipitation in the 2080s for Differing Emissions Scenarios and Differing Downscaling Methods[37]

			Summer Rainfall Region			Winter Rainfall Region		
			SON	DJF	MAM	MAM	JJA	SON
CSAG	CMIP 5	RCP8.5	↑	↑	↓	↓	↑	↑↓
		RCP4.5	↑	↑	↓	↓	↑	↑
	CMIP3	A2	↑	↓	↑	↑	↑↓	↑↓
		B1	↑↓	↑	↓	↑	↑	↑↓
CSIR	CMIP 5	RCP8.5	↓↑	↑↓	↓	↓	↓	↓
		RCP4.5	↑↓	↑↓	↑↓	↓	↓	↓
	CMIP3	A2	↑↓	↑↓	↑↓	↑↓	↓	↓

The single arrow implies consistent direction of change across the summer or winter rainfall region respectively, with upward and downward arrows indicating increases and decreases respectively; large and small arrows indicate strong and weak responses, and upwards and downwards arrows

[35] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf

[36] DEA (Department of Environmental Affairs). 2013.Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa

[37] WIREs Clim Change 2014, 5:605–620. doi: 10.1002/wcc.295

together indicate areas of both increase and decrease in the rainfall region[38]. Therefore, in going forward, for the longer term future, an erratic rainfall pattern will be used to understand the vulnerability of the sectors.

[38] WIREs Clim Change 2014, 5:605–620. doi: 10.1002/wcc.295

4. CLIMATE IMPACT AND RISK ASSESSMENT

Presented in this Chapter is the analysis based on the exposure, sensitivity and adaptive capacity of various sectors that form part of this assessment to climatic changes in Mpumalanga including ecosystems (terrestrial and aquatic), livelihoods, economic activities, infrastructure, public health and safety systems. The assessment follows the language Adopted by the IPCC to describe Confidence levels based on data collected. This chapter relies on data generated in the LTAS as indicated in Chapter 2 above. The future vulnerability and risk are considered for each sector.

4.1. Ecosystems

This section assesses the vulnerability of ecosystems to climate change in Mpumalanga. Ecosystem resources include mountain catchments, rivers, wetlands, and nodes and corridors of natural habitat among others. Together these form a network of interconnected natural elements in the landscape[39]. In the context of Mpumalanga, these ecosystem resources play a crucial role in delivering valuable services to communities (such as through fisheries), providing support to livelihoods (especially in the rural areas) and the continuance of economic activities such as tourism in the case of large conservancies (such as the Kruger National Park).

The key wetland areas in Mpumalanga are around Dullstroom, Lothair, Chrissies Meer and Wakkerstrooom. The Chrissies Meer Panveld is of particular importance as its key biodiversity features include three mammal species including Rough-haired Golden Mole, Cape Molerat and Oribi; seven bird species, for example the Blue Crane, Wattle Crane, Grey Crowned Crane, Rudd's Lark, Botha's Lark, Blue Korhaan and Yellow breasted Pipit are resident in this areas. Two plant species are also worth mentioning here. These are *Alepidea amatymbica* var. *amatymbica* and *Eucomis Montana*; and three vegetation types that include Eastern Highveld Grassland, Eastern Temperate Freshwater Wetlands and Wakkerstroom Montane Grassland. This ecosystem includes important sub-catchments; including an ecological corridor; and is important for sustenance of grassland processes[40]. The Verloren Vallei near Dullstroom has been recognised as a wetland of international importance in terms of the Ramsar Convention, and therefore has been awarded international status and protection[41].

As the climate changes, a shift in the distribution of ecosystems and species is predicted and unless measures are taken to combat these shifts, this could result in habitation loss and increased in the rate of extinction of species. Ecological climatic impacts will further aggravate the ecosystem's decline. On a lesser note, climatic impacts could also result in forced migration of certain species, in particular birds that depend on wetlands, and thus could create uncertainties around future distribution and migratory patterns[42].

[39] Technical report on the Mpumalanga Biodiversity Sector Plan, 2015
[40] SANBI, "Threatened Terrestrial Ecosystems for South Africa," http://bgis.sanbi.org/ecosystems/showecosystem.asp?CODE=MP%203
[41] South African Government, "Mpumalanga Hosts Wetlands Workshop," http://www.gov.za/mpumalanga-hosts-wetlands-workshop
[42] Technical report for the Mpumalanga Biodiversity Sector Plan, 2015

4.1.1. Aquatic Ecosystems

Aquatic ecosystems are exposed and therefore sensitive to changes in climate in the Mpumalanga province.

- ***Sensitivity***
  - The increased temperature in the **short-term** is resulting an increase in water temperatures causing stress and impacting on the physiology of aquatic life. The higher water temperatures could also result in decreased oxygen levels, changes in the rates of chemical and biological reactions, increased algal blooms as well as potential changes in species and /or environment due to the temperature shifts. The increase in evapotranspiration, due to higher temperatures. This phenomenon, together with the likely reduction in rainfall will result in an increase in concentration of salts and other constituents in the water, thereby decreasing water quality. Overtime this could see the drying of the water resource due to drought. This will specifically affect the already threatened system of Chrissiesmeer Panveld, freshwater pans at risk of becoming saline.
  - The projected extreme increases in temperatures in the **long-term** once again are likely to exacerbate the impacts felt by the aquatic system. The enhanced evaporation that will result from the dramatic increase in temperatures, coupled with shifts in the timing and quantity of rainfall would result in changes in the timing of high/ low run-off flows, increased incidences of flood and flash floods would increase instances of erosion of the aquatic boundaries erosion from high intensity rainfall events[43].
  - The positive impact of increased rainfall is the dilution of pollutants in the aquatic system, but the variability means the types of impacts expected on the ecosystem are uncertain.
  - In light of the above, the **Sensitivity** of aquatic systems to climatic impacts is **high** for both the short and long term.

- ***Exposure***
  - The studies that were reviewed show that in the **short-term** there is an increase in temperature in Mpumalanga (by up to 2°C), resulting in increased evapotranspiration. Increased temperature will also result in increased water temperatures. The short-term shows a reduction in rainfall, increasing water stress and potentially increasing droughts and drought periods. These impacts are likely to affect both biotic and abiotic systems in freshwater.
  - There is also an impact on the ground water recharge in the area, which will affect the supply of water to the wetlands and rivers[44].
  - The **longer term** sees a dramatic increase in the temperature (up to 6°C), which exacerbates all the impacts presented above. The higher temperatures could also see erratic rainfall patterns and increased flash floods, which would also affect the aquatic environment.
  - Based on the above, the aquatic environment has a **high level of exposure** to climatic changes, especially in the longer-term.

[43] Claire Davis, CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.rvatlas.org/k2c/download/handbook_climate_change.pdf

[44] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

➢ ***Risk***

- There is **high risk** to the aquatic ecosystem**.**

➢ ***Adaptive Capacity***

- The Mpumalanga Biodiversity Sector Plan prioritizes the management of ecosystems in the province. However, the results of implementing the plan will take a few years to take effect. For this reason, it is safe to argue that at present, the aquatic system has **little adaptive capacity over the short term.** Nevertheless**,** there are measures in place currently that are aimed at ensuring improved water quality, ensure water supply, controlling alien vegetation, increasing and improving wetlands. This is evident with studies such as the Water Reconciliation studies. The only downfall is that such reconciliation studies do not take into account climatic impacts.
- Whilst Mpumalanga has a Wetlands Forum to deal with issues of the wetlands, it is still early days to determine how effective the Forum has been[45].
- Therefore, bearing the above in mind, the aquatic ecosystems may have a **medium adaptive capacity for the long-term.** The studies which now include climatic impacts, the integration and implementation of various plans should improve adaptive capacity for aquatic ecosystems.

➢ ***Vulnerability***

- Within the context of this vulnerability assessment study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different compared to present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is **medium**, while long term (2020-2040 and beyond) vulnerability is **high**.

4.1.2. Terrestrial

Most of the threatened ecosystems occur within the grassland biome. The threatened ecosystems are moderately to highly transformed and are also poorly protected within formal conservation areas. The main drivers of transformation of the vegetation types/ecosystem have been as a result of forestry and agriculture. The proposed future expansion of mining operations within the Mpumalanga Highveld is also likely to further threaten the ecosystem status of vegetation types within this region and to pose a serious threat to water quality within pristine catchments.

➢ ***Sensitivity***

- There are 3 biomes occurring within the province which comprises of 68 vegetation types:
  - Grassland (high-veld and escarpment hills)
  - Savanna (escarpment foothills and lowveld)
  - Forest (south- and east-facing escarpment valleys)
- The biomes that are occurring in the Highveld are supported currently by the summer rainfall.

[45] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

- The main ecosystems in Mpumalanga are Savannas and grasslands. The sensitivity of Savanna to temperature is generally low. Savanna plants are not predicted to be overly sensitive to increases in temperature as savanna seedlings can germinate at a wide range of high temperatures. However, Savanna plants have been shown to be sensitive when temperatures reach extreme highs, and they are also susceptible to rainfall variability (since Savanna seeds need frequent rain during their germination stage).[46]
- Carbon fertilization will increase the resilience and spread of the savanna biome, resulting in a decreased grassland biome.
- Forests comprise 0.51% of province and are naturally very fragmented but contain a unique faunal and floral assemblage. Dispersal and maintaining connectivity important. Fortunately the majority of forest plant species are wind or faunal dispersed to able to colonize new habitats. However, there are some species that are unable to do so, making them vulnerable to climate change.
- In the **short-term**, the reduction of rainfall would impact on the health of these biomes and the soil moisture for tree growth. Increased temperature would result in no frost during the winters, opening the door to tree growth in the area, negatively impacting the grassland biome. Climatic shifts generally favour the spread of invasive species in the area which negatively affects the existing ecosystem.
- The escarpment region is mainly dominated by forestry and driven by orographic rainfall. A reduction in rainfall would negatively impact the escarpment.
- Enhanced evaporation has the effect of concentrating salts and other constituents in open water bodies when their water volume is reduced. It can also concentrate salts and other constituents in the soil when soil moisture is reduced as a result of evaporation at the soil surface and water losses through evapotranspiration from plants.
- In the grassland areas water flow regulation is one of the most important ecosystem services (CEPF, 2010). Grasslands also provide essential ecosystem services and changes to these biomes threaten endemic species. Furthermore, the type of biome may changes to adapt to climatic impacts, further affecting the endemic species in that area.
- Increases in temperature will increase water extraction for forestry making it important to understand forest hydrology.
- In the **long term**, increases in temperature will affect water availability for the forests. Soil and soil moisture is directly impacted by climatic changes and variability, which directly impact the health or the terrestrial ecosystem. The extreme climatic changes would once again favour invasive species. Many endemic species are reliant of the current ecosystems, and should this change, this would negatively impact on the various mammals and birds in the province.
- Therefore, the terrestrial ecosystem is also **highly sensitive** to climatic impacts and variability.

➢ *Exposure*

- Short term (2015-2020) exposure to temperature rise and rainfall changes is **low**, given that the magnitude of change in five years differs substantially from what is already seen

[46] CSIR Climate change risk and vulnerability atlas http://www.rvatlas.org/k2c/information/conservation.php#ecosystem

with existing climate variability. However, in the medium and long term, temperature rise and rainfall changes in Mpumalanga are significant.

- Changes to the ecosystem impact on the endemic species present in the province. One specific study shows a significant range contraction in almost 80% of the 179 species (including 34 bird, 19 mammal, 50 reptile, 15 butterfly and 57 other invertebrate species)[47]. The province is already seeing altitudinal shifts for several of its species – this will only be exacerbated going into the future.
- Changes to biomes are already being experienced, with 50% of the grasslands already being lost[48]. The long-term may see new regions developing, which affect the existing species present.
- It is also noted that many tick borne diseases will increase in the area, affecting trade[49].
- The province will experience **high exposure** for its terrestrial ecosystems.

➢ *Risk*

- The province will experience **high risk** for its terrestrial ecosystem. The map below captures the various terrestrial systems in Mpumalanga, including the level of risk and protection.

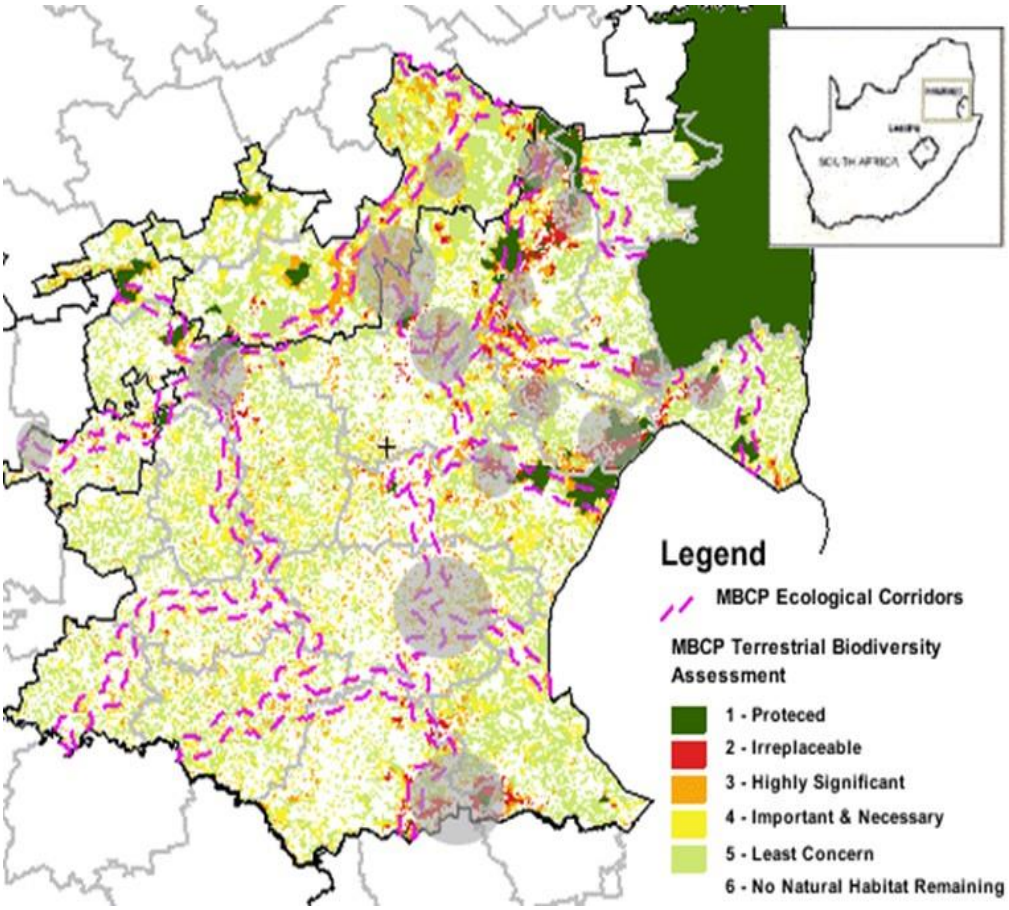


Figure 6: Terrestrial systems in Mpumalanga[50]

[47] Department of Science and Technology, *South African Risk and Vulnerability Atlas* http://www.rvatlas.org/download/sarva_atlas.pdf
[48] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality
[49] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

➢ *Adaptive Capacity*

- According to CEPF (2010), the grassland biome is one of the most threatened and least protected of all biomes types in southern Africa. It is understood that approximately 30% of South Africa's grasslands are irreversibly transformed and only 2% are formally conserved.[51] In Mpumalanga alone, 49% of the grasslands have been transformed[52] and because of land use pressures, there are relatively few choices for meeting protected area targets in some grassland vegetation types.
- The savanna biome is reasonably well protected, however, this is only true for some of its vegetation types. Lowveld and arid savannas are well protected by the Kruger National Park.
- To date, little is known about how trees will respond to elevated atmospheric CO_2 levels. For example, the growth rates of forests could change and increased impacts from carbon fertilization, which may impact significantly on forest management and timber markets, requiring an adjustment in forestry policy and planning[53].
- Grassland areas are already heavily fragmented which limits the adaptive capacities of its existing species and ecosystems. Therefore, in going forward, maintaining connectivity is crucial.
- While ecosystems tend to have the ability to adapt to gradual changes, long term changes in climate may outpace the ability of Mpumalanga's terrestrial ecosystems to adapt, especially in the absence of more concerted programs and policies aimed at conservation, resilience, and protection of these areas.
- Mpumalanga's Biodiversity Sector Plan (MBSP) does consider impacts of climate change and includes strategies to combat this; it also shows that the biodiversity connectivity in the area is severely compromised[54], however, implementation is uncertain.
- Changing habitats may require active management (i.e. clearing) to support existence and breeding of threatened animal species that are not suited to densification of woodlands.
- Therefore, given that landscape is heavily transformed and MBSP implementation is uncertain, **adaptive capacity is probably medium**, but this depends highly on government's policies to implement the MBSP.

➢ *Vulnerability*

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

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[50] SANBI, Mpumalanga Terrestrial Biodiversity Assessment http://bgis.sanbi.org/MBCP/biodiversityAssessment.asp
[51] LTAS: Climate Change implications for the Biodiversity Sector
[52] Technical Report on the Mpumalanga Biodiversity Sector Plan, 2015
[53] Department of Science and Technology, *South African Risk and Vulnerability Atlas* http://www.rvatlas.org/download/sarva_atlas.pdf
[54] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

4.2. Livelihoods

Mpumalanga has an estimated population of 4 229 300 as of 2014, which represents a 5% increase in population since the 2011 Census. The figure below illustrates the population density of Mpumalanga. As expected, there are nodes showing that the highest densities are where the economic opportunities lie. This is likely to increase in density as the Mpumalanga Economic Growth and Development Plan looks to increase job opportunities in various sectors, attracting more people to the already dense economic hubs, and will most likely see a shift in populations from the rural areas to the urban areas.

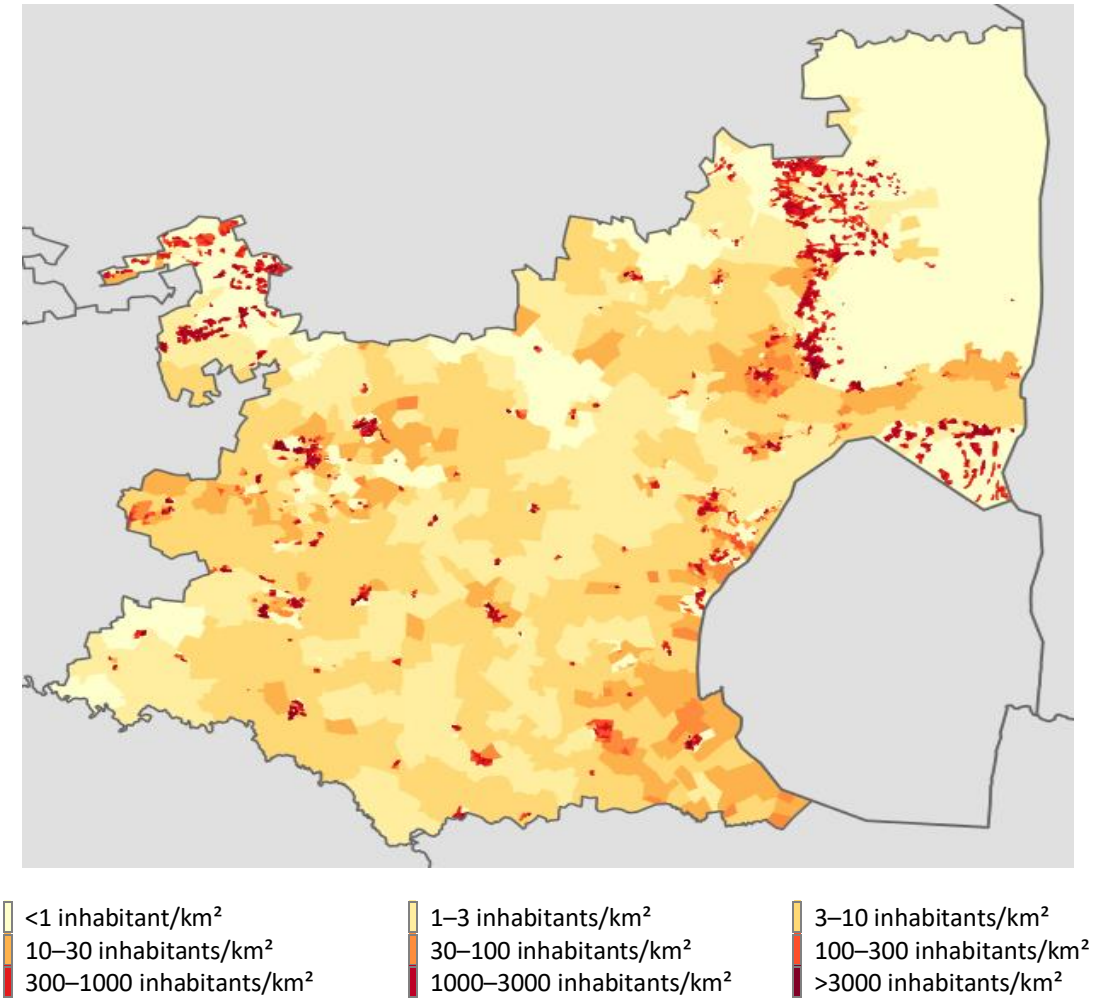

Figure 7: Population Density of Mpumalanga (2011)[55], where the darker shades indicate higher densities

The agricultural sector, in particular, plays an essential role in providing livelihoods in the province; it underpins the fight against poverty and food security for the people of Mpumalanga, and is critical to achieving the Millennium Development Goals (MDGs). The role of agriculture in supplying employment to unskilled workers, ensuring food security to rural people as well as stimulating other sectors in the value-chain such as manufacturing and trade makes it a particularly important sector towards the attainment of growth and development. Thus, it is the core of livelihoods in the region.

[55] http://commons.wikimedia.org/wiki/File:Mpumalanga_2011_population_density_map.svg

4.2.1. Rural

- ***Sensitivity***
  - In the **short-term**, likely decreases in runoff and stream flow coupled with an increased risk of drought will affect food security (as a result of lowered agricultural yields, lower quality agricultural produce, and diminished harvests). This will directly impact rural livelihoods.
  - In the **long term**, extreme temperatures coupled with erratic rainfall patterns will also affect crop production (particularly in the form of lower yields and more crop-damage), thereby impacting food security. Rural communities will also be prone to increases in water-related disasters as extreme weather becomes more frequent or intense, which will impact on the community's infrastructure and health.
  - Rural livelihoods are thus **highly sensitive** to climatic impacts, since the majority of rural livelihoods depend on natural resources, and the natural resource base is susceptible to changes brought about by changes in temperature and rainfall resulting from climate change.

- ***Exposure***
  - People who reside in informal settlements located around Mpumalanga have been identified as the most vulnerable populations that are severely impacted by drought, storms, floods and wild fires. In the **short-term**, there is huge exposure to risks from water-borne diseases due to changes in rainfall patterns and temperature increases, especially in households without proper access to potable water. Reduced stream flow is a particular threat for rural communities that are directly dependent on surface water resources[56]. Changes in climate also contribute to the emancipation of traditional practices[57].
  - The rural agricultural sector (rain-fed and subsistence farming will be impacted, as the decreased rainfall will result in increased demand for irrigation, where there is little or no infrastructure. Furthermore, rural communities who experience erratic income flows and are reliant on subsistence farming. This means that areas where malnutrition is high already experience food insecurity due to a variety of reasons such as poverty and the incapacity to grow enough of the right kinds of food. Furthermore, the increase in food prices will also contribute to malnutrition.
  - Accessibility to economic- development land for those residing in rural areas is an issue, and whilst there is the Spatial Planning and Land Use Management Act (SPLUMA) which seeks to promote consistency and uniformity in procedures and decision-making in this field. It also looks to address historical spatial imbalances and the integration of the principles of sustainable development into land use and planning regulatory tools and legislative instruments[58].

[56] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013). http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

[57] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

[58] Center for Environmental Rights, "Spatial Planning and Land Use Management Act 2013," http://cer.org.za/virtual-library/legislation/national/landuseandplanning/spatial-planning-and-land-use-management-act-2013-2

- In the **long-term**, there are increased water-related disasters such as floods and severe storms, particularly in cases where the communities are located on flood plains and there is an absence of proper water infrastructure.
- Extreme precipitation events are often preceded by lightening, which is responsible for a significant number of fatalities in rural areas every year[59].
- The extreme temperatures experienced long term in the province promote the ignition and spread of wildfires and with little infrastructure, rural livelihoods are at risk[60].
- Many rural households are not connected to the electricity grid and rely on other sources, mainly wood, but gas, dung or paraffin is also used. The long term sees impacts on forestry, which will result in households looking to other sources as the primary fuel.
- Basic services such as water supply, sanitation and refuse removal will also be impacted, noting that the level of service is very low in rural areas. In those areas, where the municipality offers no waste removal and dumping of waste occurs in close proximity to the rural settlements, there are huge health implications. Increased temperatures promote the degradation of waste, exposing the settlement to methane, increased risk to fire and the spread of diseases through runoff from rainfall events.
- Many rural areas are populated by high numbers of children and the elderly as people of a working age often migrate to urban areas in search of work. Children and the elderly are more susceptible and vulnerable to climate change impacts such as severe heat stress, food insecurity and malnutrition all of which can catalyse the opportunity for other types of illnesses. The primary health care (PHC) utilisation rate measures average visits per year, which will increase in the long term.
- Rural livelihoods have a **high-level of exposure** to climatic events, due to lack of infrastructure, water and sanitation and long-term due to extreme weather events.

➢ *Risk*

- Rural livelihoods are at **high risk** to experience climatic impacts.

➢ *Adaptive Capacity*

- Whilst the MEDGP outlines improvement in services, increased job opportunities and improved spatial planning, the **adaptive capacity for rural livelihoods in very low** due to low or lack of the following:
    - *Infrastructure and services: Access to services and dwelling types*
    - *Health: Malnutrition and primary health care*
    - *Socio-economic vulnerability: Land ownership, household income, gender and age profile*[61].

[59] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013). http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

[60] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013). http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

[61] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013).

- The adaptive capacity is further negatively impacted by lack of human capacity, both in government and society[62] especially since climate change is likely bring new environmental stressors upon the health of communities such as heat stress, waterborne diseases and increased malnutrition, access to regular and quality medical care will enhance the adaptive capacity of rural settlements.
- The threatened state of biodiversity and ecological infrastructure that support rural livelihoods due to climatic impacts also affects the rural livelihoods. Measures to conserve and protect biodiversity serve to improve the resilience of the environment noting the role wetlands and mangroves play in mitigating the impact of flooding, sequestrating carbon and in enhancing water quality[63] and thereby improving rural livelihoods.
- The Mpumalanga Provincial Legislature recently approved the Mpumalanga Human Settlements Master Plan, which is a roadmap for urban rejuvenation and rural development interventions up to the year 2030, which will only take impact in the future. The province is also looking to invest in the development of township and rural economies, including the provision of infrastructure and support for industrial development in areas where the majority of our people live will[64]. Furthermore, Department of Human Settlements has established a functional GIS system to accelerate the identification and utilisation of land that is suitably located for human settlement and local socio-economic development.
- The longer term could see an improvement in adaptive capacity if the plans are implemented.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

4.2.2. Urban

➢ ***Sensitivity***

- The well-developed urban areas in the province will experience low/medium sensitivity to climatic impacts. This is mainly due to the current infrastructure in place and dwelling types are more structured and climate resilient as compared to the informal settlements.
- Areas with informal settlements, caused by the migration of people from the rural areas to places of economic opportunities will experience high **sensitivity**.
- In the **long term** however, the urban areas overall will experience **increased sensitivity** to climatic impacts.

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http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

[62] Rural areas climate change impacts

[63] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013).
http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

[64] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf

➢ ***Exposure***

- Climate change will present a number of risks and hazards, such as an increase in temperature and an increase in the risk of flooding. For this reason, it is imperative that people's shelters are able to endure these challenges. The concern is that due to the migration of people to areas of economic development, there are a number of informal settlements that are erected from poor building materials. These pose a health hazard due to lack of circulation of air and the likelihood that the shelters may not withstand extreme climate impacts such as storms and accompanying floods.

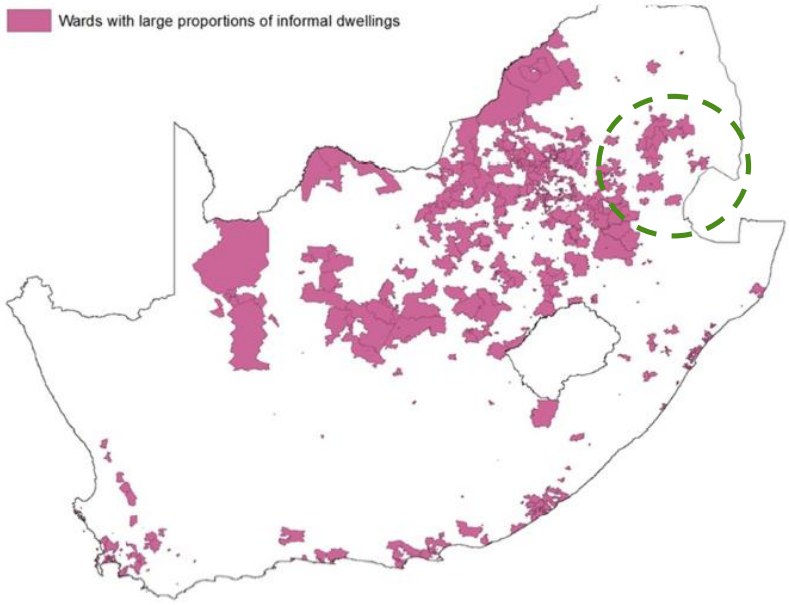


Figure 8: Map showing density of informal dwellings[65]

- In the **short term**, there urban environment will experience medium exposure to climatic impacts. During droughts less water is available to dilute wastewater discharges and irrigation return flows resulting in aggravated impacts on downstream users and aquatic ecosystems.
- In the **long-term**, the burden on the municipalities will grow, resulting in increased water demand and services such as sanitation and refuse removal.
- Increased urbanisation leads to increased return flows which current infrastructure may not be able to deal with.

➢ ***Risk***

- The risk for urban livelihoods is at a **medium** level.

➢ ***Adaptive Capacity***

[65] Linked, Department of Rural Development and Land Reform, *Climate Change Risk and Vulnerability Assessment for Rural Human Settlements* (July 2013). http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

- Increased urbanisation has some advantages, for instance, dense human settles requires less land and basic service delivery is more viable due to spatial proximity of people to services. However, on the downside, this means more pressure on resources such as water and on urban infrastructure.
- The adaptive capacity of the urban environment in the **short term** is at a low level. There are plans that are in existence, but very little take into account climatic impacts. Even the Olifants water reconciliation strategy looks at supply for increased population demand, does not factor in climatic impacts. The MEDGP, which looks at increasing job opportunities, where one of the sectors is agriculture, has not factored in that commercial forestry in the future may look a different tree growth or may shift out of the province entirely.
- In the **long term**, the burden on municipalities will grow because of the expected increases in natural disasters, water scarcity and disease, and reduced agricultural production and food security. Some municipalities will be more sensitive to these changes than others, and many municipalities may lack the adaptive capacity because of existing developmental challenges, such as low incomes, weak institutions, low levels of education and primary health care, lack of markets and infrastructure and already-degraded ecosystems[66].
- Impacts from stressed water supply, decreasing water quality and a defective energy supply will impact economic growth in the area and affect the rate at which climatic mitigation infrastructure can be put in place.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

4.3. Economic Activity

After mining and quarrying (29.8% of provincial GDP), manufacturing, power generation, tourism and agriculture are the province's other major sectors. These are discussed below

4.3.1. Agriculture and Farming

The climate in the province supports the abundance of fruits and vegetables that is grown in the area. The area sees a wealth of citrus fruit and many other subtropical fruit such as mangoes, avocados, litchis, bananas, papayas, granadillas, guavas as well as nuts. The Institute for Tropical and Subtropical Crops, situated in Mbombela, is the second-largest citrus-producing area in South Africa and is responsible for one third of the country's export in oranges. Groblersdal is an important irrigation area, which yields a wide variety of products such as citrus fruit, cotton, tobacco, wheat

[66] The impact of climate change on South Africa's rural areas, Chapter 4

and vegetables. Whilst Carolina-Bethal-Ermelo produces potatoes, sunflowers, maize and peanuts are also produced in this region.

In the Lowveld area, largely the Ehlanzeni district, focus will be placed on the production of sugarcane, nuts, vegetables, citrus and sub-tropical fruits. In the Highveld area, which includes Gert Sibande and Nkangala districts, crops that will be prioritised are summer grains, oilseeds and deciduous fruits. Animal production will also be given special attention in these districts. For the most part, dry land farming is utilised in agricultural production in the Highveld, with intensive irrigation activities taking place in the Loskop area near Groblersdal and in the Lowveld area adjacent to the Crocodile and Komati Rivers. Considerable potential for increased agro-processing exists in the Province, but this is constrained by access to water resources, water allocation and quality of water. Another challenge is the competition with the mining sector for arable land.

Piet Retief in the southeast is a production area for tropical fruit and sugar. A large sugar industry is also found at Malelane in the east. The province also sees livestock farming such as sheep and cattle. Ermelo is the district in South Africa that produces the most wool whereas Standerton, in the south, has a large dairy industry.

The province's rich agricultural produce is used by companies such as McCain, Nestlé and PepsiCo and there are also pulp and paper plants (Sappi and Mondi), fertiliser facilities and textile-manufacturing units. The decision by Sappi to start producing chemical cellulose at its Ngodwana Mill will significantly increase the manufacturing capacity of the province[67].

- ***Sensitivity***
  - Farmers rely on predictable rains for timing the planting of crops, and subsistence farmers practicing rain-fed agriculture are particularly at risk[68] in the **short term** due to the predicted decrease in rainfall.
  - In the **long term**, the extreme increase in temperatures may increase the risk of veld-fires causing damage to property, grazing, and crops. The erratic rainfall patterns may increase risk of floods, with consequent risks of damage to crops, property and loss of life.
  - Therefore, the agricultural sector in Mpumalanga is at **highly sensitive** to climatic impacts.

- ***Exposure***
  - For the most part, dry land farming is utilised in agricultural production in the Highveld, with intensive irrigation activities taking place in the Loskop area near Groblersdal and in the Lowveld area adjacent to the Crocodile and Komati Rivers. Therefore, these areas will be affected in the **short-term** due to the rise in temperature as well as the predicted decrease in rainfall. This will further aggravate the agricultural sector which is already experiences shortages in water supply as well as poor water quality due to mining impacts. Crop productivity may decrease for even small increases in temperature,

[67] South Africa Info, "Mpumalanga," http://www.southafrica.info/business/investing/opportunities/mpumalanga.htm#.VO8p7C6yHUc#ixzz3SrQDFG21
[68] Climate Change Risk and Vulnerability Assessment for Rural Human Settlements

(despite benefits obtained through increased photosynthetic activity as a result of increased carbon dioxide).

- In the **long term**, the exposure to climatic impacts increases due. High intensity rainfalls would cause damage to bulk water infrastructure, irrigation systems and water reticulation. Increased precipitation will result in water logging of soil affecting crops. The extreme change in climate and predicted higher temperatures may negatively impact organic matter; in an environment where soil organic matter retention is already affected by other stressors such as grazing, addition of fertiliser and manure, burning, and soil cultivation[69]. There could also be increased demand for irrigation, in an already stressed water environment. The quality of water for irrigation would also be impacted. This coupled with the fact that there are challenges around competition for land and water resources with mining in the area increases the risk and vulnerability of the agricultural sector in the Province.

➢ *Risk*

- The agricultural sector is at high risk in the province.

➢ *Adaptive Capacity*

- Food security and agriculture remains a concern, both for large-scale commercial farmers, smallholder and subsistence farmers. In the **short-term**, there are plans being review to look at water allocation, land allocation, however, a strategy on looking at new crop growth in the area is lacking. This needs to be a series concern for climate specific crops. Furthermore, the province could look at moving the location of crops away from river beds, to minimize damage during flood events[70].
- In the **long-term**, there is considerable potential for increased agro-processing, but this is constrained by access to water resources, water allocation and quality of water. Another challenge is the competition with the mining sector for arable land.
- Increased temperatures in this area will give rise to high evapotranspiration rates for the natural vegetation and will increase the environmental demand. In addition, there may be greater demands for agriculture in this zone. Agricultural production in the Highveld, differs from that in the Lowveld, primarily consisting of cereal and grain production which is directly linked to the food security of the country.
- The predicted changes in climate, however, could force the shutdown or relocation of agricultural business in vulnerable areas, which would have an enormous effect on economic development of the area as well as on a community which is made up largely of unskilled labour.
- Therefore the adaptive capacity of the agricultural industry is **very low**, both in the long and short term, even though there are extensive studies at a national level being done on climatic impacts on agriculture.

➢ *Vulnerability*

[69] CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.csir.co.za/nre/coupled_land_water_and_marine_ecosystems/pdfs/Davis_2010.pdf
[70] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

4.3.2. Forestry

The Mpumalanga forestry sector is one of the most important in the country: 9% of the total land area of Mpumalanga is covered either by plantations or natural forests. One of the country's largest paper mills is situated at Ngodwana, close to its timber source.

South Africa has a plantation area of more than 1.5 million hectares, representing only 1.2% of the land area. One of the largest afforested areas in South Africa (an area of 0.6 million hectares) is in the Mpumalanga province. The Forestry Industry contributes 8.7% of the gross value of the country's agricultural output. The plantation forests of South Africa use just 3% of the country's total water resource. The forestry industry is highly reliant on rainfall, as it is not an irrigated industry. Therefore, the rainfall needs to be higher than 750 mm per annum to sustain commercial forestry[71].

Mpumalanga Province has extensive commercial forests and sophisticated processing plants dealing with everything from sawn logs, pulp and paper to board. The province has South Africa's biggest sawmill and its largest panel and board plant, as well as the biggest integrated pulp and paper mill in Africa.

Forestry is one of the sectors identified as a key growth area in terms of the Accelerated and Shared Growth Initiative of South Africa (AsgiSA), which aims to reduce poverty and unemployment and help the country achieve an economic growth rate of 6% per annum. South Africa earned R14.2-billion from forestry exports in 2009, but imports cost R12.1-billion. Three primary genera are grown in these commercial forestry plantations, of which pines and eucalypts are dominant, with wattle grown to a lesser extent[72]. Depending on the end use of the tree, the rotation length can vary from 7-30years.

Firstly, the nationwide programme of spending on infrastructure will increase timber demand, particularly by the construction industry. This boom includes spending for rail, road and port upgrades and is set to continue for some years. The second factor that will help this sector is the fact that old coal mines are being reopened and new ones commissioned.

- ***Sensitivity***
  - Individual tree species have climatically optimum conditions for growth and this is impacted by changes in the climate.
  - Furthermore, climatic effects on forestry can include an impact on the growth of trees; the frequency and intensity of forest fires; the spread of forest pests, and it could

[71] SABIE, "Forestry," http://www.sabie.co.za/about/forestry/
[72] Department of Science and Technology, *South African Risk and Vulnerability Atlas* http://www.rvatlas.org/download/sarva_atlas.pdf

increase damage caused by extreme weather conditions such as drought, floods and storms[73].

- Climate influences the survival and spread of insects and pathogens directly, as well as the susceptibility of their forest ecosystems, with inter- and intra-annual variations in temperature and precipitation affecting pest reproduction, dispersal and distribution.
- The forestry industry is at medium to low risk in the short term, shifting to a higher level of risk in the long-term.

➢ ***Exposure***

- The exposure to timber farmers and companies is high, as changes in climate may not favour the current plant species/genus being grown. Due to the erratic weather patterns predicted, the plantations themselves are exposed to lightning, runaway fires, frost, snow and hail damage.
- Forestry plantations will also be impacted by increased demand in the already stressed water recourses. Plantations are generally more water intensive their native vegetation they have replaced, and can therefore, significantly reduces the flow in rivers. Plantations also reduce groundwater recharge where roots are able to tap into the groundwater table, with forest plantations having been shown to significantly depress low flows[74].
- The level of exposure to the forestry industry is ***low in the short term***, but due to the intense increases in temperature as well as the erratic rainfall patterns, this places them at a ***high level of exposure in the long-term***.

➢ ***Risk***

- There is a ***medium level*** of risk to the forestry industry

➢ ***Adaptive Capacity***

- As part of the Forest Stewardship Certification (FSC) requirements, Sappi has established protected regions within our plantations (grasslands, wetlands, indigenous forest). These however may also be affected by climate change in their range or in the presence of species that are of conservation value[75].
- For the Forestry industry, the DEA is currently implementing a climate adaptation strategy via some co-ordinated projects being facilitated by the Institute for Commercial Forestry Research (ICFR). The current adaptation includes the proposed implementation of biomass projects for fuel and energy.
- The forestry industry can supply large quantities of timber/wood/bark not used in mill production for the generation of energy from wood burning. Backing from government for these types of sustainable projects will be of an environmental and climate advantage.

[73] Department of Environmental Affairs). 2013. Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Change Implications for the Agriculture and Forestry
[74] Department of Environmental Affairs). 2013. Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Change Implications for the Agriculture and Forestry
[75] Forestry and Climate Change Adaptations, Communication from Sappi, 2015

- In addition, there is a myriad of research that is currently underway by Forestry South Africa (FSA) on tree species that are more climate-change resistant.
- In agreement with a memorandum signed with Department of Water and Sanitation (DWS), forestry is implementing the withdrawal of forested areas from riparian/wetland habitat, to reduce the impact on water availability/quantity that might also be affected by climate change.
- Sappi is looking to develop and produce more tolerant genetic material – i.e. have a range of less risky species. This includes the planting of clones and hybrids (both Pine and Eucalyptus species) that are bread and tested for pest/disease and other climate tolerances. In addition, SAPPI is fine tuning their site classification models and data, such as a frost occurrence model, to improve the deployment of trees to the most appropriate sites, where they will be less susceptible to extreme weather conditions that may be caused by climate change[76].
- Disaster management has been highlighted as a serious area that requires attention, especially the implementation of fire management due to the increase of forest fires as a climate change impact. Fire management will need to be implemented cooperatively with government, such as local and district municipalities and Mpumalanga DARDLEA[77].
- The different tree species grown have different climatic constraints (such as mean annual precipitation and mean annual temperature) which determine where they can be grown. Thus shifts in these climates will impact the suitably of certain tree types for commercial forestry, which may need to move to more appropriate climate. Furthermore, plantation Water Use Licences should be reviewed every 40yrs and this should be linked to a strategic water use plan[78].
- Alternative forms of silviculture, such as mixed species forests, agroforestry, and the use of adapted indigenous tree species could yield more resilient plantations in areas where site development uncertainty is high or water use restrictions prohibit the use of fast-growing plantation species. The expansion on forestry does not address this and therefore, the adaptive capacity of the province is at a low level.
- The ***adaptive capacity*** of the forestry industry is therefore ***medium in the short term***, but will be low if actions are not implemented.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability of the forestry industry is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

[76] Forestry and Climate Change Adaptations, Communication from Sappi, 2015
[77] Forestry and Climate Change Adaptations, Communication from Sappi, 2015
[78] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

4.3.3. Tourism (linked to impacts on ecosystems, as well as public health impacts)

Mpumalanga boasts a range of natural attractions including parks, reserves, botanical gardens, rivers and lakes, including the largest freshwater body in South Africa at Chrissies Meer, near Ermelo. Lake Chrissie is the largest natural freshwater lake in South Africa and is famous for its variety of aquatic birds, particularly flamingos. The Kruger National Park is a major national asset and is home to the Big Five. The park receives more than a million visitors annually. Some of the most luxurious private game lodges in the world are located along the park's edge.

The tourism industry, which comprises of both local and international markets, is dependent on scenic landscapes and biodiversity. If malaria spreads as a result of increased temperatures then this could influence the tourism market. Densification of woodland areas may also impact on scenic views and animals requiring more open landscapes. Active management of these areas would be required to sustain animal and tourism in some areas in order to protect nature reserves and biodiversity rich areas. In doing so, the connectivity across the landscape would be conserved, which would support the tourism industry.

The province is experiencing losses in its biodiversity which impacts its tourism industry. The 3 biomes occurring within the province comprise of 68 vegetation types as described within the Vegetation Map of South Africa, Lesotho and Swaziland. Vegetation types provide a good representation of terrestrial biodiversity because most organisms (animals, birds, and insects) are associated with a particular vegetation type. An assessment, conducted by the province through the Mpumalanga Tourism and Parks Agency (MTPA) in conjunction with SANBI, of the status of ecosystems occurring within the Province, has indicated that close to 9% of the surface area of the province is categorized as critically endangered or endangered.

- ***Sensitivity***
  - Tourism relies on a healthy biodiversity in the province. In the **short-term**, the decrease in rainfall is already impacting negatively on the national parks and biomes in the province. Water flows in the Kruger National Park (KNP) will be impacted on by both decreased rainfall and increases in temperature and related variability, which may result in increased salinity in water resources in the region. This will be detrimental to the flora and fauna in the area.
  - This will be exacerbated in the **long-term** as shifts in climate would impact and change the ecosystem. Many endemic species are reliant on the current ecosystems, and should this change, this would negatively impact on the various mammals and birds in the province.
  - The tourism industry is **highly sensitive** to climatic impacts.

- ***Exposure***
  - Increases in temperature will impact the health or the terrestrial ecosystem. The extreme climatic changes would once again favour invasive species. Many endemic species are reliant of the current ecosystems, and should this change, this would negatively impact on the various mammals and birds in the province. Changes in the timing of plant and

animal life cycles will impact conservation areas as this may in future change the species assemblages of these areas.

- The tourism industry will experience a **high-level of exposure**, especially in the long-term.

➢ ***Risk***

- The tourism industry is at **high risk**.

➢ ***Adaptive Capacity***

- Conservation agencies, particularly state-run conservation areas, have a mandate to maintain biodiversity, and through several Acts are obliged to meet a range of biodiversity targets, however, if little or no input to mitigate or adapt to climatic impacts is taken in the future planning process, the tourism industry would be extremely vulnerable in the long term.
- The province is looking to prioritise the diversification of the tourism product portfolio focusing specifically on the Blyde River Canyon, Loskop Dam Tourism Belt and the Barberton Development Clusters[79].
- Therefore, the province currently has a **low/medium adaptive capacity** for its tourism industry.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Associated risks of alien invasive species and disease create challenges for the industry.
- Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

4.3.4. Extractives

Mpumalanga is very rich mining activity (as can be seen from the figure below), particularly coal mining. More than 80% of South Africa's coal is sourced in this province, with the town of Witbank being the centre of the industry. The country's major power stations, three of which are the biggest in the southern hemisphere, are situated in this province. Mpumalanga's 11 coal-fired power stations, mostly located near the extensive coalfields in the west, provide the bulk of South Africa's electrical power. South Africa needs more power to drive its economy and so several of these power stations are being returned to service after a period of inactivity or are having their capacity increased. This is creating a demand for coal and resource companies are responding quickly to this need, investing in new equipment and opening new mines[80].

[79] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf

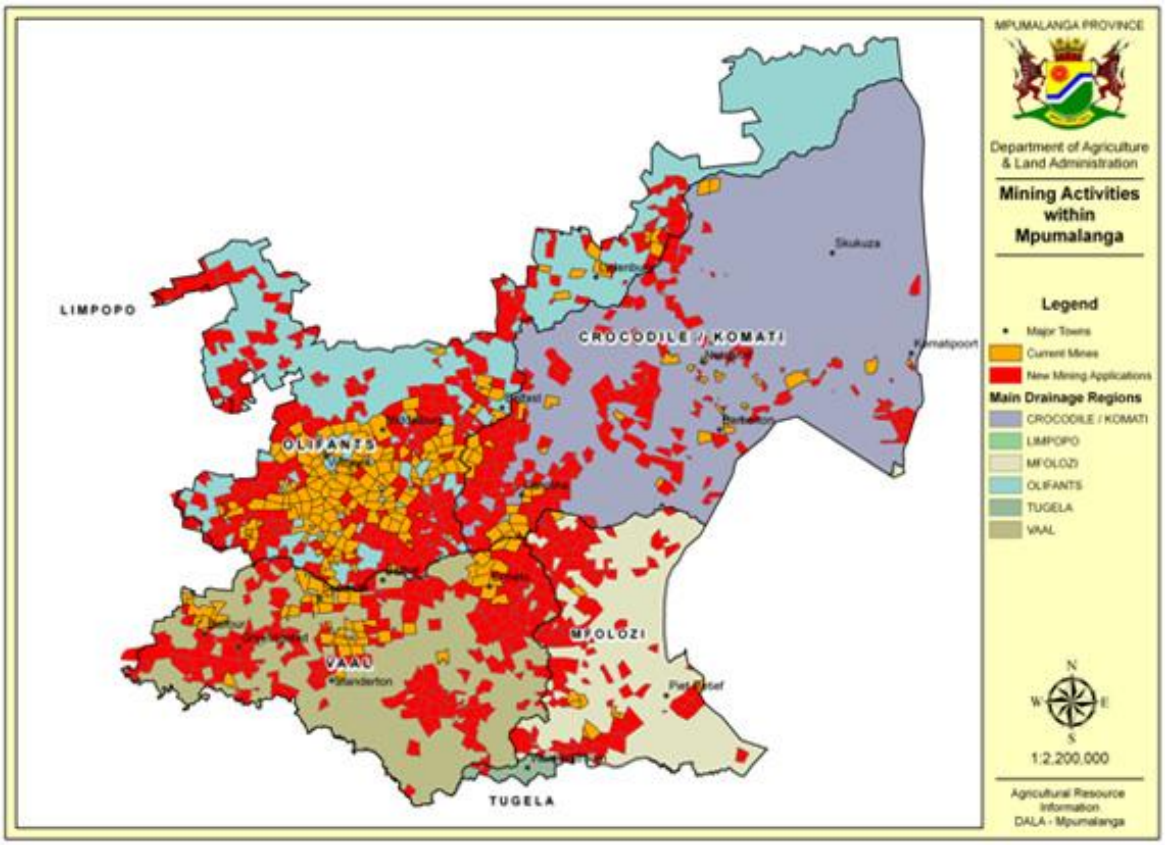


Figure 9: Mining Activities in Mpumalanga

Mpumalanga also has a strong manufacturing sector, with internationally renowned companies such as Sasol (synthetic fuels and chemicals), Evraz (steel) and Xstrata (ferrochrome) having large operations in the province. Other minerals found in the province include gold, platinum, chromite, zinc, cobalt, copper, iron and manganese.

In order to understand the future around coal and energy in South Africa, the Fossil Fuel Foundation, Eskom, coal producers and the Department of Minerals and Energy initiated a project that outlined the Coal Road Map for South Africa. The main aim was to explore how the coal value chain could contribute to a flourishing country[81] and the short, medium and long-term activities and interventions required to support the coal industry.

The South African Coal roadmap took a scenario based approach and focussed on global climate change as well as the country's mitigation response as the key drivers. The four scenarios are presented below:

[81] South African Coal Road Map, July 2013

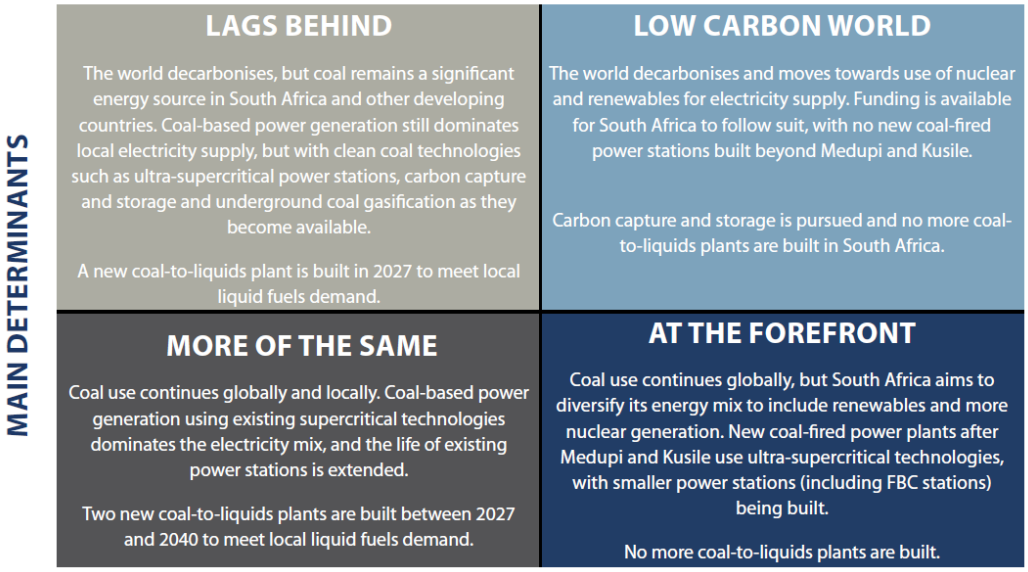


Figure 10: The future scenarios for coal in South Africa

According to the World Energy Council (WEC), coal will continue to be an expanding source of cheap energy for the foreseeable future. The use of coal for energy production results in both the primary environmental impacts associated with the mining and removal of coal for use in coal fired power stations in the province, as well as the secondary impacts resulting from the burning of this coal for energy production. The coal deposits in the Springs-Witbank belt are steadily being mined out and are said to have a future life span of no more than 30 years.

The transportation of coal for power generation has a major impact to the provincial road network especially in the Highveld. The generation of electricity through coal-fired power stations produces pollutants such as particulates, sulphur dioxide and nitrogen oxides. Emissions from coal-fired power stations are a serious concern for Mpumalanga as they cause impaired air quality in areas close to and away from the emission source and much of the demand for electricity in the country thus generates ambient air quality impacts that are felt largely in Mpumalanga and the surrounding areas. Coal combustion can also contribute to acid rain and run-off from mining can contaminate groundwater, while waste coal may spontaneously ignite. Furthermore, water and air pollution impacts are severe due to the large emissions.

The core impacts of these futures would be:

- ***Domestic and global coal market continues***

  This future sees a greater demand for coal and financial injection into the coal sector, resulting in many new coal mines and expansion of existing mines. This would result in increased employment and an improvement in economic growth and development of the country. The water demand would also grow and therefore place increased pressure on the already water-stressed country, should power stations continue on a wet-cooling path. If power stations move towards dry-cooling, the demand on the water reduces drastically. The downside of the expansion would be the introduction of AMD issues in areas such as the Waterberg or high-value sensitive areas such as the Nkangala grasslands biome (part of the Vaal, Thukela, Pongola and Usutu Rivers).

- ***Domestic and global coal market deteriorates***

  This future sees a decrease in the demand for coal resulting in contraction of the mining industry and, in some cases, the early closure of mines. The deterioration in the markets will also add a financial constraint to the sector, making less money available for closure processes. The loss of jobs would have a negative impact on growth and development of the country, and while some jobs may be created in the renewable energy sector, overall this would be insufficient. The demand on water resources would decrease; however, if no action is taken to curb the impact of AMD, this could still be detrimental to the country.

➢ *Sensitivity*

- The extractives industry is mainly affected by rainfall changes. In the short-term, decreased rainfall, resulting in decreased water available for mining activities.
- In the long-term, the erratic rainfall patterns, together with increased precipitation could result in poor coal quality.
- Therefore, the extractives industry has a medium sensitivity level.

➢ *Exposure*

- In the **short term**, the implications for decreased rainfall can be more severe in a heating future that a wetting future for coal mining. Increased water temperatures could have wide-ranging repercussions in the health sector through the creation of favourable conditions for the incubation and transmission of water-borne diseases. This will have a direct impact on the workforce for mining. Enhanced evaporation has the effect of concentrating salts and other constituents in an open water body when the water volume is reduced, resulting in the further degradation of water quality. Furthermore, during droughts less water is available for use and therefore there is less return flow to the resource which further aggravates the impacts on downstream users and aquatic ecosystems. On the positive side, less water means less ingress and reduces the risk of potential decant from AMD sits.

- In the **longer term**, the impact of increased rainfall on the population in the region with poor infrastructure and high burdens of infectious disease is likely to result in increased rates of diarrhoeal diseases after flood events. Flooding and heavy rainfall may also lead to contamination of water with chemicals, heavy metals or other hazardous substances from runoff and dam spills etc. The increased rainfall increases both the probability of future disasters and the potential for mass human exposure to hazardous materials during these events. The increased temperature results in increased evaporation, which may lead to uncertain rainfall patterns and increased storm events or flash floods. With the uncertainty in rainfall, increases in AMD volumes as a result of increased ingress may occur and perhaps exacerbate the phenomenon.

➢ *Risk*

- The extractives industry will have a **medium level of risk** to climatic impacts.

➢ ***Adaptive Capacity***

- Eskom has developed its own Climate Change Strategy that seeks to address the challenge through a comprehensive 6-step approach[82]. It also goes on to outline the adaption measures put in place, these include
  - *Increasing the robustness of infrastructure designs and long-term investments*
  - *Increasing the flexibility and resilience of managed natural and social systems*
  - *Reversing trends that increase vulnerability*
  - *Improving employee/societal awareness and preparedness for future climate change*
- Whilst many studies have looked at the future of mining and resources available, there has been little concern for the direct impact to changes in climate. Whilst the coal roadmap tried to understand climatic impacts on coal futures, no changes to mining have taken place.
- Therefore, the extractives industry has a **low level** of adaptive capacity.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is low, while long term (2020-2040 and beyond) vulnerability is medium.

4.4. Infrastructure and Utilities

4.4.1. Water Supply

Mpumalanga is the source of four of Southern Africa's major river systems with as much as 53% of the Province drained by the Olifants River System, the Orange River System (Vaal River), Nkomati River System (Crocodile, Sabie, Sand and Komati Rivers) and the Pongola River System (Usutu River). Furthermore, the province does not occupy a single clearly defined catchment, but straddles the Crocodile (East), the Sabie River, Vaal, Limpopo and the Olifants catchments, which creates even more complexity (see figure below). The long-term preservation and sustainability of ecosystems, communities and economic activities depends on the continued availability and accessibility to fresh water sources, principally obtained through rainfall (precipitation), surface flow (rivers) and groundwater.

[82] http://www.nbi.org.za/Lists/Events/Attachments/28/MRambharos_Eskom_Climate_Change_Response.pdf

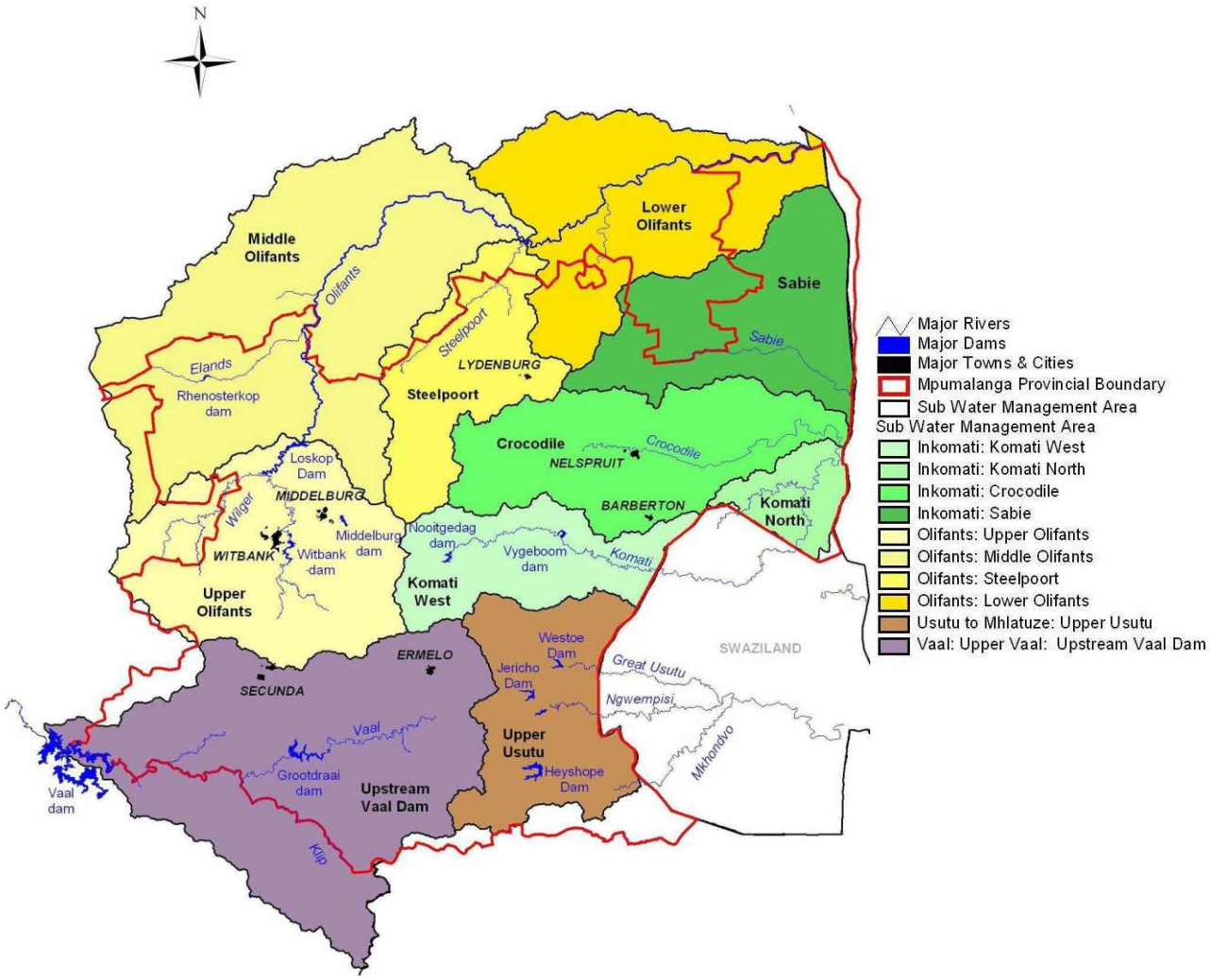


Figure 11: Mpumalanga Water Management[83]

Water is acknowledged by the Provincial Government as a scarce resource and there is concern that there has been a general decrease in water quality and quantity over the past few years. Water use within the province has increased rapidly over the last few years and the available water resources will soon be insufficient to supply the users within the various municipal areas at an acceptable level of assurance. Water quality indicators indicate an increase in surface water nutrients which portray a potential for enrichment, which could compromise riverine eco-systems and human health (Source). The most significant impacts on water quality are a result of mining, malfunctioning sewage treatment works and soil erosion from various practices especially agriculture and urban and rural development projects.

With regards to water quantity, the water resources in all the catchments in the Mpumalanga Province, with the exception of the Sabie River and upper Usutu, are over committed with current demands on the available water outstripping the water available in the system. New development

[83] Mpumalanga State of the Environment Report, Chapter 9, "Water."
http://soer.deat.gov.za/dm_documents/Mpumalanga_SoE_water_raEgx.pdf

initiatives must consider the water availability prior to engaging in unsustainable developments with high water demands.

According to DWA, Water use in South Africa is dominated by irrigation. This is also true for Mpumalanga as 46% of its water is required for irrigation. This demand for water is localised in a few of the WMAs, as is the demand for water for power generation. Water use for agricultural purposes is unevenly distributed throughout the WMAs. The second largest requirement for water is for 'transfers out'. Water resources in Mpumalanga are therefore important in supplying water to neighbouring catchments and WMAs. The issue of water sharing, both internationally with Mozambique and Swaziland as well as internally (between provinces), is extremely important, and one which requires careful management. The issue of water trading as well as water use licensing needs to be given attention for the Mpumalanga government to realise its growth trajectory. Guidance is required from the Department of Water and Sanitation.

Water supply has two arms, one being the health of the resource, and the second being the ability to meet demand. The sustainability of the rivers is linked to both the ecosystems as well as water quality an affects all sectors. As indicated in the graph below, below, water resources of the Olifants river are already stressed with power generation and mining taking up most of the available water. Of note, only a small portion of the available water is reserved for use in rural areas which, as indicated above, are densely populated and depend largely on subsistence farming for livelihoods. While the Inkomati river catchment on the other hand mainly serves to meet the South Africa's international obligations to its neighbors (Swaziland and Mozambique).

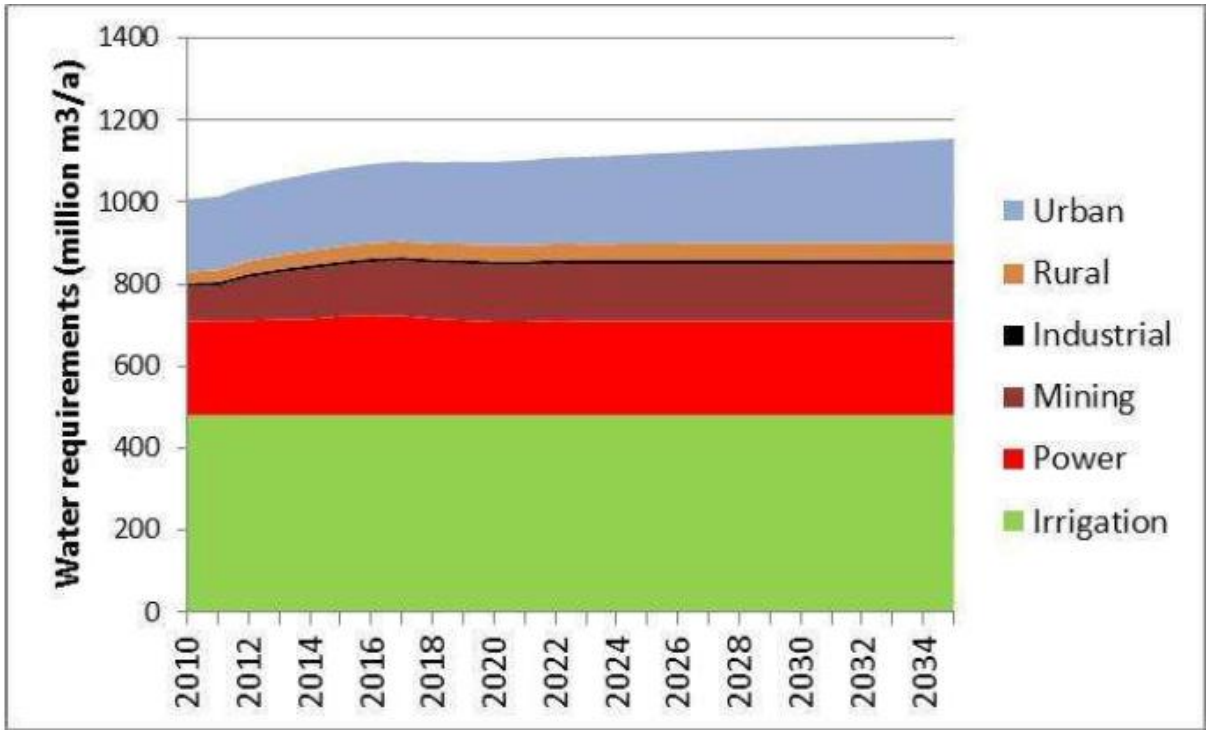


Figure 12: Projected water demand for the Olifants WMA[84]

[84] Olifants Reconciliation Study, DWA, 2011

➢ ***Sensitivity***

- The province is already experiencing water shortages and water supply to the province will be further impacted by the reduction in rainfall over the **short term**.
- The **long-term**, the water supply issues are further aggravated by the extreme increase in temperature resulting in enhanced evaporation. Increased variability and unpredictable timing of rainfall impacts directly on the management of catchments and bulk water infrastructure, further threatening the availability of water[85].
- Overall, the supply of water in the province is **highly sensitive** to climatic impacts.

➢ ***Exposure***

- The majority of catchments are currently using more than their available water to provide for domestic and other water needs. The Province of Mpumalanga which is under discussion in this report is no different. The map below depicts the picuture in the country to indicate the exposure resulting from water stress that Mpumalanga is faced with.

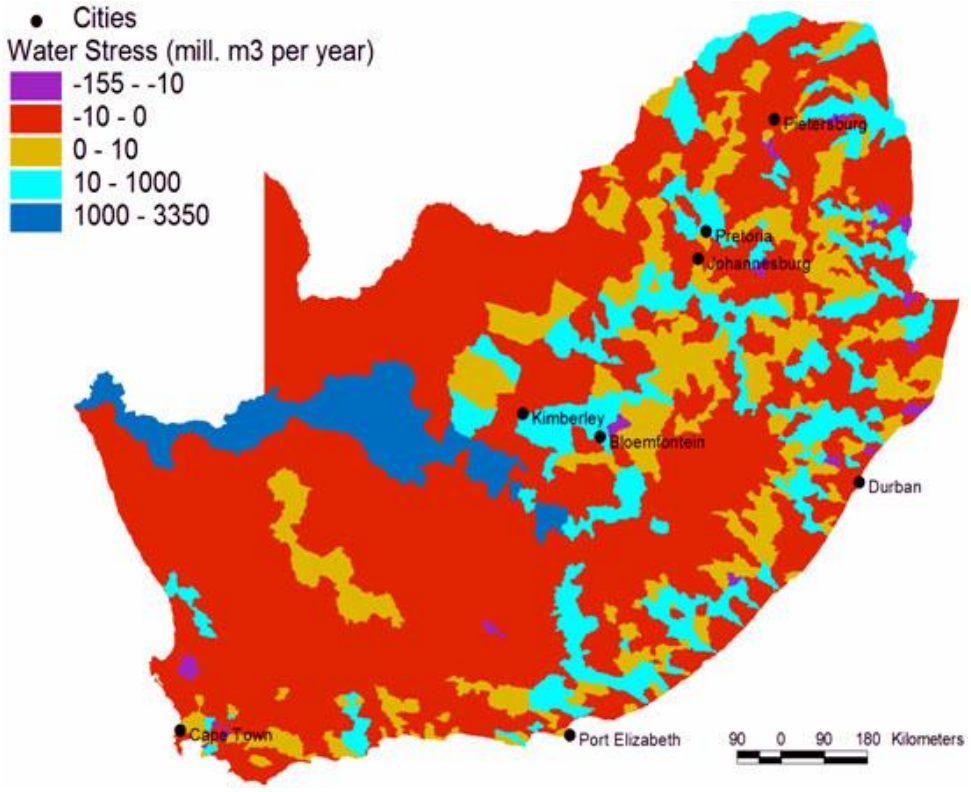


Figure 13: Map showing water stress for South Africa[86]

- The impact of climate change on hydrological processes such as runoff, soil moisture and evapotranspiration occurs as a result of changes in precipitation, temperatures and carbon dioxide, which are the key drivers of these hydrological processes. Climate change will have

[85] CSIR, "Climate Change Handbook for Northeastern South Africa," 2010. http://www.csir.co.za/nre/coupled_land_water_and_marine_ecosystems/pdfs/Davis_2010.pdf
[86] Rolling Alpha, September 16, 2014. http://www.rollingalpha.com/2014/09/16/and-speaking-of-eskom-water/

an effect on water resources in the province and therefore poses a challenge to water resource managers. Hydrology directly affects aquatic environmental conditions, the configuration of water use and supply systems and has a significant impact on the availability of water to meet demands.

- Rainfall intensity affects catchment wash-off processes as it increases the erosion of soil and other pollutants that accumulate on the surface of the catchment. It can also lead to surcharging sewers when sewage pipes become blocked with washed-off debris, or the discharge of partially treated wastewater from over-loaded wastewater treatment works (WWTW). This in turn poses a health risk to humans and can impact on aquatic ecosystems when the increased organic loads decompose and consume oxygen in the process.
- The erratic decreased availability of water in rivers as a result of net effect of increased temperatures and increased evaporation, coupled with shifts in the timing and amounts of rainfall; changes in the concentration and timing of high and low flows due to changes in rainfall; increased incidence of floods as the incidence of very heavy rain events increases all affect water supply. Extreme weather also results in the increased risk of water pollution and decreased water quality which further aggravates the issue of water supply.
- Therefore, water supply in the province will experience a **high level** of exposure.

➢ ***Risk***

- There is a **high risk** that the province will be unable to meet water demand.

➢ ***Adaptive Capacity***

- There are currently 84 Bulk Water supply and 43 water reticulation projects under construction across all our municipalities. The province will also provide steel reservoirs to 9 targeted areas to enhance bulk water storage capacity. Steel Reservoirs with a capacity of 2 mega litres storage were completed in Phola, Matsulu, Ka-Bokweni, Ka-Shabalala, Steenbok, Mangweni, Casteel, Thusanong and Cunningmore to cater for the areas in critical need in the Mbombela, Nkomazi and Bushbuckridge Municipalities. The province is looking to scale-up their War-on-Leaks Programme for water conservation and water demand management and implemented by all municipalities as part of revenue enhancement strategies. Furthermore, the province will also look to continue to upgrade the wastewater treatment plants in order to connect people to decent sanitation services and reduce the impact on water quality[87].
- The construction of strategic dams to increase the availability of water supply for development is also seen as a priority. In this regard, Mbombela will commence with processes leading to construction of a dam that will incorporate hydro-energy generation.
- The province has also partnered with the National Department of Water and Sanitation as well as Rand Water to provide water to communities. Boreholes will be drilled in all areas in need in order to provide reliable and constant water supply.
- The Province aims to develop a comprehensive water management plan will contain water management programs that will prioritise water conservation and identify water conservation opportunities. The plan will include clear information on water uses and allocation in the province, current water consumption and its costs and future allocation of

[87] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf

water to improve economic growth. The plan is also looking at climate change impacts. To this end, the CMAs need to start implementing the ecological reserve[88]. There is also a call to re-establish the river health committees.

- There is a strong call to eradicate unlawful use, and strengthen the capacity of the department to enforce both monitoring and compliance[89].
- There is also a need to look at energy sources that have a lower demand on water resources[90].
- The Reconciliation Study looked at increasing water availability primarily for domestic and industrial use. Increased irrigation and forestry has not been included in the future planning, however, should a scheme be implemented, conjunctive use will be considered. The study showed no indications that climate change has been considered as part of the study and it has not been included in the further studies.
- The adaptive capacity of the province is at a **medium level** due to a number of plans and strategies that have been developed at both a national and provincial level. However, in the long-term, the adaptive capacity becomes low should these plans and strategies not include mitigation and adaptation responses to climatic impacts.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

4.4.2. Energy supply

➢ ***Sensitivity***

- The supply of energy is impacted by the quality of coal that is mined, water supply and water quality, and is therefore, indirectly affected by climate change impacts. Currently, the entire country is experiencing power shortages due to various reasons and energy demand is expected to increase substantially by 2030.
- Energy supply is at a medium level of sensitivity, but this sensitivity could increase in the long term.

➢ ***Exposure***

- It is expected that the demand for electricity will increase with the increase in temperatures that will be experience by the province. This affects the amount of power needed for cooling processes in industrial applications as well as domestic cooling. Many of Eskom's older stations still use wet-cooling processes, and this impacts on the water supply.

➢ ***Risk***

[88] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality
[89] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality
[90] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

- The energy supply of the province is at high risk, but due a number of other factors. From a purely climate change risk point of view, the risk in the short term is low, and is a medium level risk in the long term.

➢ *Adaptive Capacity*

- Mpumalanga's energy plan will prioritise working closely with the sugar industry on baggase, the forestry industry on biomass, Hydro and other forms of energy sources to supplement the Eskom grid as electricity is key for economic activity particularly industrialisation. However, going forward, the impacts of water use and water quality should also be considered here, especially in times of drought.
- There is a need for managing and eradicating the illegal electricity connections[91].
- Highly impacted Ngankala District due to mining and power generation. However, the district has developed their own Climate Change Mitigation and Response strategy in 2013, improving their adaptive capacity.
- Besides coal, Mpumalanga has vast renewable energy resources can must be exploited to power the productive industries. The transition to a green economy is framed around the three central sustainability concepts of climate resilience, resource-efficiency and job creation. The green economy has the potential to significantly stimulate economic growth and create jobs.
- The green energy sub-sectors that have been identified to have great potential to increase the province's energy diversification include bio-fuels and biomass. Other key focus areas expected to support the green economy in the province include focusing on green buildings and using municipal waste to generate energy.
- The construction of the 68 km Majuba rail way is progressing well and the completion of this project will alleviate pressure on our coal haulage network, as it will change the transportation mode of coal to a number of power stations, especially Majuba Power Station, from road to rail[92]. The first coal-loaded train is scheduled to begin operating on this year. The province has starting upgrading and maintenance of the coal haulage network, which will further improve coal supply, and thereby energy supply.
- The adaptive capacity of the province is a medium level.

➢ *Vulnerability*

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in this assessment, short term vulnerability is low, while long term (2020-2040 and beyond) vulnerability is medium.

[91] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality
[92] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf

4.4.3. Transportation

The two main transport infrastructures in the province are the Maputo Development Corridor (MDC) that runs from Gauteng province to the port city of Maputo in Mozambique and the coal haulage routes mainly within the Gert Sibande and Nkangala district municipalities.

The Mpumalanga rail system covers a distance of 2 233 km and generates the most freight traffic in South Africa enabling the Province to play an important strategic economic role in the national economy. The most important lines are the Pretoria-Maputo and the Johannesburg-Durban lines (of which portions run through the Province). The remainder of the Province is generally fairly served in terms of rail infrastructure which serves most of the urban nodes. The Moloto Rail Development Corridor project will expand the rail system of the province.

Overall, Mpumalanga has a road infrastructure that varies in state from good to extreme disrepair. The backlog in roads infrastructure maintenance is a major challenge and has negative implications for commerce and industry. The farming industry is particularly affected by the state of rural access roads as transport costs affects competitiveness. The lack of good surfaced roads into many of the rural nodes could seriously hamper the future tourism development of these areas. The province also does not have adequate train stations which is vital for expanding rail services to all parts of the province.

The impacts of climate change are already being felt in Mpumalanga and will exacerbate existing challenges and create new ones in relation to climate variability, extreme weather events and changing rainfall patterns. This will affect a wide range of economic sectors and livelihoods and impact in major ways on the development of infrastructure into the future. Infrastructure asset management needs to play an important role in both maintaining existing infrastructure and modifying existing infrastructure or constructing new infrastructure to ensure optimum under climate change as well as looking at cost effective ecological infrastructure options to enhance or replace hard infrastructure.

- ***Sensitivity***
  - Changes in temperature cause roads and bridges to crack and buckle. Similarly, changes in rainfall can either make the underlying land dry or can lead to more water-related damage (from floods and runoff).
  - Overall, Mpumalanga has a road infrastructure that varies in state from good to extreme disrepair. In the **short-term**, the backlog in roads infrastructure maintenance is a major challenge and has negative implications for other sectors. The reduction in rainfall will impact water availability for such maintenance.
  - In the **long-term**, the climate change could further impact and destroy the state of transport infrastructure, especially with the prediction of increased extreme weather events such as flash floods.
  - On the whole, even though temperature and rainfall have impacts on roadways, in relative terms road infrastructure has a **low-level of sensitivity** to climatic impacts.

➢ ***Exposure***

- Mpumalanga's current road infrastructure is not well maintained, resulting in increased exposure to climatic events. This poor state of the province's road infrastructure impacts on the key economic sectors. The farming industry is particularly affected by the state of rural access roads as transport costs affect its competitiveness. The lack of good surfaced roads into many of the rural nodes could seriously hamper the future tourism development of these areas. The province also does not have adequate train stations which is vital for expanding rail services to all parts of the province.
- Infrastructure asset management plays an important role, and in the short needs to play an important role in both maintaining existing infrastructure and modifying existing infrastructure or constructing new infrastructure to ensure optimum under climate change as well as looking at cost effective ecological infrastructure options to enhance or replace hard infrastructure.

- The impacts of climate change are already being felt and new challenges will be seen from further changes in climate variability. In the **long-term**, this will affect a wide range of economic sectors and livelihoods and impact in major ways on the development of infrastructure into the future.

➢ ***Risk***

- The risk to transport infrastructure is **low in the short term**, but will be aggravated in the long-term, should no action be taken to mitigate climatic impacts.

➢ ***Adaptive Capacity***

- The Infrastructure Development Plan for the province aims at ensuring that by 2020, Mpumalanga's infrastructure is resilient coordinated and contributes to economic growth and increased quality of life. In the **short-term**, the Province's infrastructure development programme continues to prioritise socio-economic infrastructure such as roads, hospitals and schools[93]. The province had aside R1.7 billion for investment in the construction and maintenance of roads to enhance mobility and support the economy to create employment opportunities. Owing to the close proximity of the province to Mozambique and its gas deposits, the Province is looking to set up gas powered energy generation infrastructure which assists in addressing the overall needs of South Africa.
- There is a need to move towards solar traffic lights and ensure better synchronisation of the traffic lights to ease traffic congestion[94].
- This means a **medium adaptive capacity** in the **short-term**, but the implementation of the above plans beyond 2020 would build in the adaptive capacity required for the **long term**, thereby ensuring that the Mpumalanga's road infrastructure has **high adaptive capacity** in the future.

➢ ***Vulnerability***

[93] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf
[94] Inputs from Vulnerability Assessment Workshop, 23 March 2015, Nkangala District Municipality

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is low due to low exposure, while long term (2020-2040 and beyond) vulnerability is also low, assuming that the sector will develop adaptive capacity as planned.

4.5. Public Health and Safety

The health of humans is closely linked with their surrounding environment. Climate change is expected to affect the fundamental requirements for a healthy society: clean air, safe drinking water, sufficient food resources and secure shelter. Impacts from increased temperatures, heat waves, changes in rainfall regimes, extreme weather events coupled with migratory patterns of the population in the province will be explored in this section.

4.5.1. Human Health

➢ ***Sensitivity***

- In the **short term**, the direct health effects from increases in average temperature of climate change would include heat stress, increased morbidity and mortality rates, as well as result in non-communicable diseases such as respiratory and cardiovascular diseases. Over time, a changing climate would lead to changes in the distribution of vectors of disease such as mosquitoes and ticks.
- In the longer term, the direct health effects of climate change in the province would include extreme events such as floods, flash floods, and thermal stress (such as strokes, rashes and dehydration). Indirect health effects of climate change may include the spread and/or increase of the incidence of infectious and vector-borne diseases, water-borne pathogens, water quality, air quality, and food availability and quality. Increasing temperatures may favour the geographical expansion of the borders of malaria and cholera.
- Therefore, based on current evidence, human health is **moderately sensitive** to climatic impacts in the province.

➢ ***Exposure***

- Current climate conditions already show effects on mental and occupational health, and therefore, in the short term any adverse impacts would be worsened by food insecurity, hunger and malnutrition[95]. An increase in air temperature and increase in water temperature affects the quality of water for irrigation, dissolved oxygen content of water and the rates of chemical and biological reactions in water. These all could have wide ranging repercussions in the health sector through the creation of favourable conditions for the incubation and transmission of water-borne diseases[96]. The reduction in rainfall, leading

[95] LTAS Factsheet on Climate Change and Human Health
[96] LTAS Climate change impacts on water sector

to drought periods will also have negative impacts on human health, as the decreased availability of water coupled with the increase in the concentration of salts and exacerbation of the effects of eutrophication (algal blooms).

- In the **long term**, climate change increases both the probability of future disasters and the potential for mass human exposure to hazardous materials during these events. Flooding and heavy rainfall may lead to contamination of water with chemicals, heavy metals or other hazardous substances Climate influences the spatial distribution, intensity of transmission, and seasonality of diseases transmitted by vectors. Due to poor infrastructure in the province, the province could see increased rates of infectious diseases such as diarrhoea, especially in marginalised communities with increased instances of flood. People with pre-existing diseases, compromised immune systems and young children are highly sensitive and susceptible to climatic impacts, especially those with cardiovascular and respiratory diseases. Opportunistic infections including diarrhoeal diseases, which are climate sensitive, are known to develop in malnourished people or in people with immunosuppressing diseases like HIV/AIDS.

- Therefore, the province will experience **high exposure** to climatic impacts.

➢ ***Risk***

- Public health and safety is at **high risk** in the province, especially over the long term if no mitigating measures are put place.

➢ ***Adaptive Capacity***

- The actual health impacts that will occur in the future are strongly dependent on local environmental conditions, the socio-economic status of the area, and the range of adaptation measures put in place to reduce the threats. Individual mechanisms may include improving one's socio-economic status in order to afford the necessary means for coping with climate impacts such as medical care, proper nutrition and living in a secure and climate-resilient neighbourhood. Mpumalanga has both the spatial development plan well as their economic plan that is looking to increase jobs in the province, thereby improving the socio-economic status of its inhabitants. Institutional mechanisms may include surveillance and warning systems, vaccination programmes, treatment facilities, environmental limits or standards, sanitation systems, capacity building programmes, training facilities, public education and communication programmes and research and development programmes.

- Adaptive capacity is also dependent on sectoral policy decisions. Decisions and actions affecting the health of the population are often influenced by decisions taken in sectors other than health, such as energy, transportation and human settlement. While there are plans in place for these sectors, it is unknown to what degree there is inter-sectoral planning in order to build adaptive capacity for climatic impacts.
- Mpumalanga has two strategies for the **short-term**: piloting the National Health Insurance system in the Gert Sibande District, and the implementation of the Department of Health's

turnaround strategy to assist in stabilising the Mpumalanga Department of Health[97]. There are also plans to improve the Health Department's financial and human resource management systems, which will build in adaptive capacity needed. However, whilst there are policies and plans in place, the short term adaptive capacity of the province is low as there is much work required and due to the plans not taking into account climatic impacts.

- In the **longer term**, the adaptive capacity of the province may increase and the MEGDP is looking to review existing plans and policies and include strategies to combat climatic impacts, which can be implemented in the long term.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium (due to limited exposure), while long term (2020-2040 and beyond) vulnerability is high (due to insufficient evidence that the presently poor adaptive capacity will strengthen as needed).

4.5.2. Disaster Management Related to Extreme Weather Events

From the figure below, it can be seen that Mpumalanga is at serious risk for veld and forest fires. Whilst the Mpumalanga province did have a strategy for disaster management drawn up in 2004, the mandate for disaster management now sits with CogTA and feeds down to the provinces. The management of disasters is important for the province, not only from the point of veld fires, but also due to the potential for erratic weather in the future, where there may be increases incidences of floods and drought events.

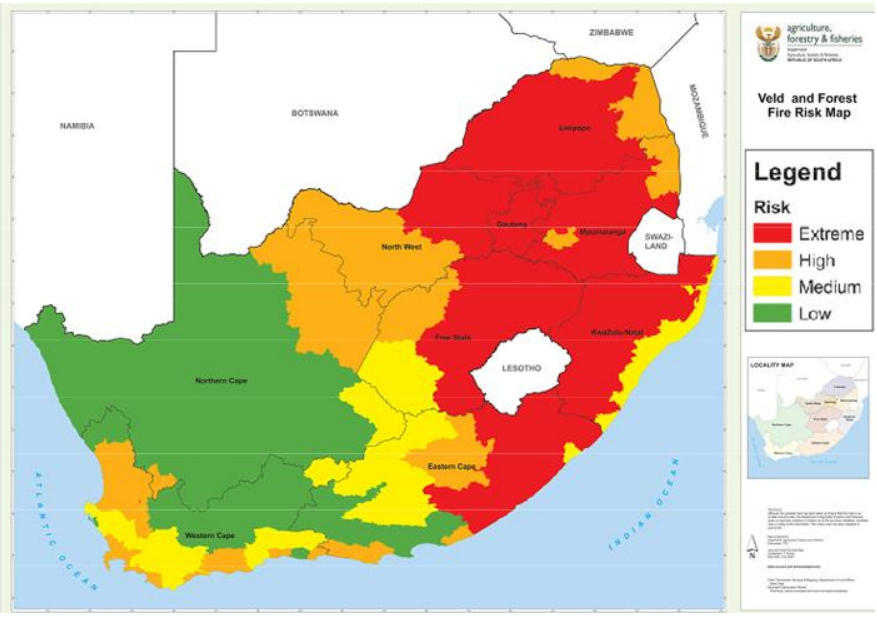


Figure 14: Map showing veld and fire risk in South Africa[98]

[97] State of the Province Address by Premier DD Mabuza, 2015. http://www.mpumalanga.gov.za/media/speeches/otp/SOPA2015.pdf

[98] Department of Rural Development and Land Reform, "Climate Change Vulnerability Assessment for Rural Human Settlements," 2013. http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/Climate_Change/Latest_Risk_and_Vulnerability_july_2013_09072013.pdf

➢ ***Sensitivity***

- Due to predicted climatic changes in temperature and rainfall – the **longer term** sees the drastic increase in temperatures, which would enable the ignition and spread of wildfires. The increased evapotranspiration would result in erratic rainfall patterns, with potential increases in high intensity rainfall events. These extreme events will cause loss of homes during flooding and wildfires, livestock losses during droughts and thereby deeply affecting marginal communities[99].
- The area is **highly sensitive** to extreme events in the long term.

➢ ***Exposure***

- In the **short term**, there is a **medium level** of exposure as the weather patterns are not yet erratic as predicted in the future.
- In the **longer term** however, the climatic impacts on human security is an important consideration as it not only increases health risks, but it has socio-economic impacts, especially in vulnerable and marginalised communities. Population displacements may become a reality owing to extreme weather events. Rainfall intensity affects catchment washoff processes as it increases the erosion of soil and other pollutants that accumulate on the surface of the catchment. It can also lead to surcharging sewers when sewage pipes become blocked with washed-off debris, or the discharge of partially treated wastewater from over-loaded WWTW. This in turn poses a health risk to humans.

➢ ***Risk***

- This poses a **high risk** for the province in the long term.

➢ ***Adaptive Capacity***

- A major challenge currently is to quantify the impacts of climate change on human health due to lack of long-term health data for a specific area or areas that can be linked to changes in the climate system. The links between human health, the natural environment and systems operating at different time and spatial scales contribute to the complexity associated with distinguishing the health effects of climate change from other global environmental changes.
- Ecological infrastructure can play an important role buffering effects of severe weather events.
- Natural disasters are currently dealt with at the municipal level, using national funds that are set aside for this purpose[100].
- The province currently has a spatial development plan in place, which it is looking to review in the long term. This will have an impact on those who live far from basic services and will improve access to water, jobs, clinics etc. This is important, especially if the province experience increases in health related issues due to climatic impacts.

[99] LTAS Human Health Sector report
[100] Rural areas climate change impacts

- Therefore, in the **long term**, the adaptive capacity of the province will be high should the plans be in place and implemented. Currently, the adaptive capacity is low as these are still being developed and implemented.

➢ ***Vulnerability***

- Within the context of this study, short term (2015-2020) vulnerability is the same as existing vulnerability to climate variability (given that exposure is not significantly different than present-day temperature and rainfall trends, and that adaptive capacity is unlikely to rise markedly within five years). Thus, in our assessment, short term vulnerability is medium, while long term (2020-2040 and beyond) vulnerability is high.

5. HOTSPOTS AND PRIORITY AREAS FOR BUILDING ADAPTIVE CAPACITY

From a sectoral standpoint, the literature review and analysis in this report (further validated by provincial stakeholder workshops) points to the following sectors as priority areas for building adaptive capacity:

- **Agriculture and Forestry**
- **Rural and urban livelihoods and settlements**
- **Terrestrial and aquatic ecosystems**
- **Tourism**
- **Water supply**
- **Public health and safety**
- **Disaster management**

In addition, given the central role of the mining sector in Mpumalanga, the follow-up report that develops adaptation strategies will also devote some attention to the mining sector and how it can strengthen its adaptive capacity. This sector was especially highlighted by stakeholders at a workshop on May 13, 2015, and thus even though our analysis assesses the sector as having medium vulnerability, the adaptation strategies stage of the project (i.e. the subsequent report) will treat it as a highly vulnerable sector.

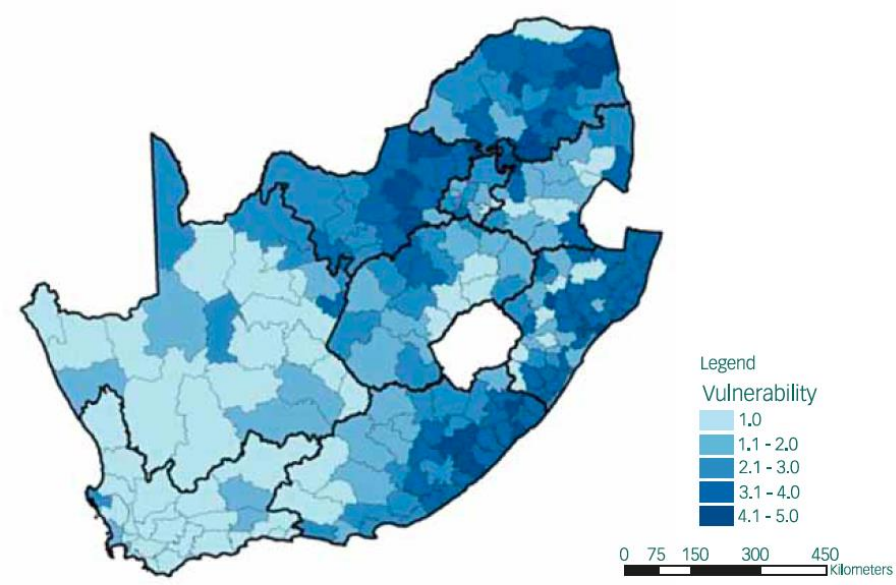
While the scope of the current project has always been to operate on a province-wide scale (and the constraints of resources and time available to this project – a mandate to cover three provinces in five months – also necessitate that the study take place only at the province level), it is important to note that as the province moves forward with its work on climate change adaptation in the key sectors identified it must allocate resources based on geographic need and vulnerability as well. There is a critical need for sub-provincial climate vulnerability assessments (for instance, the Mbombela District Municipality has already commenced such a study of its own) and for future resources to be dedicated to identifying geographic hotspots in relation to the specific sectors.

Prior to findings from such localized studies, it is possible to examine human existing vulnerability data for the province and surmise that climate change vulnerability may mirror, or at least overlap to a great extent, the areas that are already vulnerable due to low adaptive capacity overall (for instance, based on income levels, education levels, the presence of informal housing, access to water, sanitation, and electricity etc.).

One such recent nation-wide effort allows for a spatial view of which municipalities in Mpumalanga may have the greatest vulnerability to climate change. The figure below is from the report by the Financial and Fiscal Commission, and it shows the gradation of municipal climate vulnerability in South Africa, based on the methodology adopted in that report. The report identified Mpumalanga as having only one of South Africa's twenty most vulnerable municipalities in the context of climate change – Thembisile Hani, and noted that in relative terms, several municipalities in Mpumalanga

were comparatively resilient to climate change impacts.[101] Other Mpumalanga local municipalities that were identified as vulnerable to climate change include Nkomazi, Mkhondo, and Dr. J.S. Moroka. Thus in relative terms Mpumalanga may display less vulnerability compared to other provinces, but nevertheless there is climate vulnerability in Mpumalanga, which must be addressed.

Figure 15: Index of Vulnerability to Climate Change for South African Municipalities (Source: Financial and Fiscal Commission, South Africa): This figure shows the relative climate vulnerability of municipalities in South Africa, with the ones shaded in dark blue displaying the highest vulnerability, and the lighter blue ones with lesser climate vulnerability.



Source: Calculated using WorldClim[14] (past-present data) and the CCFAS[15] (future, spatially downscaled predictions) global climate databases.

Table 5: Twenty Most Vulnerable Municipalities in South Africa to Climate Change (Source: Financial and Fiscal Commission, South Africa).

Municipality Name	Municipality Code	Municipality Type	Municipality Name	Municipality Code	Municipality Type
Mnquma	EC122	B4	Thulamela	LIM343	B4
Intsika Yethu	EC135	B4	Aganang	LIM352	B4
Engcobo	EC137	B4	Ephraim Mogale	LIM471	B4
Port St Johns	EC154	B4	Elias Motsoaledi	LIM472	B4
Ntabankulu	EC444	B4	Fetakgomo	LIM474	B4
Indaka	KZN233	B4	Thembisile	MP315	B4
Mandeni	KZN291	B4	Moretele	NW371	B4
Maphumulo	KZN294	B4	Moses Kotane	NW375	B4
Greater Giyani	LIM331	B4	Ditsobotla	NW384	B3
Greater Letaba	LIM332	B4	City of Matlosana	NW403	B1

[101] Financial and Fiscal Commission, "Submission for the 2013/2014 Division of Revenue," May 2012. http://www.gov.za/sites/www.gov.za/files/Submission%20for%20the%202013-14%20Division%20of%20Revenue%203-%20pdf%20reduced2.pdf

The study found that levels of vulnerability in general are higher amongst households and communities who are resource-poor and presently lack adequate shelter or access to services. Climate vulnerability – especially in relation to health and safety as well as water supply and disaster risk – often correlates with such overall human vulnerability.

Within Mpumalanga, one of the proxies for identifying this target group for building adaptive capacity is whether a household lives in informal settlements (such as in shacks that are not within their own backyard) or in formal housing structures.[102] This proxy metric flags the municipalities of Emalahleni and Govan Mbeki in particular, but also Steve Tshwete, Lekwa, Mbombela, and Thembisile (together accounting for over two thirds of people in Mpumalanga living in shacks outside of their backyards). Similarly, across District Municipalities, Gert Sibande appears to have higher numbers of people living in shacks than the other two DMs.

Figure: Households Living in Shacks (Not in Backyards), by Local Municipality in Mpumalanga (Source: Housing Development Agency)

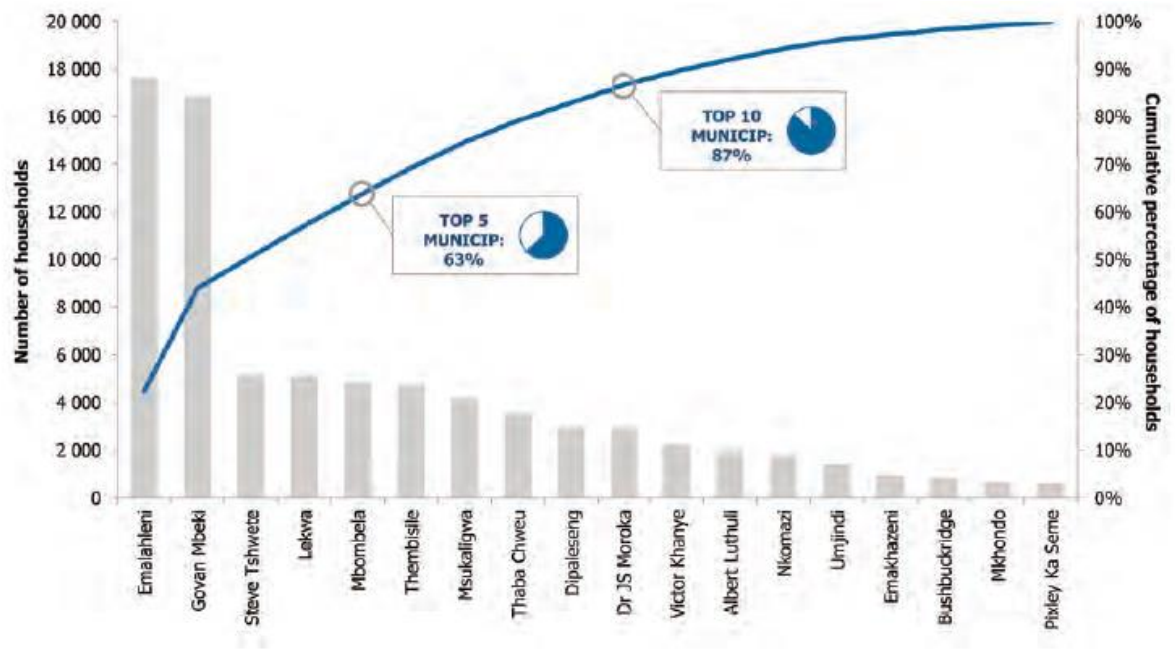


Table: Households Living in Shacks in Mpumalanga by District Municipality (Source: Housing Development Agency)

TABLE 5 **HOUSEHOLDS LIVING IN SHACKS IN MPUMALANGA BY DISTRICT MUNICIPALITY**

Municipality	Shack not in a backyard		Shack in a backyard	
	Number of HH	Percentage of HH that live in SNIBY	Number of HH	Percentage of HH that live in SIB
Nkangala	33 667	9%	15 847	4%
Gert Sibande	32 425	12%	13 510	5%
Ehlanzeni	12 441	3%	8 916	2%
Mpumalanga	**78 532**	**7%**	**38 274**	**4%**

[102] Housing Development Agency, "Research Report: Mpumalanga Informal Settlements," August 2013. http://www.thehda.co.za/uploads/images/HDA_Mpumalanga_Report_lr.pdf

The identification of these areas provides a helpful starting point towards identifying geographic vulnerability hot spots.

As this effort moves into the adaptation strategies phase, focus will be on the high priority sectors identified by this project, but the strategies will also take into account geographies with higher vulnerability where greater resources may need to be deployed when the provinces create implementation plans for the strategies.

In concluding, it is important to note that a lot of work is already being done in Mpumalanga – both in the public and private sectors as well as in academia – on climate change vulnerability. Relative to some other provinces, Mpumalanga has more capacity on climate change and has trained, skilled, and empowered individuals working on the issue in various capacities. Thus even though there are several vulnerable sectors in Mpumalanga, there is a strong and growing knowledge base and advanced adaptation approaches are already being put in place in the province. This was a very strong message that emerged from a provincial workshop in Nelspruit; experts and stakeholders in attendance attested to the fact that Mpumalanga is already doing a lot on its own and has a robust evidence base and successful adaptation programs and projects underway. Based on the unequivocal stakeholder feedback received about the level of activity already underway in Mpumalanga, it emerges as a province that does not need the type of external support and resources that some other provinces need, and has the solutions in place already. Opinions expressed in the workshop also suggested that the focus in Mpumalanga should rather be on scaling up all the strategies that the province already has embraced, and that the need for new initiatives is not as pronounced as in other provinces.

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