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Department:

Economic Development, Environment, Conservation and Tourism

North West Provincial Government

REPUBLIC OF SOUTH AFRICA

North West Climate Risk and Vulnerability Assessment Report

Technical review of adaptation responses and integration of the mitigation component into the climate change response strategies for the provinces of KwaZulu-Natal, Limpopo, North West and Northern Cape

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Version Control

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Executive Summary

The North West province is known as the “platinum province”, a name derived from the abundance of the metal found there with approximately 50% of the world’s platinum mined in the province (Statistics SA 2018; NWREAD 2016a). The North West is landlocked and located along the northern border of South Africa, neighbouring Botswana to the north, and the South African provinces Limpopo to the north-east, Gauteng to the east, Free State to the south, and Northern Cape to the south-west. The province covers an area of approximately 110,000 square kilometres and its capital city is Mahikeng (GCIS 2020). Major towns include Brits, Klerksdorp, Lichtenburg, Potchefstroom, Rustenburg and Vryburg (NWREAD 2016a).

The purpose of this report is to develop an updated Climate Risk and Vulnerability Assessment (CRVA) for the North West province to lay the foundation for a climate change strategy and implementation plan that considers the risks and vulnerabilities associated with climate change for the province.

Methodology

The North West Provincial Government completed a provincial Vulnerability Assessment (NW VA) in 2016 (NWREAD 2016a). This updated report draws on the information developed in the 2016 Vulnerability Assessment and aligns it with the *National Climate Risk and Vulnerability (CRV) Assessment Framework Summary Document* published in June 2020 (DEFF 2020). A number of stakeholder engagements (surveys, interviews and online meetings) were also conducted as part of this review process. The stakeholder engagement processes highlighted particular concerns that stakeholders have at a sectoral level.

Key Climate Hazards

The key climate change hazards identified for the North West are:

- Increasing temperatures
- Increasing rainfall variability
- Increasing periods of drought
- Increasing storms and flooding events

Sector Review

For various sectors in the North West, this report outlines possible impacts of these hazards, reviews the sensitivity of each sector to climate change, and reviews the capacity within the sector to respond to climate change.

The table below is a summary of the level of concern per sector based on the sector reviews.

Sector	Level of Concern
Ecosystems	High Concern
Rural Livelihoods	High Concern
Urban Livelihoods	Medium Concern
Agriculture	Medium Concern
Tourism	Medium Concern
Mining	Medium Concern
Water Supply	High Concern
Energy Supply	Medium Concern
Transport	High Concern
Waste Management	High Concern
Human Health	High Concern
Disasters Resulting from Extreme Weather	High Concern

Ecosystems

The Ecosystems sector is of **High Concern** due to the following reasons:

Exposure:

- The Savanna Biome covers about 70% of the North West's terrestrial area and the Grassland Biome covers the rest. The North West includes the Barberspan wetland, the Kgaswane Mountain Reserve and part of the Griqualand West Centre of Endemism (NWDEDECT 2018).

Impacts:

- Ecosystems are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increased average temperatures may lead to land degradation and affect biodiversity.
 - Increased rainfall variability can lead to severe periods of drought and increased number of fire-danger days.
 - Deterioration of water quality may threaten aquatic ecosystems.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's ecosystems as having high sensitivity to climate change. Key sensitivity factors include:
 - Impacts of environmental degradation on biodiversity.
 - The poor state of wastewater treatment works and aged water infrastructure.
 - Unsustainable use of natural resources.

Adaptive Capacity:

- The majority of stakeholders viewed the province's ecosystems as having low to medium adaptive capacity to respond to climate change. In particular, it was noted that while there are existing plans in place, there are limited human and financial resources to implement these plans.

Rural Livelihoods

The Rural Livelihoods sector is of **High Concern** due to the following reasons:

Exposure:

- Around 60% of the population in the North West live in rural areas. The rural population mainly depends on agriculture for their livelihoods (NWREAD 2016a).

Impacts:

- Rural livelihoods are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increased temperatures disrupt natural resources leading to increased levels of food insecurity.
 - Decreased quality and quantity of water resources, which affects the health of rural communities.
 - Increased prevalence of extreme weather events leading to loss of life and livelihoods.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's rural livelihoods as having high sensitivity to climate change. Key sensitivity factors include:
 - Existing land degradation in rural areas.
 - Heavy reliance on natural resources for livelihoods.
 - Poverty and higher proportion of vulnerable persons.

Adaptive Capacity:

- The majority of stakeholders viewed the province's rural livelihoods as having low adaptive capacity to respond to climate change. In particular, it was noted that rural communities do not have access to resources, such as knowledge and finances to respond to the effects of climate change.

Urban Livelihoods

The Urban Livelihoods sector is of **Medium Concern** due to the following reasons:

Exposure:

- The Madibeng, Rustenburg, Mahikeng, and City of Matlosana local municipalities together account for about half of the North West's population, about 58% of its workforce, and about 63% of the total economic activity in the province (NWPG 2017a).

Impacts:

- Urban livelihoods are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Decreased water supply leading to disruption to urban livelihoods.
 - Decreased quality and quantity of water resources, which affects the health of urban communities.
 - Increased prevalence in disasters from extreme weather leading to loss of life.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's urban livelihoods as having medium sensitivity to climate change. Key sensitivity factors include:
 - Increased heat stress and health issues.
 - Increased rural to urban migration, which will put pressure on urban service delivery.
 - Access to basic services and resources to respond to climate change.

Adaptive Capacity:

- The majority of stakeholders viewed the province's urban livelihoods as having low to medium adaptive capacity to respond to climate change. In particular, it was noted that urban livelihoods have access to basic services, however, water scarcity and poor management within municipalities compromises this access.

Agriculture

The agriculture sector is of **Medium Concern** due to the following reasons:

Exposure:

- The North West province has approximately 6.3 million hectares of land that is being used for commercial agriculture. In the North West, the agriculture, forestry and fisheries sectors contributed 2.6% to the provincial gross domestic product in 2017 (Statistics SA 2019).

Impacts:

- Agriculture is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature leading to decreased water supply for irrigation.
 - Changes in temperature and rainfall affect crop production.
 - Increased temperatures can lead to heat stress on livestock.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's agriculture and farming as having high sensitivity to climate change. Key sensitivity factors include:
 - Increased temperatures affect water availability for irrigation.
 - Increased runoff and erosion.
 - Effect of extreme weather on crops and livestock.

Adaptive Capacity:

- The majority of stakeholders viewed the province's agriculture as having medium adaptive capacity to respond to climate change. In particular, it was noted that agriculture is a water intensive activity, however, farmers that have access to resources will be able to implement farming practices to respond to climate change.

Tourism

The Tourism sector is of **Medium Concern** due to the following reasons:

Exposure:

- The total tourism spend as a percentage of the North West's GDP was 4.1% in 2019. The formal tourism sector in the North West employed over 33,000 people prior to the COVID-19 pandemic (NWDC 2021).

Impacts:

- Tourism is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature and rainfall patterns have significant effects on the biodiversity and natural attractions.
 - Increased temperatures discourage activity-based tourism.
 - Changes in temperature and rainfall patterns lead to decreased water availability for tourism.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's tourism as having high sensitivity to climate change. Key sensitivity factors include:
 - Tourism requires water availability for activities.
 - Increased temperatures may deter tourists.
 - Sensitivity of nature to increased temperatures.

Adaptive Capacity:

- The majority of stakeholders viewed the province's tourism as having medium adaptive capacity to respond to climate change. In particular, it was noted that while the tourism sector has been significantly impacted by COVID-19, it has some institutional capacity to respond to climate change.

Mining

The Mining sector is of **Medium Concern** due to the following reasons:

Exposure:

- The North West has a large mining industry. The main commodities mined in the North West are diamonds, gold and platinum-group metals. The mining industry contributes approximately 33.8% to the total industrial GVA of the province and 14.5% of formal employment (NWDC 2021).

Impacts:

- Mining is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature and rainfall patterns affect water availability for mining operations.
 - Increases in temperature lead to increases in the number of very hot days and disrupts mining operations because of poor working conditions.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's mining sector as having high sensitivity to climate change. Key sensitivity factors include reliance on water supply for operations and the impact of extreme weather events.

Adaptive Capacity:

The majority of stakeholders viewed the province's mining as having medium adaptive capacity to respond to climate change. In particular, it was noted that the technological and financial resources are available to respond to climate change impacts.

Water Supply

The Water Supply sector is of **High Concern** due to the following reasons:

Exposure:

- Important river systems in the North West include the Crocodile West, Groot Marico, and Vaal River systems. Water from these river systems is used for agriculture (including irrigation), domestic, mining, and industrial purposes (NWDEDECT 2018).

Impacts:

- Water supply is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in rainfall patterns result in changes in spatial/geographic distribution of water.
 - Increasing temperatures and rainfall variability reduces water availability and results in many households experiencing a high degree of water stress.
 - Warmer temperatures result in changes in water quality such as a decline in biochemical oxygen demand (BoD) or slight decreases in pH levels, salinisation and sedimentation.
 - Disruption of water infrastructure by climate change-related extreme weather events.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's water supply as having high sensitivity to climate change. Key sensitivity factors include:
 - North West is a water scarce province.
 - Increased temperatures reduce water quality and quantity.

Adaptive Capacity:

- The majority of stakeholders viewed the province's water supply as having low adaptive capacity to respond to climate change. In particular, it was noted that the North West is a water scarce province and there is poor management of water resources in the province.

Energy Supply

The Energy Supply sector is of **Medium Concern** due to the following reasons:

Exposure:

- The North West uses an estimated 12% of South Africa's available electricity. The number of households with access to electricity in the province increased from 73% in 2011 to 81% in 2016 (NWDEDECT 2018).

Impacts:

- Energy supply is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Disruptions in energy supply as a result of damage to energy supply infrastructure during climate change-related extreme weather events.
 - Increase in demand for air conditioning in warmer temperatures.
 - Changes in water availability for cooling in power plants.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's energy supply as having high sensitivity to climate change. Key sensitivity factors include:
 - Reliance on water supply for activities.
 - Reliance of fossil fuels for energy generation.
 - Poor infrastructure and maintenance.

Adaptive Capacity:

- The majority of stakeholders viewed the province's energy supply as having a medium to high adaptive capacity to respond to climate change. In particular, it was noted that while fossil fuels are still being used in electricity generation, there is a slow movement toward clean energy production.

Transport

The Transport sector is of **High Concern** due to the following reasons:

Exposure:

- The North West's Road network is relatively well developed with key highways and an increasing number of paved roads. As a largely rural province, much of the road network remains unpaved.

Impacts:

- Transportation is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increases in heavy rainfall can cause erosion of dirt roads and landslides causing road blockages.
 - Roads and bridges buckling and cracking in warmer temperatures.
 - Disruption of transportation infrastructure by climate change-related extreme weather events.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's transportation as having high sensitivity to climate change. Key sensitivity factors include:
 - Poor quality of existing infrastructure.
 - Effects of disaster events on transport infrastructure.

Adaptive Capacity:

- The majority of stakeholders viewed the province's transportation as having medium adaptive capacity to respond to climate change. In particular, it was noted that there was little consideration of climate change effects in the design and construction, and poor maintenance of infrastructure.

Waste Management

The Waste Management sector is of **High Concern** due to the following reasons:

Exposure:

- There are 68 waste disposal sites in the North West (as of July 2021), 53 of which are municipal owned, while the other 15 are privately owned (Moselakgomo 2021). Of the 53 municipal waste disposal sites in the province, 25 are operational and 28 have been earmarked for closure or are closed (Moselakgomo 2021). Of the 15 privately owned waste disposal sites, 5 are operational and 10 have been earmarked for closure or are closed (Moselakgomo 2021).

Impacts:

- Waste management is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Intense rainfall events wash waste into streams, rivers and stormwater systems, increasing blockages in these systems and distributing waste into the aquatic environment.
 - Damage to waste management facilities and disruption of waste management services as a result of extreme weather events.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's waste management as having high sensitivity to climate change. Key sensitivity factors include:
 - Non-compliance with waste legislation.
 - Unsustainable disposal of waste at landfills.

Adaptive Capacity:

- The majority of stakeholders viewed the province's waste management as having low adaptive capacity to respond to climate change. In particular, it was noted that there is a lack of financial and human resources to adequately manage waste in the province.

Human Health

The Human Health sector is of **High Concern** due to the following reasons:

Exposure:

- The North West has a population of approximate 4,108,816 people. Women have an average life expectancy of 65 years and men an average life expectancy of 58.6 years (Statistics SA 2020b).

Impacts:

- Human health is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Drought could lead to dehydration, lowered food security (due to less access to adequate nutrition), and an increase in water-borne disease (from more users using limited water supplies, increasing the risk of contamination).
 - Flood events can cause effluent overflow which in turn can cause an increase in water-borne diseases.
 - Increases in temperature can result in heat stress which can exacerbate existing chronic health conditions, cause dehydration, result in heat strokes and increase the presence of pests.
 - The pattern of increasing extreme rainfall events and rising temperatures favour the geographical expansion of the borders of vector-borne diseases such as malaria, dengue fever and yellow fever.

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's public health as having medium sensitivity to climate change. Key sensitivity factors include:
 - Insufficient basic services and primary health care.
 - Increased deaths as a result of disaster events.

Adaptive Capacity:

- The majority of stakeholders viewed the province's human health as having medium adaptive capacity to respond to climate change. In particular, it was noted that vulnerable members of communities will be more susceptible to climate changes affects, especially in rural areas.

Disasters Resulting from Extreme Weather

The Disasters Resulting from Extreme Weather events are of **High Concern** due to the following reasons:

Exposure:

- Climate change is likely to lead to increased disaster situations in the province (NWREAD 2016a).

Impacts:

- Disasters resulting from extreme weather are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Floods
 - Droughts
 - Wildfires

Sensitivity:

- The majority of stakeholders who participated in an online consultation event for this report viewed the province's disasters resulting from extreme weather as having high sensitivity to climate change. Key sensitivity factors include:
 - Increased temperatures will lead to increased fire risk.
 - Lack of disaster management in rural areas.
 - Poor infrastructure development to protect from disaster events.

Adaptive Capacity:

The stakeholders viewed the province's disasters resulting from extreme weather as having medium adaptive capacity to respond to climate change. In particular, it was noted that there are disaster management plans in place, however, there is a lack of coordination from the relevant departments to respond to disaster events.

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List of Acronyms

Acronym	Definition
AR5	IPCC Fifth Assessment Report
BMU	The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CBD	Convention on Biological Diversity
CO ₂	Carbon dioxide
CRV	Climate Risk and Vulnerability
CSA	Climate-Smart Agriculture
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD	Department of Agriculture, Land Reform and Rural Development
DEA	Department of Environmental Affairs (now known as the Department of Forestry, Fisheries and the Environment)
DEFF	Department of the Environment, Forestry and Fisheries (now known as the Department of Forestry, Fisheries and the Environment)
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
DWA	Department of Water Affairs (now known as the Department of Water and Sanitation)
DWS	Department of Water and Sanitation
GCIS	Government Communication and Information System
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GVA	Gross value added
HIV	Human Immunodeficiency Virus
IKI	International Climate Initiative
INEWS	Integrated National Early Warning System
IPCC	Intergovernmental Panel on Climate Change
KPIs	Key Performance Indicators
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
NOX	Nitrogen Oxide
NW	North West Province
NW CRVA	North West Climate Risk and Vulnerability Assessment
NWDARD	North West Department of Agriculture and Rural Development
NWDC	North West Development Corporation

Acronym	Definition
NWDEDECT	North West Department of Economic Development, Environment, Conservation and Tourism
NWREAD	North West Department of Rural, Environment and Agriculture Development
NWMS	National Waste Management Strategy
NWPG	North West Provincial Government
NW VA	North West Vulnerability Assessment 2016
PM	Particulate matter
PM ₁₀	Particulate matter with a diameter of 10 micrometres or smaller
PM _{2.5}	Particulate matter with a diameter of 2.5 micrometres or smaller
PV	Photovoltaic
RCP	Representative Concentration Pathway
SA	South Africa
SADC	Southern African Development Community
SAFFG	South African Flash Flood Guidance
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SANRAL	The South African National Roads Agency SOC Ltd
SAWS	South African Weather Service
SO ₂	Sulphur Dioxide
TB	Tuberculosis
TPA	Tonnes per annum
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
VA	Vulnerability Assessment
WWTW	Wastewater Treatment Works

1 Introduction

1.1 Report Purpose

This report is submitted by Urban Earth to GIZ Pretoria Office for the project 'Technical review of adaptation responses and integration of the mitigation component into the climate change response strategies for the provinces of KwaZulu-Natal, Limpopo, North West and Northern Cape' (Ref: Contract No: 83368487). The purpose of the project is to support the four provinces to prepare for the promulgation of the *National Climate Change Bill* (No. 580 of 2018) which, when enacted, will oblige each province to develop a climate change strategy and implementation plan. The bill requires that implementation plans must:

- include measures or programmes relating to both adaptation and mitigation;
- take account of the risks and vulnerabilities associated with climate change;
- include mechanisms for effective implementation aligned with national sector plans; and
- cover all priority sectors.

The purpose of this report is to outline a climate risk and vulnerability assessment for the North West province to lay the foundation for a climate change strategy and implementation plan that considers the risks and vulnerabilities associated with climate change for the province. To complement the climate risk and vulnerability assessment, an Appendix A: Municipality Vulnerability Indexes, has been included at the end of the report to show the spatial variation of vulnerability by municipality. The information presented in this appendix is largely drawn from the municipal risk profiles of the Green Book (<https://greenbook.co.za/>).

1.2 Provincial Overview

The North West province is known as the “platinum province”, a name derived from the abundance of the metal found there with approximately 50% of the world’s platinum mined in the province (Statistics SA 2018; NWREAD 2016a). The North West is landlocked and located along the northern border of South Africa, neighbouring Botswana to the north, and the South African provinces Limpopo to the north-east, Gauteng to the east, Free State to the south, and Northern Cape to the south-west. The province covers an area of approximately 110,000 square kilometres and its capital city is Mahikeng (GCIS 2020). Major towns include Brits, Klerksdorp, Lichtenburg, Potchefstroom, Rustenburg and Vryburg (NWREAD 2016a).

The *2016 Community Survey* by Statistics South Africa estimated that the North West had a population of approximately 3.75 million people (about 7% of the total population of South Africa), making it the province with the third-smallest population (Statistics SA 2018).

The majority of economic activity in the North West (83%) takes place in the eastern part of the province including the town of Rustenburg and between Klerksdorp and Potchefstroom. Mining activities in the province account for about 23% of South Africa’s mining industry, and contribute about 33% of the value of the provincial economy (NWPG 2017a). The area from Rustenburg to Brits produces 94% of South Africa’s platinum (GCIS 2020).

The North West is strategically located between South Africa’s economic centre, Gauteng, and Botswana and well-positioned as a hub for shared services throughout the Southern African Development Community (SADC) region (NWPG 2017a). Its well-developed rail and road

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infrastructure provide transportation links to other SADC countries, and it plays an important role in the supply of energy and transport to the SADC region (GCIS 2020; NWPG 2020; 2017a).

The North West has a wide range of tourist attractions, including the Pilanesberg National Park, Sun City, Madikwe Game Reserve, and parts of the Taung Skull Fossil Site and Vredefort Dome, two of South Africa's World Heritage sites (GCIS 2020). Tourism statistics reveal that the North West experienced a decrease in domestic tourists and an increase in international tourists visiting the province in 2018 (NWDC 2021). Since then, the Covid-19 pandemic and related international travel restrictions have resulted in an overall decrease in tourism in the province.

The North West is predominantly rural, with around 60% of the population living in rural areas and the remainder in urban areas. The rural population mainly depends on agriculture for livelihoods (NWREAD 2016a). In 2016, it was estimated that about 13% of households in the North West undertook agricultural activities, mostly poultry or livestock farming (Statistics SA 2018).

Commercial farming in the North West produces more than 20% of all white maize grown in South Africa (GCIS 2020; NWPG 2017a). Livestock (cattle) and sunflowers are also important commercial farming outputs in the province, and some of the largest cattle herds in the world are found in Stellaland (GCIS 2020). In total, agriculture in the North West contributes only about 3% of the value of the provincial economy (NWPG 2017a) but plays an important role in household food security and rural livelihoods.

The economy of the province is predominantly based on natural resources, with the main contributor being the mining sector (33.6%). In addition to platinum, other minerals mined in the province are gold, diamonds, chrome, vanadium, granite, slate, limestone, dimension stone, nickel, silica, manganese, phosphate, fluorspar and zinc. General government services account for 12.1% of the economy and financial services, real estate and business services account for 11.1% (NWREAD 2016a).

The North West is divided into four district municipalities; within the district municipalities there are 18 local municipalities (Figure 1).



Figure 1: North West province and its municipalities

2 Report Framework

The North West provincial government completed a provincial Vulnerability Assessment in 2015 (NWREAD 2016a). This current report draws on the information developed in the 2015 Vulnerability Assessment and aligns it with the *National Climate Risk and Vulnerability (CRV) Assessment Framework Summary Document* published in June 2020 (DEFF 2020).

The framework is aligned with the conceptual framing of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. The framework highlights that “*the risk associated with experiencing climate impacts is defined as resulting from the interaction of climate hazards, exposure and vulnerability. The vulnerability component of risk focuses on the sensitivity and adaptive capacity of those or that exposed to certain climate hazards*” (DEFF 2020, 8). The interaction between the various elements described in the framework is shown in Figure 2 (DEFF 2020).

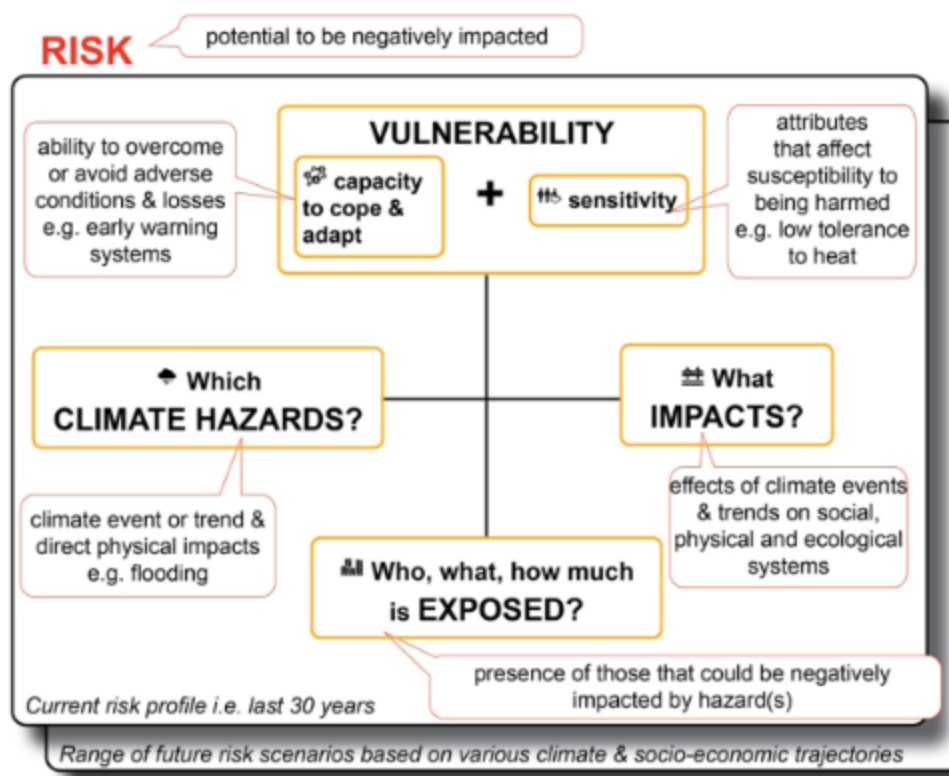


Figure 2: The component of climate vulnerability and climate risk, adapted from IPCC AR5 (DEFF 2020, 9)

The key terms discussed in the framework are defined as follows:

- **Risk:** “The potential for consequences (= impacts) where something of value is at stake and where the outcome is uncertain, recognising the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.” (DEFF 2020, 11)
- **Hazard:** “The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In [the IPCC] report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.” (DEFF 2020, 11)
- **Impacts:** “Effects on natural and human systems. In the [IPCC] report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.” (DEFF 2020, 11)
- **Exposure:** “The presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.” (DEFF 2020, 11)
- **Sensitivity:** “Factors that directly affect the consequences of a hazard. Sensitivity may include physical attributes of a system (e.g. the building material of houses or the type of soil on agriculture fields), social, economic and cultural attributes (e.g. age structure or income structure)” (DEFF 2020, 11).

- **Adaptive capacity:** “The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (e.g. knowledge of alternative farming methods)” (DEFF 2020, 11).

3 Scope of Risk and Vulnerability Assessment

The first step in assessing the climate risk and vulnerability of the North West province is to establish the scope of the assessment (DEFF 2020). According to the *National Climate Risk and Vulnerability (CRV) Assessment Framework Summary Document* (DEFF 2020), the scope defines the purpose and context of the climate risk and vulnerability (CRV) assessment. It describes why a CRV assessment is needed and provides clarity on the circumstances in which the assessment will be undertaken and used (DEFF 2020).

The Climate Risk and Vulnerability Assessment for the North West province (NW CRVA) provides the basis for an updated climate change strategy for the province to be developed as part of this project and as a reference document for use by those district municipalities in the North West that do not yet have a climate change strategy. The NW CRVA utilises the CRV assessment framework detailed in the *National Climate Risk and Vulnerability (CRV) Assessment Framework Summary Document* and is aligned with the *National Climate Change Bill* (Republic of South Africa 2018).

The NW CRVA is for use by:

- The Premier, Members of the Executive Council (MECs) and Mayors of the various district and local municipalities, as the leadership that will guide the climate change response in the North West province;
- Technical staff in provincial and municipal sector departments;
- Community-based organisations and non-governmental organisations, particularly those working with the various biospheres in the province; and
- Academic communities including the North-West University and other tertiary institutions.

3.1 Methodology

The Climate Risk and Vulnerability Assessment for the North West made use of participatory methods at the provincial scale to compare various climate hazards and risks and to enable the prioritisation of climate change adaptation actions. This included a hybrid approach, including desktop research methodology, an online survey of stakeholders and stakeholder consultation meetings. The NW CRVA draws on relevant data held by the provincial government, local governments in the province, national datasets and other relevant datasets.

The following sectors have been used to structure the NW CRVA. These sectors were drawn from the North West Vulnerability Assessment (NW VA) that was completed in 2016 (NWREAD 2016a), and the additional sector of waste management has also been included:

- Ecosystems
 - Terrestrial (biodiversity, forests, invasive species)
 - Aquatic (rivers, lakes, wetlands)

- Livelihoods
 - Urban
 - Rural
- Economic activity
 - Agriculture
 - Tourism
 - Mining
- Infrastructure and utilities
 - Water supply
 - Energy supply
 - Transportation
 - Waste
- Public health and safety
 - Human health (including diseases)
 - Extreme weather and disasters (wildfires, floods, drought)

The key participatory methods used in the development of this report were:

1. A survey of North West stakeholders regarding the impact of climate change on sectors above. This survey asked stakeholders to indicate which of the impacts identified in the previous vulnerability assessment are of significance in the North West and also asked stakeholders to identify any other impacts of concern.
2. A consultation meeting on 11 August 2021, where stakeholders were invited to rate the Adaptive capacity and sensitivity of each of the sectors above and to provide additional information on adaptive capacity and sensitivity.

4 Hazards

The key climate change hazards identified for the North West are:

- Increasing temperatures;
- Increasing rainfall variability;
- Increasing periods of drought; and
- Increasing storms and flooding events.

These are discussed in detail below.

The Intergovernmental Panel on Climate Change (IPCC) has developed four Representative Concentration Pathways (RCPs). These are scenarios that project the effects of climate change from the present day to the year 2100 based on different levels of global greenhouse gas (GHG) emissions and atmospheric concentrations of GHGs (Van Vuuren et al. 2011; IPCC 2014). To understand the extent to which climate change may affect the North West, the highest GHG emissions scenario (RCP 8.5) is used throughout this section.

4.1 Increasing Temperatures

With regards to current temperatures in the province the annual average temperature in degrees Celsius (°C) for two key long-term weather stations (Mahikeng and Vryburg) in the North-West (Table 1) ranged between 27.1 °C and 28.3 °C in 2018 (SAWS 2019). Highest daily temperatures were between 38.4 and 40.7 across the two stations (SAWS 2019).

Table 1 Maximum temperature overview for Mahikeng and Vryburg weather stations 2018 (in °C) (SAWS 2019)

Station	Average	Normal	Rank (Highest since 1981)	Highest Annual Average (since 1981)	Highest Daily 2018	Highest Daily (since 1981)	Lowest Daily 2018	Lowest Daily (since 1981)
Mahikeng	28.3	26.5	29.0 (2015)	25.3 (2009)	40.7	41.5 (2016.01.07)	16.4	8.9 (2006.08.02)
Vryburg	27.1	27.1	30.4 (2015)	25.5 (2006)	38.4	43.7 (2016.01.06)	19.3	7.4 (1996.07.07)

By 2050, the North West is projected to be affected by higher annual average temperatures (CSIR 2019; NWDEDECT 2018; NWREAD 2016b). Figure 3 shows the projected change in annual average temperatures over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period (CSIR 2019). RCP 8.5 is a “business as usual” global warming scenario which illustrates an outcome in which greenhouse gas emissions are not significantly reduced.

Figure 3 shows that by 2050, under the RCP 8.5 scenario, most of the western and northern parts of the North West are projected to experience an increase in annual average temperatures of 3°C to 3.5°C, while the eastern and south-eastern parts of the province are projected to experience an increase of 2°C to 2.5 °C (CSIR 2019). These higher average temperatures will likely increase evaporation rates, may reduce agricultural output in the North West, and may also harm water and food security in the province (NWDEDECT 2018; NWREAD 2016b). To provide a national context, Figure 4 shows the projected changes in annual average temperatures throughout South Africa over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period.

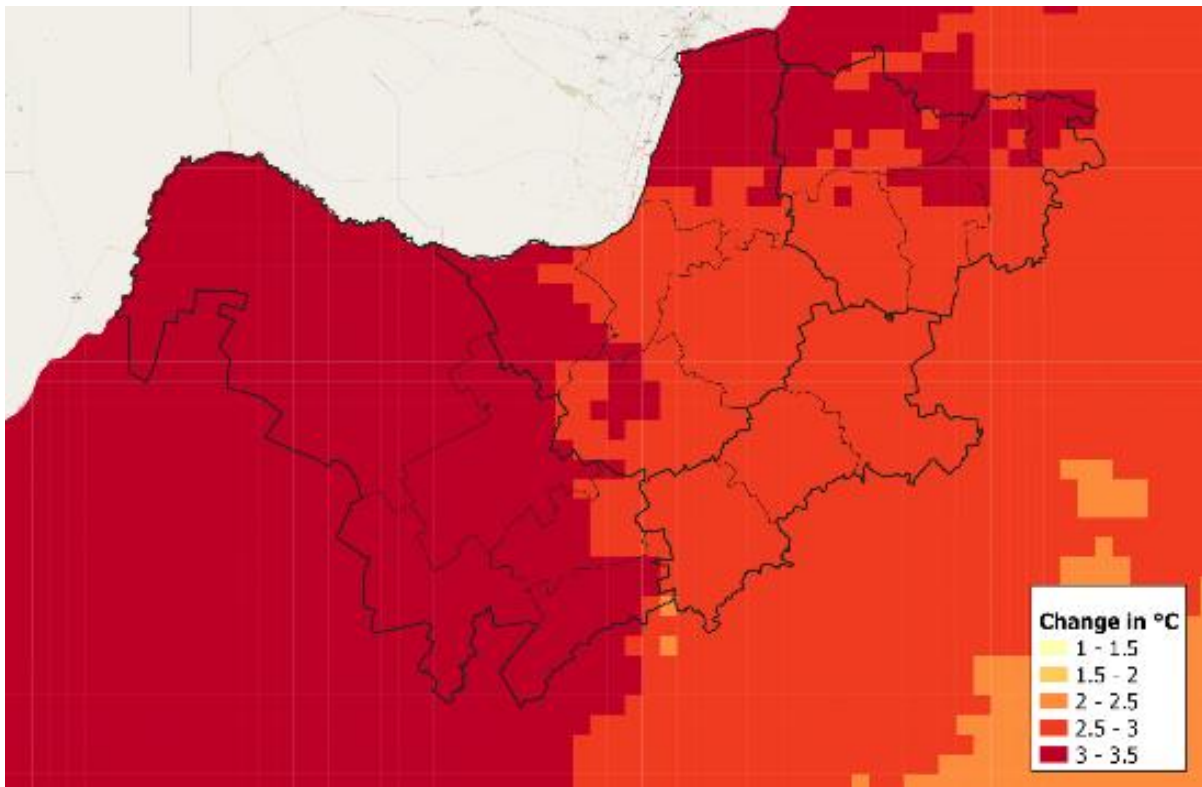


Figure 3: Projected changes in annual average temperatures throughout the North West over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

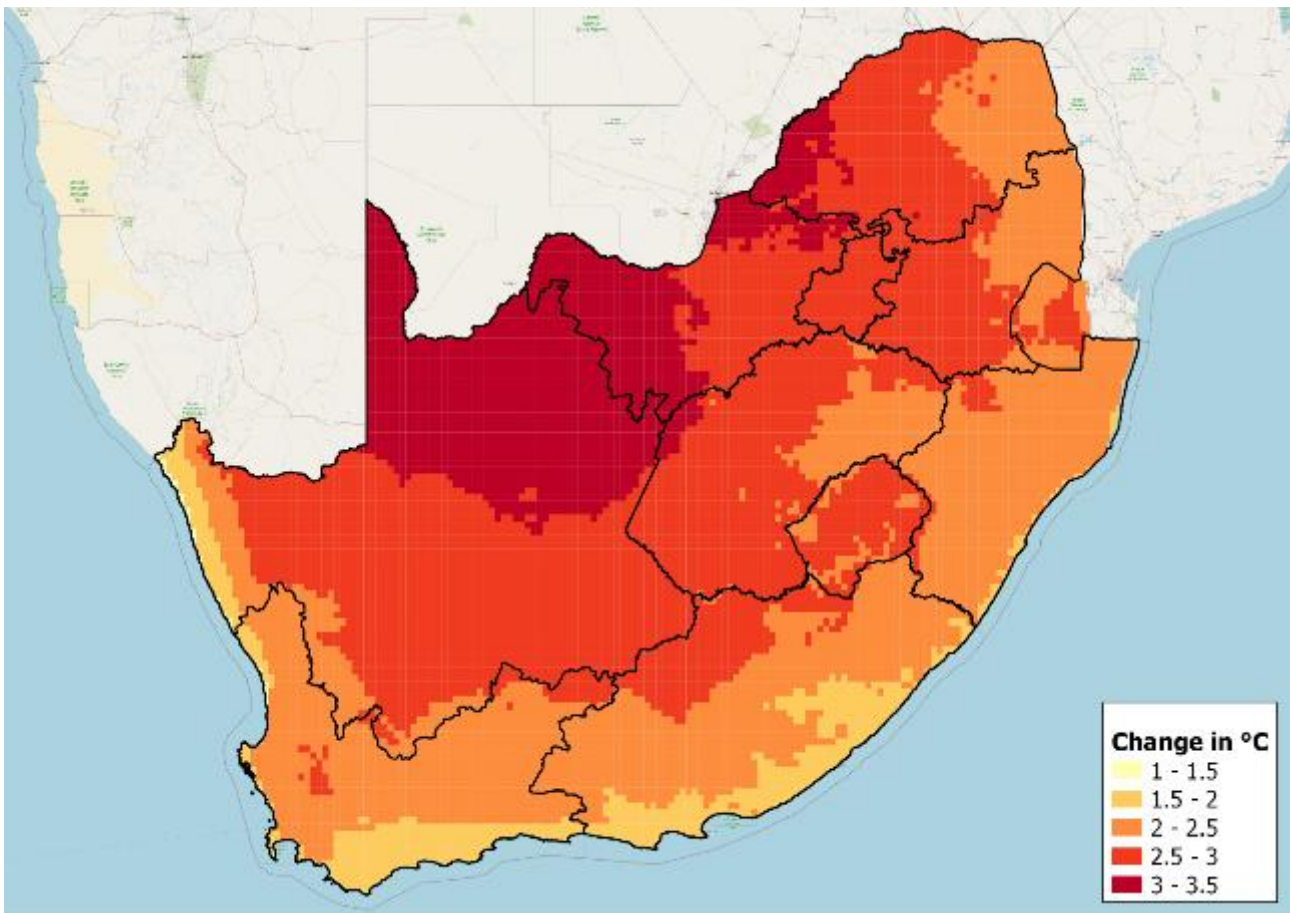


Figure 4: Projected changes in annual average temperatures throughout South Africa over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

4.2 Increasing Rainfall Variability

The annual average rainfall for South Africa as a whole is about 450 millimetres per year (DWA 2013). In the North West, the total rainfall in millimetres (mm) for the Mahikeng and Taung weather stations for 2020 (Table 2) amounted to 546 mm and 612 mm respectively (SAWS 2021). In Taung, this was considerably above the 30-year average rainfall which is 438 mm (SAWS 2021).

Table 2: Rainfall overview for Mahikeng and Taung Long Term Climate Stations 2020 (in mm) (SAWS 2021)

Station	Total Rainfall 2020	Average Annual Rainfall (1981-2010)	Lowest Annual Rainfall Total (since 1981)	Highest Daily Rainfall Total 2019	Highest Daily Total (since 1981)	Number of days with rain \geq 1 mm in 2020	Average number of days per year with rain \geq 1 mm (1981-2010)
Mahikeng	546	544	293 (2015)	51	128 (1995.11.18)	46	52
Taung	612	438	73 (2009)	64	160 (1988.02.20)	53	44

Figure 5 shows the projected change in annual average rainfall over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period (CSIR 2019). It shows that much of the North West is projected to experience a slight increase in annual average rainfall, while some areas in the west, south-west and north-east are projected to experience a slight decrease in annual average rainfall (CSIR 2019). However, it should be noted that there is some uncertainty around future changes in rainfall in the North West (NWDEDECT 2018; NWREAD 2016b; CSIR 2019).

The North West already experiences rainfall variability over space and time, and this is predicted to increase due to the effects of climate change (NWDEDECT 2018; NWREAD 2016b). Projected changes in annual average rainfall in Figure 5 indicate this variability, suggesting this would increase related risk to, for example, water security in the province (CSIR 2019; NWDEDECT 2018; NWREAD 2016b). To provide a national context, Figure 6 shows the projected changes in annual average rainfall throughout South Africa over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period.

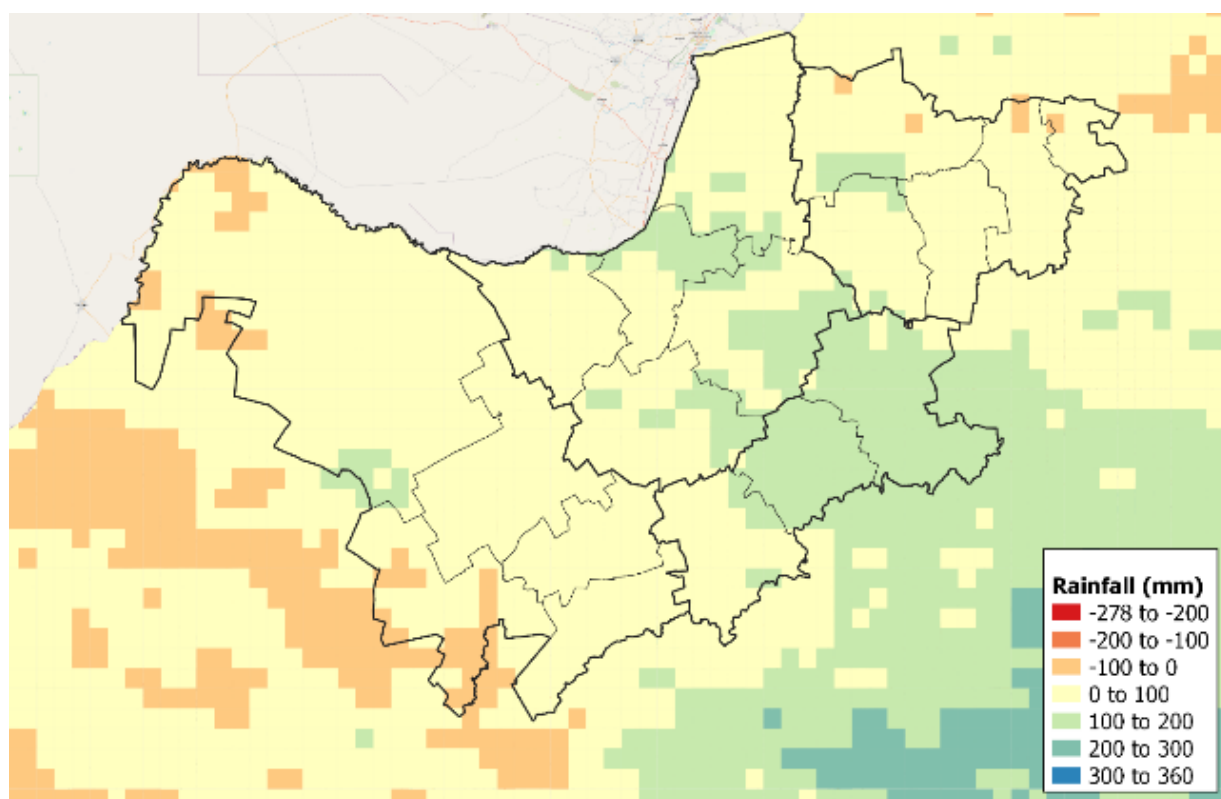


Figure 5: Projected changes in annual average rainfall throughout the North West over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

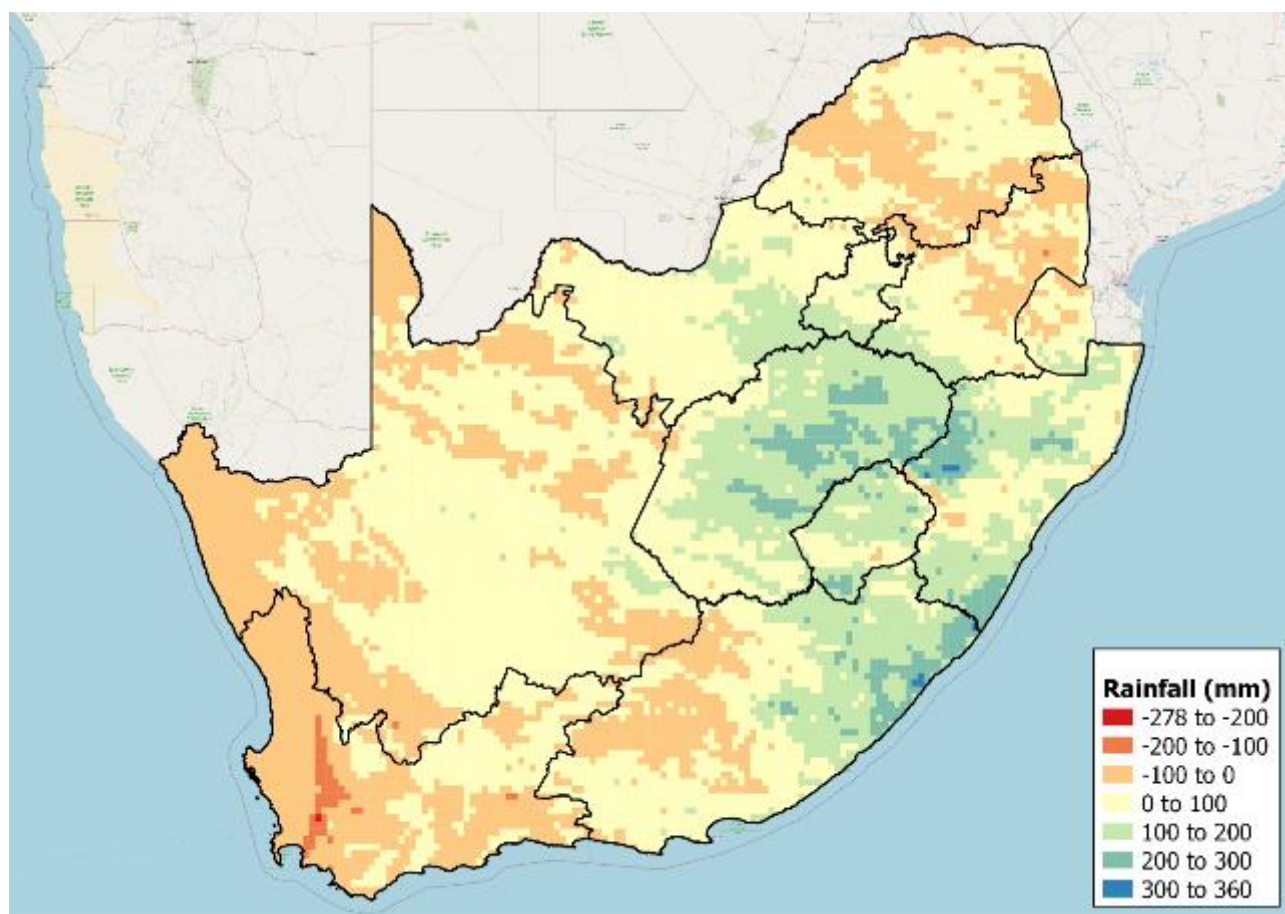


Figure 6: Projected changes in annual average rainfall throughout South Africa over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

4.3 Increasing Periods of Drought

Projected increases in average temperatures and rainfall variability in the North West will increase evaporation rates and is likely to increase the potential for drought in the province, however, there is some uncertainty around future changes in rainfall in the North West (NWDEDECT 2018; NWREAD 2016b; CSIR 2019). Increases in the frequency and severity of droughts will negatively affect water security, human health, food security and biodiversity (NWDEDECT 2018; NWREAD 2016b). Increased periods of drought and rainfall variability are also likely to increase risks related to water supply, water quality and water pollution (NWDEDECT 2018; NWREAD 2016b).

4.4 Increasing Storms and Flooding Events

While future changes in annual average rainfall in the North West is uncertain, rainfall intensity and variability are projected to increase, and these hydrological factors are likely to increase the frequency and severity of flooding events in the North West (NWDEDECT 2018; NWREAD 2016b; DEA 2013b).

An extreme rainfall event is defined as 20 millimetres of rain occurring within 24 hours over an 8km x 8km grid point (CSIR 2019). Extreme rainfall events include severe thunderstorms and lightning (CSIR 2019). Figure 7 shows the projected change in the annual average number of extreme rainfall days over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period (CSIR 2019).

Figure 7 indicates that most of the North West will either see a slight decrease or a slight increase in the annual average number of extreme rainfall days (CSIR 2019). This suggests that some parts of the North West could experience storm and flood events more often while other parts experience such events less often. Figure 7 also indicates that there will be increased rainfall variability in the North West (CSIR 2019). To provide a national context, Figure 8 shows the projected changes in the annual average number of extreme rainfall days throughout South Africa over the period 2021 to 2050 under the RCP 8.5 scenario relative to the baseline period.

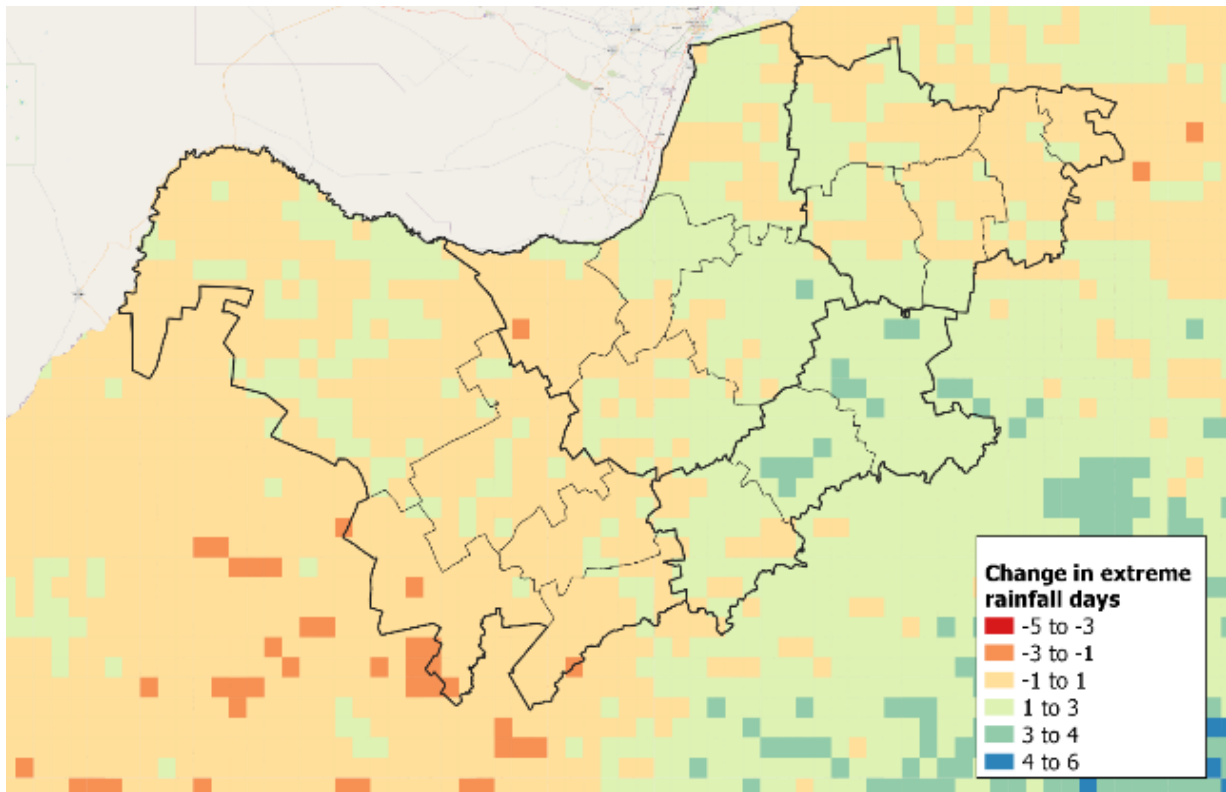


Figure 7: Projected changes in the annual average number of extreme rainfall days throughout the North West over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

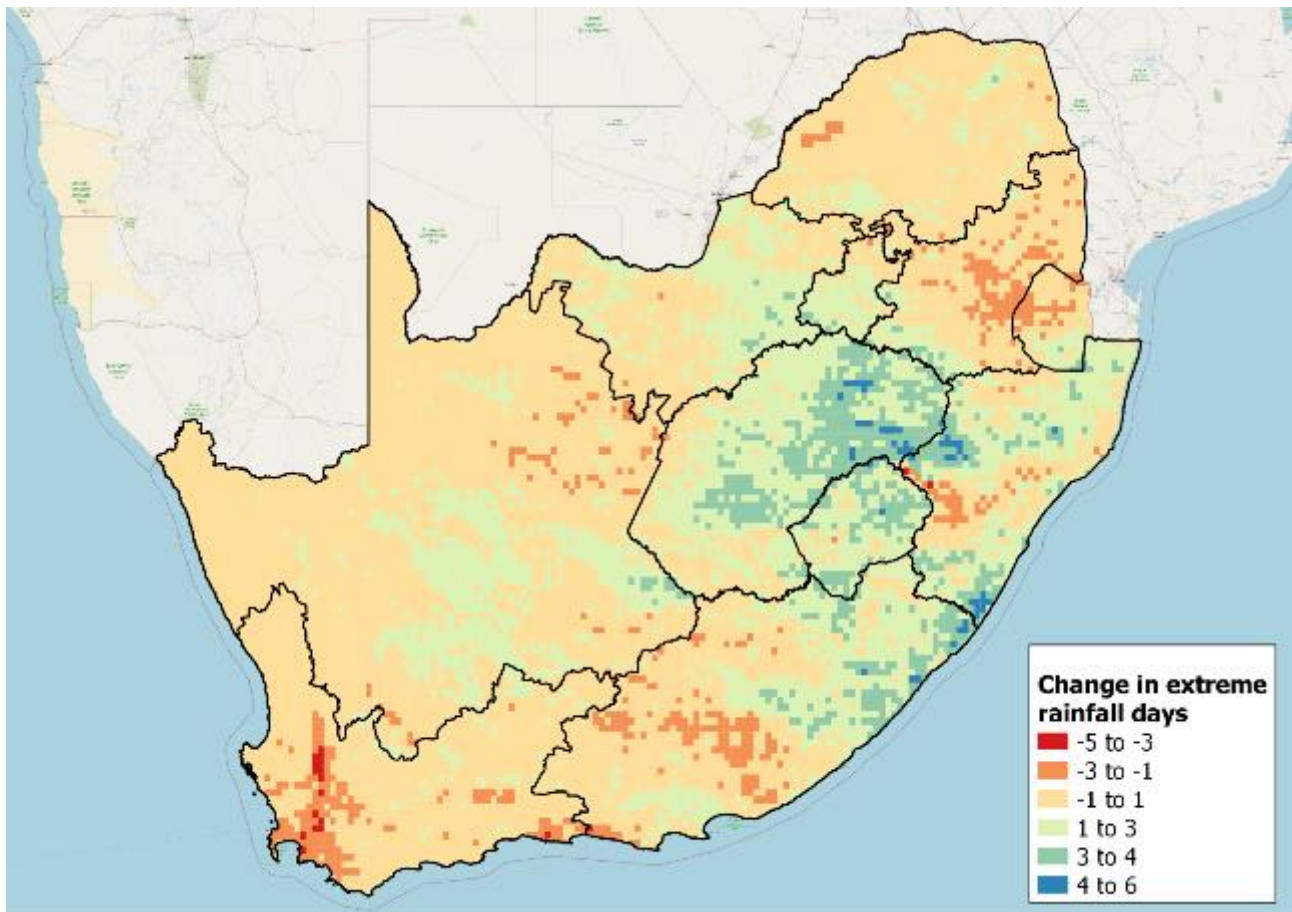


Figure 8: Projected changes in the annual average number of extreme rainfall days throughout South Africa over the period 2021-2050 under the RCP 8.5 scenario (CSIR 2019)

5 Sectors

As the hazards discussed are expected to be exacerbated by climate change, they are projected to affect numerous sectors and sub-sectors in the North West. In this section, each sector is broken down into sub-sectors. For each sub-sector, the impacts of the hazards on that sub-sector are presented, the exposure of the sub-sector to these hazards is discussed, the sensitivity of the sub-sector to the hazards is detailed, and the adaptive capacity of the sub-sector is considered.

5.1 Ecosystems

For this report, ecosystems consist of terrestrial (land-based) ecosystems such as forests, grasslands and deserts, and aquatic (freshwater) ecosystems such as rivers, lakes and wetlands.

a Impacts

Various hazards associated with climate change can negatively affect ecosystems and related goods and services in the North West resulting in the following impacts:

- Increases in average temperature may increase the risk of extinction of plants and animals that are unable to move away or adapt to the higher average temperatures and increased evaporation rates that are projected (NWREAD 2016b; NWDEDECT 2018).
- Increases in average temperatures, the number of very hot days, periods of drought, rainfall variation and evaporation rates are projected to increase the annual average number of high fire-danger days in the North West (CSIR 2019), which may increase the risk of wildfires in the province. The intensity and impacts of wildfires on ecosystems in the province may be exacerbated by concurrent increases in bush encroachment and the spread of invasive alien plants due to climate change (NWDEDECT 2018; SANBI 2019).
- Increases in average temperature may exacerbate land degradation through bush encroachment, the spread of invasive alien species, and increased soil erosion (NWREAD 2015; NWDEDECT 2018; SANBI 2019). Bush encroachment by indigenous and alien woody plants into the Grassland Biome is predicted to be exacerbated by changing climate and increasing carbon dioxide concentrations in the atmosphere (NWREAD 2015; NWDEDECT 2018; SANBI 2019). Bush encroachment will negatively affect habitats and species in the Grassland Biome, and it is predicted that this will increase the vulnerability of these habitats and species and their risk of extinction, which will negatively affect biodiversity in the province (NWREAD 2015). An increase in woody plants in grassland areas would also reduce the amount of water flowing into rivers and streams (a reduction in mean annual runoff) as woody plants in general have a higher level of water use than grasses (Archer et al. 2017).
- Increases in rainfall variability and the frequency and severity of droughts and flood events may exacerbate soil erosion, land degradation and the effects of these impacts on biodiversity in the province (NWREAD 2015; NWDEDECT 2018).

b Exposure

The two biomes of the North West province that are exposed to the impacts of climate change are the Savanna Biome, which covers about 70% of the North West's terrestrial area, and the Grassland Biome which covers the remaining area (NWDEDECT 2018). The province contains 41 nationally recognised vegetation types across the two biomes (NWDEDECT 2018). As of 2014, approximately

65% of the province fell into the 'natural and near-natural' land cover category (NWREAD 2015). In addition, the Griqualand West Centre of Endemism includes parts of the south-west portion of the province (NWDEDECT 2018). Furthermore, the central grassland areas in the North West have one of the highest concentrations of pan or wetland systems in South Africa (NWDEDECT 2018).

As of 2015, biodiversity priority areas in the North West collectively cover 59% of the total provincial spatial area (NWDEDECT 2018; NWREAD 2015). These biodiversity priority areas include terrestrial critical biodiversity areas (Figure 9), aquatic critical biodiversity areas (Figure 10) (29.1% of the total provincial spatial area); terrestrial and aquatic ecological support areas¹ (27.6%); and protected areas (2.3%) (NWDEDECT 2018; NWREAD 2015). Of these areas, only the protected areas (2.3%) are formally protected.

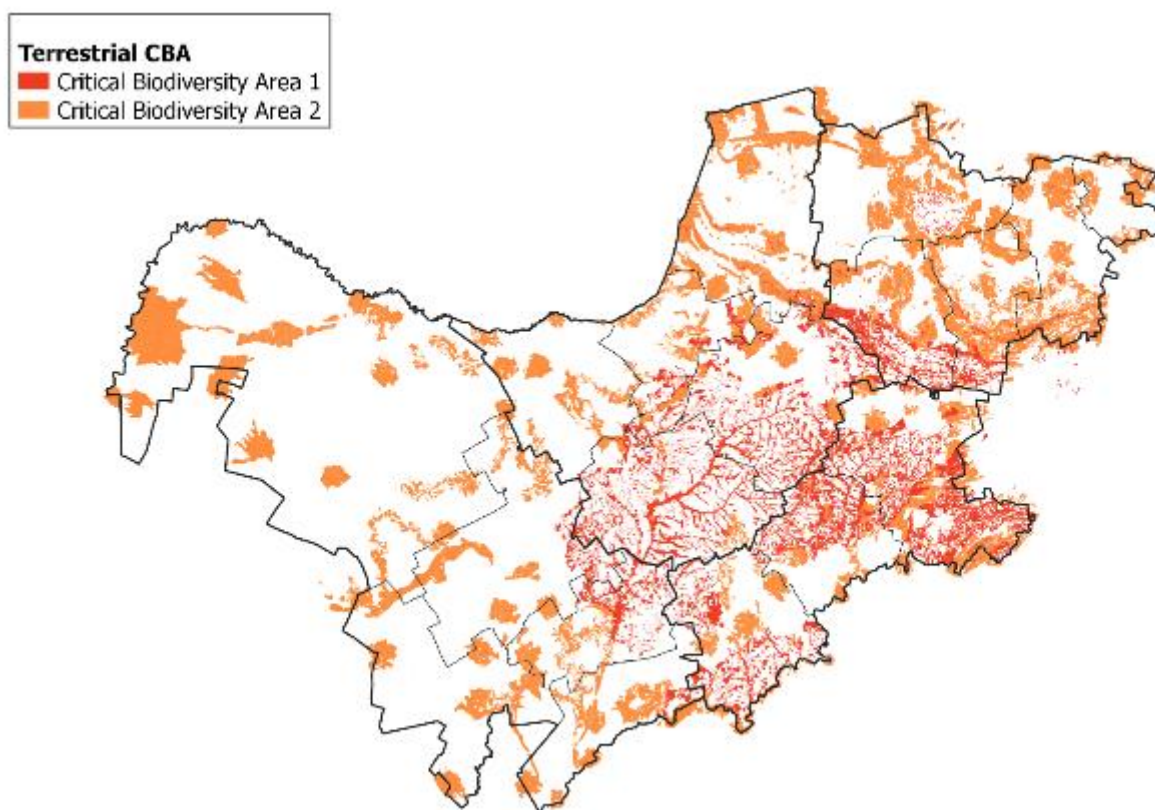


Figure 9: Terrestrial critical biodiversity areas in the North West (NWREAD 2015)

¹ The terrestrial and aquatic ecological support areas include a category labelled "No Natural Habitat Remaining earmarked as Ecological Support Areas" that has an extent of 5.2% of the provincial area.

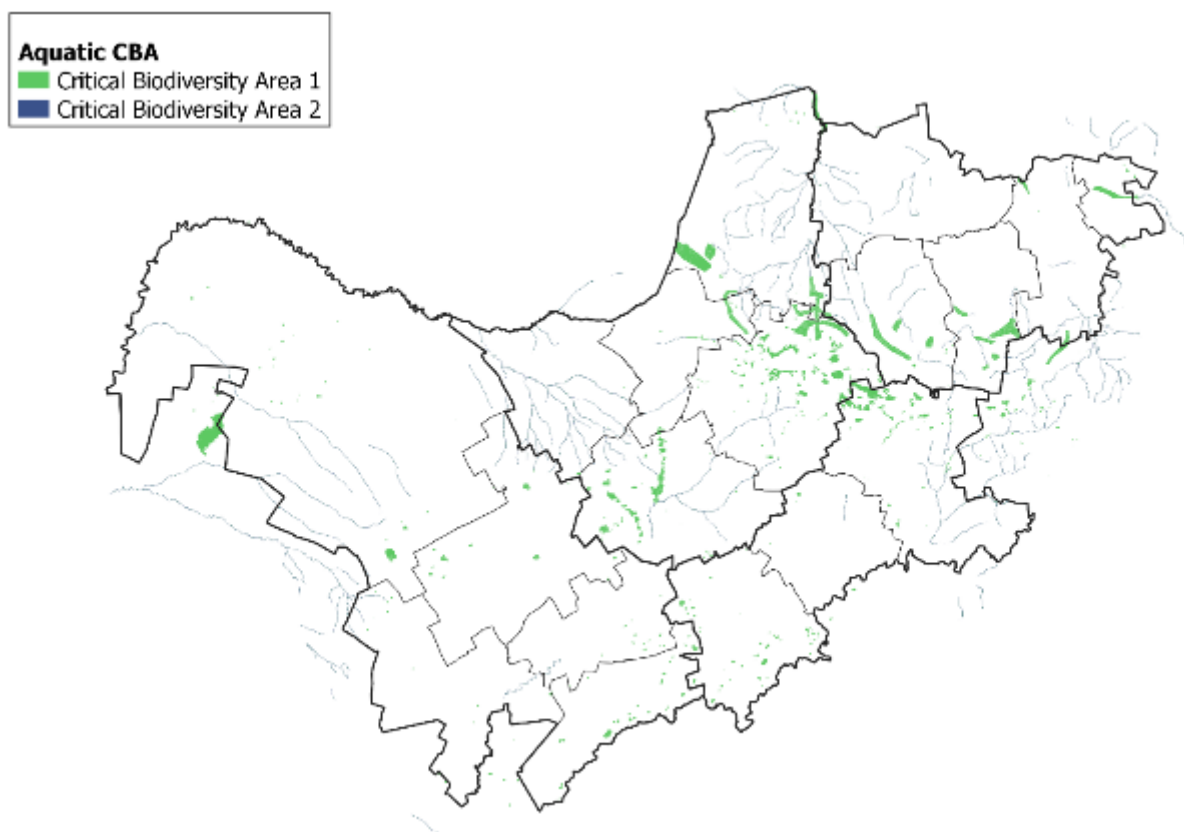


Figure 10: Aquatic critical biodiversity areas in the North West

Under the international Ramsar Convention, the Barberspan wetland and the Kgaswane Mountain Reserve in the North West are recognised as Ramsar wetlands of international importance (NWDEDECT 2018; The Ramsar Convention Secretariat 2019). In addition, the Kgaswane Mountain Reserve is also recognised as being part of a UNESCO Biosphere Reserve (The Ramsar Convention Secretariat 2014; 2019).

c Sensitivity

Climate change is also predicted to cause Savanna and Grassland Biomes to shift from where they are currently found in the North West (Figure 11) to a projected future configuration of biomes (Figure 12) (SANParks 2011). As the Grassland Biome is the most threatened in South Africa, and is projected to show the greatest reduction in spatial extent due to climate change (DEA 2013a), it is highly sensitive. Furthermore, the Grassland Biome is projected to entirely disappear under a high risk (worst case) scenario by the year 2050 (Figure 12), resulting in habitat loss (DEA 2013a).

The Savanna Biome is projected to dominate in areas where the Grassland Biome disappears as higher carbon dioxide levels and increased temperatures support the growth of woody plants (NWREAD 2016a). The Savanna Biome is likely to benefit from climate change in the North West and is thus less sensitive to climate change than the Grassland Biome.

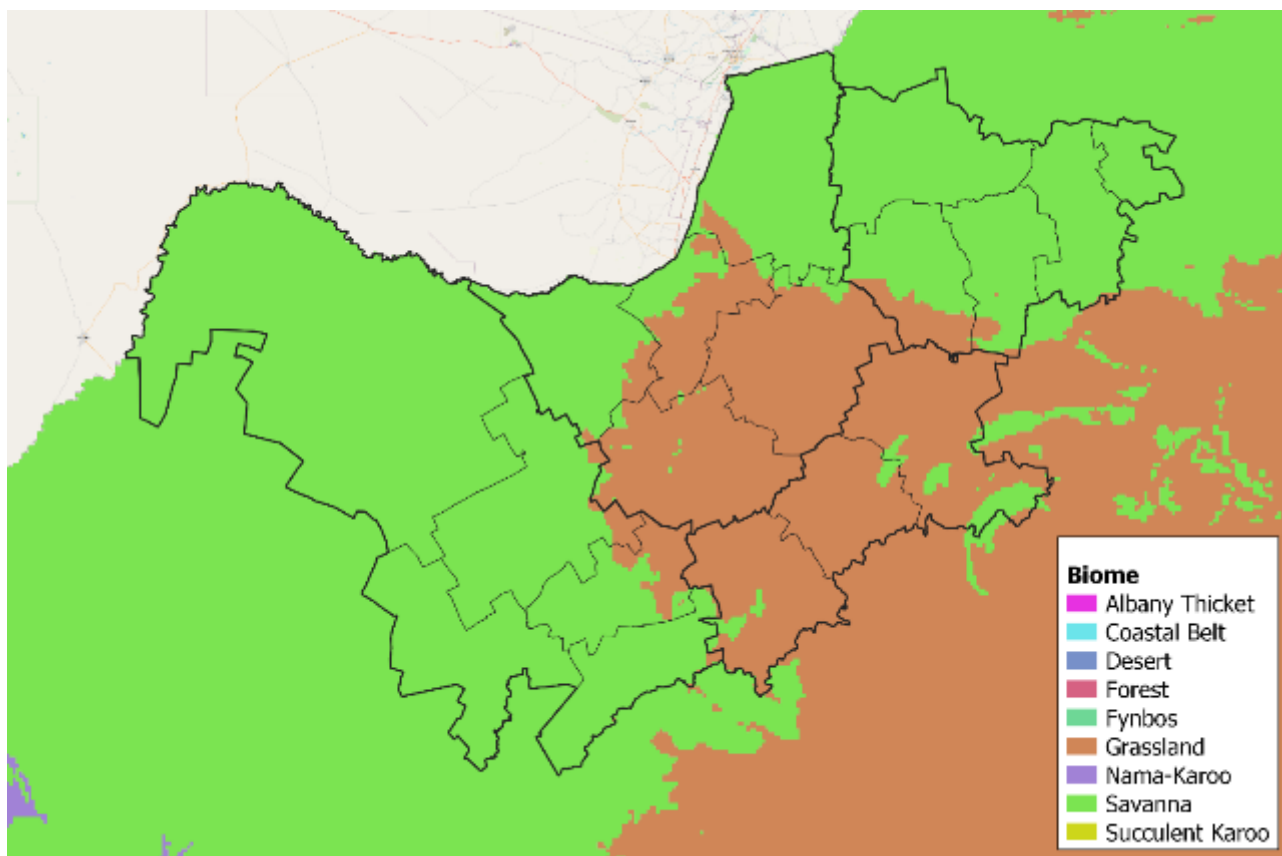


Figure 11: The current delineation of biomes in the North West (SANParks 2011)

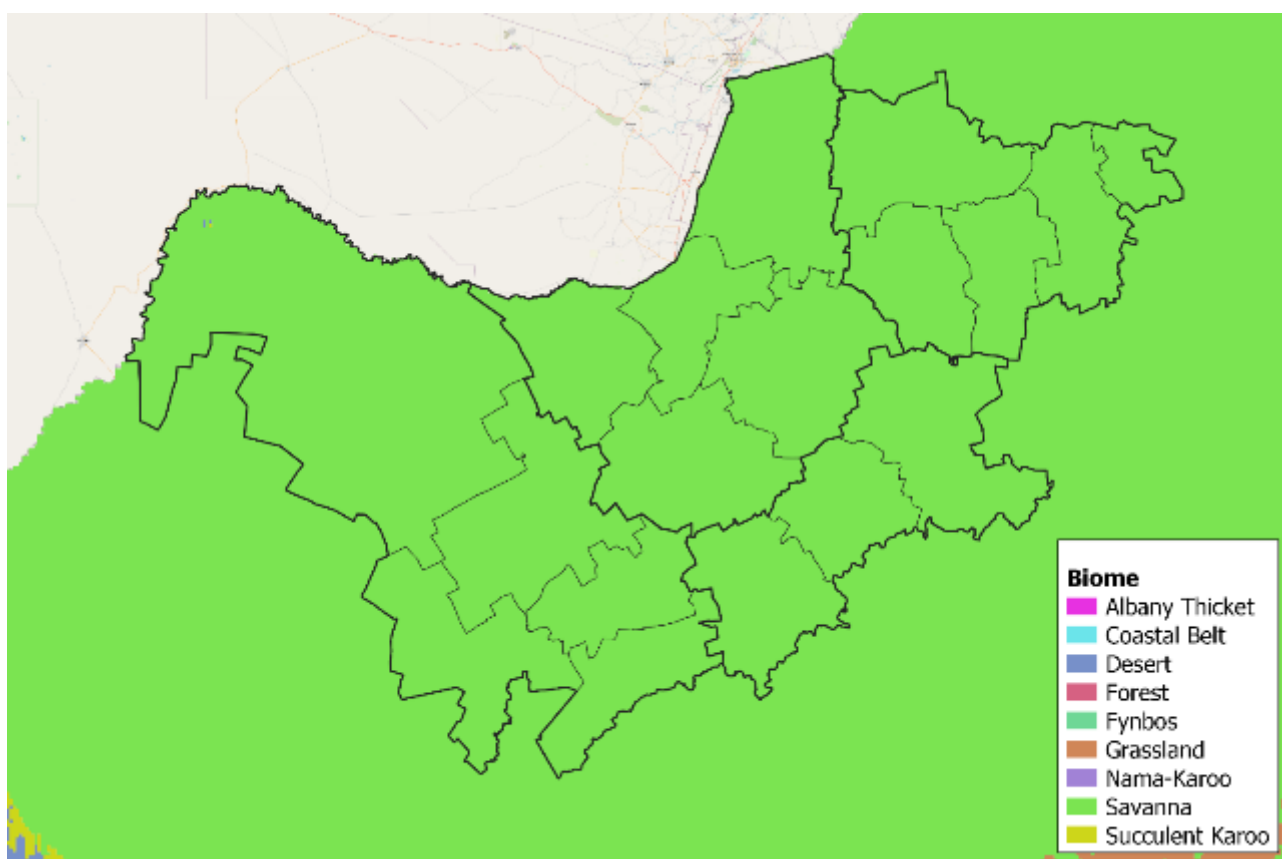


Figure 12: The predicted shift in biomes in the North West using a high-risk scenario (SANParks 2011)

Of the 41 nationally recognised vegetation types in the North West, 12 are already classified as vulnerable, endangered or critically endangered (NWDEDECT 2018). As the Grassland Biome is projected to disappear from the North West, the number of threatened vegetation types in the province will very likely increase.

The sensitivity of ecosystems in the North West to the projected impacts of climate change is further increased through the fragmentation of natural areas, unsustainable rates of water use, the poor state of wastewater treatment works, aged water infrastructure, agricultural runoff, mining effluent, invasive alien species, land degradation (including poor land-use management and land-use change), and pollution.

Stakeholder perspectives

The majority of stakeholders viewed the province's ecosystems as having **high sensitivity** to climate change. Reasons cited included:

- The North West is a water scarce province.
- Impacts of historical pollution and environmental degradation.
- Mining that is taking place in Rustenburg.
- The fragmentation of natural areas, unsustainable rates of water use, the poor state of wastewater treatment works, aged water infrastructure, agricultural runoff, mining effluent, invasive alien species, land degradation (including poor land-use management and land-use change), and pollution.
- Slow adaptation rate of fauna and flora to sudden/accelerated changes.
- Changes in climate conditions and rainfall will affect the biome that is already classified as a threatened area.
- Loss of habitat and encroachment.
- Unsustainable resource use practices and focus on resource efficiency do not appear to be a priority.
- Intact habitats and ecosystems support natural ecosystem service and biodiversity are critical for the continuation of life on earth.
- Lack of planning instruments at local government.
- Rapidly increasing climate change impacts.
- Anthropocentric air pollution due to emission of ozone depleting substances as a result of chemicals emitted from combustion of fossil fuels.
- Government departments, Eskom, Transnet, SANRAL, state-owned enterprises (SOEs), municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to veld fires, loss of life, and has a negative impact on livelihoods and food security.
- The unavailability of the updated impacts of climate change, which may limit the understanding of current impacts and the required mitigation actions.
- Increase in informal settlements.

d Adaptive Capacity

The adaptive capacity of ecosystems in the North West is varied, with habitats and ecosystems in the Savanna Biome likely to have higher adaptive capacity than habitats and ecosystems in the Grassland Biome, given the latter's vulnerability to climate change (DEA 2013a).

There are 21 formally protected areas and two municipal reserves in the North West, and they cover approximately 2.25% of the province's total land area (NWDEDECT 2018). Most of the protected areas are located within Savanna Biome areas in the eastern half of the province, leaving the Grassland Biome under-protected (NWDEDECT 2018). These protected areas enhance the adaptive capacity for ecosystems in the North West. However, threatened ecosystems within the province are poorly protected, and areas in the North West categorised as critical biodiversity areas or ecological support areas largely fall outside the boundaries of the formally protected areas (NWREAD 2015; NWDEDECT 2018). Of the 21 formally protected areas, 15 are provincial game reserves and none of these (as of 2018) had approved management plans, negatively affecting the adaptive capacity of their ecosystems (NWDEDECT 2018). In addition, fragmentation of natural areas habitat loss, land degradation, bush encroachment, invasive alien species and pollution negatively affect biological diversity, exacerbate the transformation of natural areas, and reduce the adaptive capacity of ecosystems in the North West (NWDEDECT 2018). Furthermore, the expansion of protected areas is likely to be limited in the North West (in spite of the target for conservation areas to cover 13.2% of the province) due to a combination of habitat loss, development pressures, and high land values (NWDEDECT 2018).

The adaptive capacity of ecosystems in the North West has been enhanced by the *North West Biodiversity Sector Plan 2015* (NWREAD 2015) and the *North West Environment Outlook Report 2018* (NWDEDECT 2018). However, adaptive capacity in the North West may be reduced by the limited nature of biodiversity surveillance programmes which, due to under-capacitated government institutions, may conceal the ongoing degradation of biodiversity in the province due to land-use change and poor land management, as well as the ecosystem impacts discussed earlier (NWDEDECT 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's ecosystems as having **low to medium** adaptive capacity to respond to climate change. Reasons cited included:

- Increase in erosion.
- Bush encroachment remaining an unmitigated threat to grassland biomes.
- Increase in illegal dumping.
- Off road driving.
- Increase in land use change.
- Lack of policies or strategies.
- A lack of prioritisation by local government in terms of planning instruments.
- Necessary conditions for capacity are not activated for example, not having management plans approved.
- Poor implementation of recommendations made in the North West Biodiversity Sector Plan 2015 and North West Environment Outlook Report 2018.
- Inadequate planning and resource allocation to ensure that elements of the ecosystem already identified as sensitive are protected.
- Ecosystems being managed by government or semi-government spheres, and implementation is therefore difficult. Government should create a conducive environment for the private sector to implement.

- There are systems to manage the ecosystem by both the provincial department and the North West Parks Board.
- Government departments, Eskom, Transnet, SANRAL, state-owned entities, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998.
- Lack of environmental compliance and enforcement.
- Poor management of wastewater treatment plants throughout the province.
- Increase in alien invasive plants.
- Reduced water and air quality.
- Lack of human resources in the province.
- Grassland Biome protection needs attention.
- Covid-19 making it difficult for the province to respond.
- Limited scientific data on aquatic ecosystems in terms of long-term trends in degradation of river systems and wetlands.
- Raw data authentication and whether sufficient to be able to make conclusions.
- Expansion of protected areas does not necessarily contribute to the adaptive capacity without effective management of those protected areas.
- Protected areas are usually near a natural state/intact ecosystem which has a higher resilience. For example, increased tree cover and altitude in mountain areas for adaptive cooling, connectivity and refuge for species. However, the lack of enforcement (management plans and regulations for protected areas) and cooperation from law enforcement to handle environmental crimes results in degradation of these habitats and the fragmentation of these habitats as urbanisation/mining and agriculture (and their impacts) continue to encroach on them. An example being the unsustainable commercial scale deforestation of hard-slow growing species in the Magaliesberg Biosphere that is not being addressed by any legislation or law enforcement body at any tier of government. These species will not regenerate in the face of climate change.
- Protected areas and biomes are identified and classified, and these can therefore be monitored, and mitigation plans developed and implemented where loss is identified. There is however a resource constraint.
- Human-wildlife conflicts and land-use challenges which hamper ability to protect and conserve both aquatic and terrestrial ecosystems.
- The rate of climate change being accelerated which gives a low opportunity for ecosystems to adapt accordingly.
- Increasingly stressed savannah rangelands will exacerbate overgrazing of community livestock, and this will not only have direct impacts on carrying capacity, water runoff as well as the inevitable incursion of community livestock into conservation areas.
- Most of the key facts are very vulnerable to the impact of mining and the demand that it has on water and air quality that will make it difficult to respond.
- Projected climate change impacts based on spatial and progressive land-use change adaptive capacity appear to be fairly/considerably manageable. However, ecosystem sensitivity is likely to be influenced by unsustainable resource use practices and resource efficiency is of great concern.

Summary

The ecosystem sector is of **High Concern** due to the following reasons:

- **Exposure:** The Savanna Biome covers about 70% of the North West's terrestrial area and the Grassland Biome covers the rest. The North West includes the Barberspan wetland, the Kgaswane Mountain Reserve and part of the Griqualand West Centre of Endemism (NWDEDECT 2018).
- **Impacts:** Ecosystems are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increased average temperatures may lead to land degradation and affect biodiversity
 - Increased rainfall variability can lead to severe periods of drought and increased number of fire-danger days
 - Deterioration of water quality may threaten aquatic ecosystems.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's ecosystems as having high sensitivity to climate change. Key sensitivity factors include:
 - Impacts of environmental degradation on biodiversity
 - The poor state of wastewater treatment works and aged water infrastructure
 - Unsustainable use of natural resources
- **Adaptive Capacity:** The majority of stakeholders viewed the province's ecosystems as having low to medium adaptive capacity to respond to climate change. In particular, it was noted that while there are existing plans in place, there are limited human and financial resources to implement these plans.

5.2 Livelihoods

5.2.1 Rural livelihoods

a Impacts

Various hazards associated with climate change can negatively affect rural livelihoods in the North West with the following impacts:

- Increases in average temperatures and rainfall variability can negatively affect ecosystem goods and services, which rural households are heavily reliant on (NWREAD 2016a).
- Increases in average temperatures, the number of very hot days, periods of drought, rainfall variability, and evaporation rates will negatively affect subsistence farming (small-scale farming of livestock and field crops), which rural households depend on for sustenance and food security (Lötter 2019).
- Increases in periods of drought may negatively affect employment levels in the agricultural sector and thus rural livelihoods. This, along with the likely increases in food insecurity, could lead to economic and social instability in the province (Lötter 2019).
- Increases in average temperatures may expand the geographic range of vector-borne and water-borne diseases.

b Exposure

The North West is predominantly rural, with around 60% of the population living in rural areas and the remainder in urban areas. The rural population mainly depends on agriculture for their livelihoods (NWREAD 2016a).

c Sensitivity

The North West is largely rural and about 46% of the population live in conditions of poverty. This is higher than the national average of about 40% of the population (NWDEDECT 2018). The high level of poverty indicates that people living in rural areas in the North West are sensitive to climate change.

In the North West, rural areas are already affected by land degradation caused by poor land management, overgrazing and soil loss, leading to reduced biodiversity and ecosystem goods and services (DEFF 2020). This results in rural livelihoods having increased sensitivity to the effects of climate change (NWREAD 2016a).

Households in traditional authority areas and others living in rural areas in the North West are heavily reliant on ecosystem goods and services (including fishing) and subsistence or small-scale agriculture for sustenance and food security (NWREAD 2016a). This reliance on ecosystem goods and services makes such households sensitive to the projected impacts of climate change.

Stakeholder perspectives

The majority of stakeholders viewed the province's rural livelihoods as having **high sensitivity** to climate change. Reasons cited included:

- Soil loss.
- Hailstorms.
- Flash floods.
- Overgrazing.
- The reduction in the natural ecosystem due to heavy reliance on natural resources in rural areas.
- Poor land use management.
- Land degradation.
- Lack of knowledge on users of land and lack of adaptive farming methods such as conservation agriculture and following proper grazing capacity by livestock farmers.
- Lack of awareness.
- High temperatures.
- Lack of infrastructure.
- Change in weather conditions.
- Low economic diversification levels.
- Rural communities being susceptible to failures in agriculture and having limited or no resources to adapt their practices to account for or mitigate the impacts of extreme conditions.
- Climate change increasing the difficulty for rural livelihoods to gain access to water and energy to secure food security.

- Poorest communities living in rural dwellings, and mostly vulnerable elderly and children are affected by reduced food production and adverse temperature and floods.
- Increasing poverty.
- The exacerbation by climate change of a number of socio-economic issues already experienced by many communities.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998.
- The location of many rural settlements being vulnerable to disasters. Disaster management and site-specific alert strategies are not in place for scattered rural communities.
- Soil conditions as a critical sustainability factor and basic source of food security, grazing capacity, and infrastructure development appear not to be considered as critical factors of land-use and spatial planning.

d Adaptive Capacity

Rural communities in the North West have low adaptive capacity due to low levels of infrastructure development and access to markets (physical capital); high unemployment rates; high rates of human immunodeficiency virus (HIV); low literacy levels (human capital); low economic diversification and assets (financial capital); and a high dependence on the agriculture sector, and to a lesser degree, the mining sector (NWREAD 2016a; Lötter 2019).

The population of the North West who live in conditions of poverty (approximately 46%) have reduced adaptive capacity as they have limited access to resources and rely heavily on natural ecosystem goods and services (NWDEDECT 2018).

Generally, households in rural areas, particularly poor rural communities, are not connected to the municipal water or electricity grid (DEA 2016). To meet their water and energy needs, these households depend on natural resources (DEA 2016). This particularly affects rural women who spend much time collecting water and wood for use in their homes (DEA 2016). These circumstances all reduce the adaptive capacity of these communities.

Stakeholder perspectives

The majority of stakeholders viewed the province's rural livelihoods as having **low capacity** to respond to climate change. Reasons cited included:

- Rural areas' lack of infrastructure and dependence on primary natural resources for livelihood.
- Inadequate inclusivity and capacitation of the affected local stakeholder (rural communities) on the climate change impact information to make real action.
- Lack of choice and resources to respond effectively.
- Economic circumstances as well as the incapacity of the municipalities and local businesses to support these populations in times of crises.
- Most communities have not been empowered to understand what a warmer world means for their everyday lives, and what measures need to be put in place to reduce impacts.
- People in rural areas not having the capacity, through poverty and ignorance, to respond effectively.

- The lack of knowledge around water smart farming, or training that is available for subsistence farmers – there are no extension officers out in the community training on mulching, composting, drip irrigation, no till farming and agroforestry etc. Big farmers are starting to use tunnels and bringing in beehives so they will likely be okay.
- Lack of awareness drives to encourage small scale on rural livelihood.
- Very little infrastructure maintenance and development.
- Of the 46% of people living in poverty in the province, the vast majority will be in rural areas and their livelihoods are dependent on subsistence agriculture, in turn dependent on ecosystem services which will be negatively impacted by climate change.
- Climate change increases the difficulty for rural livelihoods to gain access to water and energy and to food security. They have less control over factors that will assist to turn the situation around.
- Rural development is the prerogative of the Rural Development and Land Reform Department.
- Developmental challenges (budget cuts) in the province.
- No clear climate change adaptation strategy where rural communities are concerned.
- Over-utilisation of natural resources (overgrazing, lack of proper management of land, bush encroachment, population growth and soil erosion), and The Department of Agriculture not having sufficient capacity to address land management.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.
- Risk of further migration to urban areas leaving behind those who are less adaptable and able to cope such as the vulnerable aged and young people.
- A different approach on agricultural manufacturing.

Summary

The rural livelihoods sector is of **High Concern** due to the following reasons:

- **Exposure:** Around 60% of the population in the North West live in rural areas. The rural population mainly depends on agriculture for their livelihoods (NWREAD 2016a).
- **Impacts:** Rural livelihoods are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increased temperatures disrupt natural resources leading to increased levels of food insecurity
 - Decreased quality and quantity of water resources, which affects the health of rural communities
 - Increased prevalence of extreme weather events leading to loss of life and livelihoods.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's rural livelihoods as having high sensitivity to climate change. Key sensitivity factors include:
 - Existing land degradation in rural areas
 - Heavy reliance on natural resources for livelihoods
 - Poverty and higher proportion of vulnerable persons

- **Adaptive Capacity:** The majority of stakeholders viewed the province's rural livelihoods as having low adaptive capacity to respond to climate change. In particular, it was noted that rural communities do not have access to resources, such as knowledge and finances to respond to the effects of climate change.

5.2.2 Urban Livelihoods

a Impacts

Various hazards associated with climate change can negatively affect urban livelihoods in the North West with the following impacts:

- Increased average temperatures and the number of very hot days may negatively affect human health in urban areas, for example, increasing the risk of heat stress and mortality in vulnerable groups through an increase in the frequency and severity of heatwaves (NWREAD 2016a). Projected increases in average temperatures may be made worse in urban areas by the heat island effect (Le Roux, Arnold, et al. 2019).
- Increased storms and flooding events can escalate the risk of floods in urban areas (NWREAD 2016a).
- Increased average temperatures may expand the geographic range of vector-borne and water-borne diseases.
- Increased periods of drought will result in water shortages and fire risks in urban areas (NWREAD 2016a).

b Exposure

The Madibeng, Rustenburg, Mahikeng, and City of Matlosana local municipalities together account for about half of the North West's population, about 58% of its workforce, and about 63% of the total economic activity in the province (NWPG 2017b). Each of these local municipalities includes one of the North West's primary activity nodes, such as Rustenburg (Rustenburg Local Municipality), Klerksdorp (City of Matlosana), Potchefstroom (JB Marks Local Municipality), Mahikeng (Mahikeng Local Municipality), and Brits (Madibeng Local Municipality) (NWPG 2017b).

c Sensitivity

Migration of people from poor regions to large economic nodes is common in the North West (NWDEDECT 2018; NWREAD 2016a). Also common is seasonal migration from rural areas to mining areas and towns for work (NWDEDECT 2018).

It is projected that between 2011 and 2050, the Rustenburg Local Municipality will be the fastest growing local municipality in the province, with an additional 570,000 people, equal to a 104% increase (Le Roux, Arnold, et al. 2019). The Kgetlengrivier Local Municipality is also projected to grow by more than 100% by 2050, and as it is the smallest local municipality in the province (by population size), this increase is predicted to be about 41,000 people (Le Roux, Arnold, et al. 2019). Other local municipalities in the North West projected to grow by more than 80% by 2050 are Madibeng Local Municipality (with an expected increase of about 400,000 people), Ditsobotla Local Municipality (about 140,000 people) and JB Marks Local Municipality (about 140,000) (Le Roux, Arnold, et al. 2019). At the same time, the populations of the Greater Taung Local Municipality and the Moses Kotane Local Municipality are projected to decline by 40% (71,000 people) and 32% (79,000 people) respectively (Le Roux, Arnold, et al. 2019).

Growing population pressures in urban areas may cause some local municipalities in the North West to become more sensitive to climate change. Furthermore, increases in heat stress and the urban heat island effect will likely also increase the sensitivity of urban areas to climate change (Le Roux, Arnold, et al. 2019). Higher levels of water and air pollution, which are typical of urban areas as well as urban land-use practises, will likely also increase the sensitivity of urban areas to climate change (Le Roux, Arnold, et al. 2019).

Stakeholder perspectives

The majority of stakeholders viewed the province's urban livelihoods as having **medium to high sensitivity** to climate change. Reasons cited included:

- Population dynamics.
- Increased population leading to increased use of resources.
- Movement of people from rural to urban areas in search of better livelihoods.
- Growing population pressures in urban areas and higher levels of water and air pollution in urban areas.
- Land grabs as people coming to the areas with more economic activities, can't find a place to stay, and as a result they occupy any piece of land which may also lead to increase in pollution and land degradation.
- Massive uncontrolled urbanisation resulting in increasing costs and additional pressures on urban services from the rampant urbanisation, primarily in informal settlement, as rural livelihoods become under pressure as rural areas fail because of climate change.
- An increase in migrant labour creating local pressure competing for local social development and livelihoods.
- Job creation in the mining sector.
- Increased heat stress, linked to health issues.
- Slightly better off compared to rural people.
- Lack of planning and infrastructural development.
- Severe storms being experienced lately in Rustenburg.
- The possibility that, if no water is available for supply by municipality, there will be a greater impact on urban areas than on rural areas, as urban areas are used to having easy access to water.
- May be less sensitive than rural areas, as urban areas make use of municipal services, but if no water is available for supply by municipality, the impact on urban areas may even be greater than on rural areas, as urban areas are used to having easy access to water.
- With collaboration and support of municipalities and big business, risk management measures - rapid alert/response strategies can be put in place for potential disasters and food insecurity.
- Covid-19 making it difficult for most of the municipalities to cope, as many people are often off sick.
- Local governance has the regulatory framework and tools to minimise climate change e.g., is has responsibilities in terms air pollution, fire and disaster management, and waste bylaws.
- The sensitivity is high due to factors that were raised above such as heat stress, poor water and air quality.

- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, leading to loss of life, livelihoods and food security.

d Adaptive Capacity

In general, urban areas have higher adaptive capacity than rural areas in the North West as they have more financial and infrastructure resources than their rural counterparts (NWREAD 2016a).

Through the Local Government Climate Change Support Programme in 2016, the Department of Forestry, Fisheries and the Environment (DFFE) and the South African Local Government Association (SALGA) worked with district municipalities in the North West to prioritise climate change planning in the municipal sphere of government (NWREAD 2016a). The prioritisation of climate change planning will hopefully increase the adaptive capacity of urban and rural areas in the province.

The migration of people from rural to urban areas will increase population pressure on urban infrastructure, which will likely reduce the adaptive capacity of urban areas in the province (NWREAD 2016a).

Stakeholder perspectives

The majority of stakeholders viewed the province's urban livelihoods as having **medium capacity** to respond to climate change. Reasons cited included:

- Availability of infrastructure.
- Availability of financial resources.
- Having the financial means to prepare themselves for the worst.
- The growing population in urban areas, leading to air and ground pollution.
- Failure of big towns in the North West to accommodate more people migrating to urban areas.
- Areas like Rustenburg are able to respond to the increase in population although it is still lacking a bit, it is doing well compared to other areas. Madibeng is behind in terms of township development that can cope with the increased population and people started moving away from the city to reside in rural areas that are close to the CBD or town.
- Inward mobility - migrant labour driven by platinum mining commodities and social services are not sustainable for the regional economic sustainability of the local communities in the long run.
- Being better suited to adapt compared to rural people - particularly urban areas in the east of the province (which is the most densely populated).
- North West municipalities being in disarray, as are being reported in the media and due to their financial constraints, they do not have the capacity to mitigate contributing factors.
- Service delivery from municipalities already being under threat. Increasing water scarcity will materially erode service delivery even further at all levels.
- Areas like Northam mine on the border between the North West and Limpopo provinces have a great impact on Moses Kotane livelihoods.
- Focus needs to change from current Corporate Social Responsibility to Social Sustainability Strategy.

Summary

The urban livelihoods sector is of **Medium Concern** due to the following reasons:

- **Exposure:** The Madibeng, Rustenburg, Mahikeng, and City of Matlosana local municipalities together account for about half of the North West's population, about 58% of its workforce, and about 63% of the total economic activity in the province (NWPG 2017a).
- **Impacts:** Urban livelihoods are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Decreased water supply leading to disruption to urban livelihoods
 - Decreased quality and quantity of water resources, which affects the health of urban communities
 - Increased prevalence in disasters from extreme weather leading to loss of life.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's urban livelihoods as having medium sensitivity to climate change. Key sensitivity factors include:
 - Increased heat stress and health issues
 - Increased rural to urban migration, which will put pressure on urban service delivery
 - Access to basic services and resources to respond to climate change.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's urban livelihoods as having low to medium adaptive capacity to respond to climate change. In particular, it was noted that urban livelihoods have access to basic services, however, water scarcity and poor management within municipalities compromises this access.

5.3 Economic Activity

5.3.1 Agriculture

a Impacts

Various hazards associated with climate change can negatively affect the agricultural sector in the North West with the following impacts:

- Increased average temperatures and rainfall variability may make it more difficult to raise livestock and grow crops, as the temperature thresholds of crops are breached and livestock, as well as farm workers, are negatively affected by heat stress (Lötter 2019).
- Increased average temperatures, the number of very hot days, periods of drought, rainfall variability, and evaporation rates will negatively affect the dryland farming of field crops (such as the majority of maize grown in South Africa), as this type of farming depends on rainfall (Lötter 2019). Rangelands (the growth rates and quality of grasses) that livestock farmers depend on will also be negatively affected (Lötter 2019).
- Increased average temperatures may lead to an increase in diseases (including vector-borne diseases) for livestock in the province (NWREAD 2016b).
- Increased rainfall variability and the frequency and severity of droughts and flood events may exacerbate soil erosion and land degradation, negatively affecting agricultural produce levels, food security and subsistence farmers in the province (NWREAD 2015; NWDEDECT 2018).

- Increased periods of drought may negatively affect employment levels in the agricultural sector and thus livelihoods, which, along with increased food insecurity, could lead to economic and social instability in the province (Lötter 2019).

b Exposure

In 2018 it was estimated that the North West Province has about 5.3 million hectares (ha) of land being used for commercial agricultural (Statistics SA 2020a). This land is exposed to the climate change impacts for the agriculture sector listed above. According to 2017 figures, this agricultural land is split into the following different branches of agriculture (DALRRD 2021):

- 1,573,497 hectares (ha) of field crops (e.g., maize);
- 100,682 ha of horticultural plants including vegetables, fruit and tree nuts;
- 4,183,827 ha for animal production;
- 323,764 ha of mixed farming;
- 101,593 ha of irrigated crops and orchards; and
- 2,239 ha of forestry.

In the North West, the percentage contribution of the agriculture, forestry and fisheries sectors to the provincial gross domestic product was 2.6% in 2017 (Statistics SA 2019).

c Sensitivity

Except for the 101,593 ha of irrigated crops and orchards (1.6% of the total agricultural and forestry ha in the North West in 2017), the remaining 98.4% of agricultural and forestry land in the North West is cultivated as dryland agriculture which relies entirely on rainfall. These dryland agricultural areas may have a lower tolerance for increased average temperatures, rainfall variability, and evaporation rates than agricultural areas under irrigation and may thus be more sensitive to the projected impacts of climate change. Irrigated crops and orchards rely largely on groundwater reserves for water for irrigation. In several parts of the North West, where dolomitic aquifers occur, groundwater has been and continues to be used at an unsustainable rate (NWDEDECT 2018). Over-extraction reduces water security in these areas especially in times of drought and makes such areas more sensitive to climate change (NWDEDECT 2018).

Small-scale and subsistence farmers are generally more sensitive to climate change than commercial farmers, due to the difference in the availability, accessibility and quality of the institutional infrastructure that is available to commercial farmers. Subsistence farmers generally have less capital-intensive technology and management practices available to them (Gbetibouo and Ringler 2009). In 2017, the North West had an estimated 147,400 small-scale farmers and an estimated 4,920 commercial farms (DALRRD 2021). The large number of small-scale and subsistence farmers increases the North West's sensitivity to climate change.

Land degradation (including vegetation and soil degradation from human activities and natural disasters) reduces the productivity of the land and influences the sensitivity of the agricultural sector to climate change (Gbetibouo and Ringler 2009). In the North West, the agricultural sector both negatively affects, and is negatively affected by land degradation (NWDEDECT 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's agriculture as having **high sensitivity** to climate change. Reasons cited included:

- A lack of resources.
- Ownership.
- Effect of land degradation.
- Increased surface soil encrustation.
- Increased erosion as opposed to aquifer recharge.
- Agricultural infrastructure.
- Effect of heat stress.
- Effect on food security.
- Low rainfall affecting food production and security.
- Irrigated crops and orchards rely largely on groundwater reserves for irrigation.
- Effect of water scarcity.
- Borehole abstraction will be a function of rainfall recharge.
- Depletion and contamination of groundwater (unless the Lesotho highlands scheme is extended), particularly for irrigated crops and orchards
- Increased rain variability.
- Increased concomitant runoff.
- Lack of infrastructure for irrigation.
- Already experiencing the impact of climate change.
- Need for adoption of climate resilient crops.
- A lack of research on climate resilient crops and agriculture methods.
- The vulnerability of crops to a single drought, flood, or heavy hailstorm.
- Increased temperatures influencing crop production.
- Increased mining activity negatively impacting agriculture.
- In urban areas/urban periphery, the agricultural sector is being threatened by increased urbanisation and mining interests, taking food production away from urban markets and increasing vulnerability to food scarcity.
- Not enough being done to increase conservation agriculture, smart agriculture and change the mindset of farmers in general.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.

d Adaptive Capacity

Adaptive capacity is generally low in the North West due to high dependence on agriculture, high unemployment rates, extensive HIV prevalence and low levels of infrastructure development and maintenance (NWREAD 2016a).

Small-scale and subsistence farmers generally have lower adaptive capacity than commercial farmers as they have access to fewer resources and have less financial, social and human capital available (Gbetibouo and Ringler 2009).

In the province, the North West Department of Agriculture and Rural Development is responsible for providing agricultural extension and advisory services (such as information dissemination) to

subsistence and commercial farmers (NWDARD 2019; Qamar 2013). In addition, extension officers from the national Department of Agriculture, Land Reform and Rural Development have been helping to educate farmers (NWREAD 2016a). These agricultural extension and advisory services improve the adaptive capacity of farmers by providing information on climate change and improved agricultural practices (NWREAD 2016a).

There is at least one primary agricultural cooperative (Baobab Cooperative Limited) in the North West that has also improved the adaptive capacity of farmers in the province (DAFF 2012). Commercial farmers in the North West may also belong to farmers' associations such as Agri SA and the African Farmers Association of South Africa (Qamar 2013). These organised formations may contribute to the adaptive capacity of commercial farmers through knowledge sharing and other forms of support.

While climate-smart agriculture (CSA) practises can increase the adaptive capacity of the agricultural sector, and are a priority for the National Department of Agriculture, Land Reform and Rural Development, CSA practices are limited in the North West (NWREAD 2016b; CSIR 2019). CSA practices that have been implemented in the North West, have been done so on an informal basis (NWREAD 2016b), however, the North West Provincial Government is in the process of finalising and implementing a CSA Strategy (NWDEDECT 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's agriculture as having **low to medium capacity** to respond to climate change. Reasons cited included:

- Increased economic and agricultural droughts.
- Water scarcity.
- Continued and increased water scarcity and water quality issues, which is not being addressed by the Department of Water and Sanitation (DWS).
- Water resources that are poorly managed and highly impacted from urbanisation.
- No commitment to address water quality issues - pollution leaching of pesticides and agricultural chemicals. Mono cropping and vulnerability of insects for example.
- Commercial agricultural operations do not always respect surface and groundwater recharge quotas.
- Cattle and crop farming being totally dependent on water.
- Dry land conditions.
- Increased likelihood of extreme weather.
- A lack of training, empowerment and mentorship.
- Low capacity to implement climate-smart agriculture (CSA) practises.
- 50% of rural land in the province needs an awareness drive on agriculture.
- Some experienced farmers with finances are starting to use smart farming.
- If bigger agricultural unions are on board in the process (Agri SA and AGri NW etc.), they can increase knowledge, training and programmes for farmers that can increase adaptive capacity.
- People in the agriculture sector are already aware of the impact of climate change.

- Emerging farmers are resistant to change, and the agricultural land continues to be degraded.
- Slow uptake of adaptive technology and agricultural practices more suited to changing climate and weather conditions.
- Resources are scarce and there is very little support from respective departments.
- Although efforts are being made, there is insufficient capacity by the Department to disseminate information on climate smart agriculture.
- Lack of transparency and updated data on groundwater - the North-West University has a department of Ground Water/Hydrology that could be consulted for this.
- Agriculture relies heavily on the climate of a region - different crops may however be moved to and grown to adapt to the relevant climate.
- The commercial sector will be in a position to adapt to climate change through modern sound agricultural practices and their financial abilities (they can access loans/grants from banks and government), whereas the small-scale farmer will suffer due to lack of resources (funding, knowledge and infrastructure).
- Most of the commercial farmers have a capacity to adapt to climate change impacts due to their financial abilities and they can access loans/grants from banks and government.
- Competition of natural resources (water supply availability) between mining and agriculture to an extent and combined might tilt the scale or outweigh social water needs for quality and potable water supply between urban and rural demand, though still manageable.
- Application of aerosol fertilizers and pesticide is detrimental to troposphere ozone layer.

Summary

The agriculture sector is of **Medium Concern** due to the following reasons:

- **Exposure:** The North West province has approximately 6.3 million hectares of land that is being used for commercial agriculture. In the North West, the agriculture, forestry and fisheries sectors contributed 2.6% to the provincial gross domestic product in 2017 (Statistics SA 2019).
- **Impacts:** Agriculture is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature leading to decreased water supply for irrigation
 - Changes in temperature and rainfall affect crop production
 - Increased temperatures can lead to heat stress on livestock
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's agriculture as having high sensitivity to climate change. Key sensitivity factors include:
 - Increased temperatures affect water availability for irrigation
 - Increased runoff and erosion
 - Effect of extreme weather on crops and livestock.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's agriculture as having medium adaptive capacity to respond to climate change. In particular, it was noted

that agriculture is a water intensive activity, however, farmers that have access to resources will be able to implement farming practices to respond to climate change.

5.3.2 Tourism

a Impacts

Most tourist attractions in the North West are closely linked to the environment and climate itself, making tourism a highly climate-sensitive economic sector. The impacts of climate change on tourism in the North West province are likely to manifest in the following ways (DEA 2010):

- The condition of environmental resources such as wildlife, heritage sites, properly functioning systems and beautiful views from natural scenery may degrade.
- Decreased water availability will result in a loss of biodiversity, a reduction in the aesthetic value of landscapes and altered agricultural production.
- The implementation of climate change mitigation policies may change tourist and mobility flows.

b Exposure

In 2019, it was estimated that the total number of trips by domestic and international tourists in South Africa was 39,277,754 and the total tourism spend as a percentage of the GDP at current prices was 5.4% (DT 2019). The travel and tourism sector has become one of the country's major employers, contributing 1,482, 200 jobs and comprising about 9.1% of the country's total workforce (DT 2019).

Tourism plays a significant role in supporting the provincial economy and offering employment opportunities to the people of the North West province (Table 3). In 2019, the estimated total number of trips by domestic and international tourists in the North West was 2,536,403 (6.46% of the national total) (NWDC 2021). The total tourism spend as a percentage of the GDP in the province was 4.1% in 2019. In terms of employment, the formal tourism sector in the North West employed over 33,000 people prior to the Covid-19 pandemic (NWDC 2021).

There is variation across the province in the estimated total number of trips by tourists and the percentage contribution of the tourism industry to the GDP of the province (Table 3). The Bojanala Platinum District enjoys the highest number of trips by tourists to the North West at 51.7% (about 1,311,762 tourist trips) (NWDC 2021). The Bojanala Platinum District also benefits from the highest percentage contribution to the GDP of the tourism and travel industry in the province, at about 4.6% (NWDC 2021). All the other districts host a lower number of trips by tourists, and they contribute a lower percentage to the GDP of the province.

Table 3: Tourist trips and expenditure

	Number of trips by tourists (domestic and international) (NWDC 2021)	Percentage of trips by tourists (domestic and international) (NWDC 2021)	Total tourist spend as a percentage of provincial GDP (NWDC 2021) and (DT 2019).
Bojanala Platinum	1,311,762	51.7	4.6
Dr Kenneth Kaunda	451,221	17.8	3.6
Dr Ruth Segomotsi Mompoti	307,447	12.1	3.7
Ngaka Modiri Molema	465,973	18.4	3.5

	Number of trips by tourists (domestic and international) (NWDC 2021)	Percentage of trips by tourists (domestic and international) (NWDC 2021)	Total tourist spend as a percentage of provincial GDP (NWDC 2021) and (DT 2019).
North West	2,536,403.00	6.46	4.1
South Africa	39,277,754.00		5.4

c Sensitivity

Tourist attractions that rely on the quality of environmental resources, wildlife, biodiversity and well-functioning ecosystems will be more sensitive to the impacts of climate change. For example, reserves such as the Pilanesberg National Park, Madikwe Game Reserve and Barberspan Bird Sanctuary are more sensitive to the impacts of climate change which contribute to environmental degradation.

Most tourist attractions in the North West province include outdoor activities such as fishing, camping, mountain hiking and birding. Tourist attractions that offer these activities are more sensitive to heat-related effects of climate change. Tourists are less likely to participate in these activities when temperature conditions are not favourable.

The North West is already a water-stressed province. Tourism attraction sites requiring the ready availability of water to function successfully, such as the Sun City resort, will be more sensitive to the water availability impacts of climate change.

The Covid-19 pandemic has adversely affected both domestic and international tourism due to travel restrictions and has thus increased the sector's overall vulnerability, including to climate change impacts.

Stakeholder perspectives

The majority of stakeholders viewed the province's tourism as having **high sensitivity** to climate change. Reasons cited included:

- Tourism is fundamental to economic growth.
- North West tourism is primarily wildlife attractions.
- Sensitivity of nature reserve management and establishments are linked to ecosystems which are very sensitive to increased temperatures.
- Job loss as a result of less tourists visiting those areas due to high temperatures and loss of habitat.
- Tourism attraction sites requiring the readily availability of water to function successfully will be more sensitive to the water availability impacts of climate change.
- Areas prone to adverse climatic conditions will more likely not be preferred tourist destinations.
- Poor air quality is making outdoor activity (a big drawcard for tourism) dangerous.
- The province already experienced the effects of climate change.
- Road maintenance and rehabilitation, as well as laying of fibre and pipelines, leave sites treeless and unattractive.

- Carbon taxes on business and individuals are likely to increase, which may impact volumes of travellers locally and internationally.
- Covid-19 and a lack of vaccination.
- Impact by short-term economic drivers, e.g., mining and surface discharges.
- This sector has the ability to adapt to climate change as it is mostly better controlled.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.

d Adaptive Capacity

The Department of Economic Development, Environment, Conservation and Tourism is responsible for tourism and oversees the North West Tourism Board. Tourism industry bodies and associations operating in the North West include the Tourism Business Council of South Africa, which is an umbrella organisation for business in the travel and tourism sector and the Federated Hospitality Association of South Africa, which is an umbrella body for accommodation, conferencing, catering and food and beverage establishments for South Africa.

The tourism industry has a well-established communication and collaboration strategy, which can help support information sharing and development of sector-wide adaptation strategies (NWREAD 2016b). The province's large parks are undertaking measures, such as fire controls and reviewing animal-stocking plans, that benefit biodiversity and ecosystems and thereby build adaptive capacities. There are numerous conservation initiatives in the province, such as 15 reserves under the management of the North West Parks Board and 8 community park forums (NWREAD 2016b). There is increasing conflict between the long-term prospects of nature-based tourism and the shorter-term returns on investment from mining, and this may undermine the sector's adaptive capacity. For example, the Pilanesberg-Madikwe tourism corridor, focused on nature-based tourism, is threatened by mining operations due to their impact on key factors, such as aesthetics, ecosystems, water resources (NWDEDECT 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's tourism as having **medium capacity** to respond to climate change. Reasons cited included:

- Availability of institutions to respond.
- The sector can respond to the consequences of climate change.
- Enclosed areas that can respond to adaptive practice.
- There are numerous conservation initiatives in the province already, therefore, the initiatives must be formalised, and additional forums must be established.
- Medium because of COVID-19 and challenges in terms of tourists.
- Tourism is barely recovering from COVID-19 restrictions on travel.
- Role players in tourism, as in agriculture, have already seen the effects of climate change.
- Expansion and the proper management of nature reserves can take place if properly managed and funded by North West Parks Board.
- Tourism is premised on landscape, biodiversity and wildlife and requires large quantities of water (500 litres/tourist/day). Impacts will be gradual.
- In the Platinum belt, mining is booming (new applications for open-cast mines everyday)

- Threat of converting tourism based natural habitats and scenic landscapes to mining for short-term employment opportunities and economic growth.
- Increases in commercial tunnel agriculture and agri-processing, which is also impacting on natural landscapes.

Summary

The tourism sector is of **Medium Concern** due to the following reasons:

- **Exposure:** The total tourism spend as a percentage of the North West's GDP was 4.1% for 2019. The formal tourism sector in the North West employed over 33,000 people prior to the COVID-19 pandemic (NWDC 2021).
- **Impacts:** Tourism is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature and rainfall patterns have significant effects on the biodiversity and natural attractions
 - Increased temperatures discourage activity-based tourism
 - Changes in temperature and rainfall patterns lead to decreased water availability for tourism.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's tourism as having high sensitivity to climate change. Key sensitivity factors include:
 - Tourism requires water availability for activities
 - Increased temperatures may deter tourists
 - Sensitivity of nature to increased temperatures.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's tourism as having medium adaptive capacity to respond to climate change. In particular, it was noted that while the tourism sector has been significantly impacted by COVID-19, it has some institutional capacity to respond to climate change.

5.3.3 Mining

a Impacts

Climate change has resulted in a significant decrease in the availability of water and energy resources, such that the use of these resources is at times restricted. Most of the mining operations that require large amounts of water are in water-scarce parts of the province, exacerbating the province's water scarcity issue. In the event of heavy rainfall due to climate change, acid mine drainage – when acidic water from metal or coal mines flows into surrounding areas (BSR 2011) – could be worsened.

Climate change will also increase the likelihood of injuries, accidents and fatalities related to rising surface temperatures, especially in open cast mining operations. Labour productivity will likely be reduced.

b Exposure

The North West is one of the four provinces with a large mining industry that contributes significantly to the country's GDP. The main commodities mined in the North West are diamonds

(197 mines), gold (34 mines) and platinum-group metals (27 mines) (DMRE 2017). Platinum and gold mining operations require a considerable amount of water and energy to operate efficiently.

The mining industry plays a significant role in supporting the provincial economy and providing formal employment. According to the Department of Mineral Resources, current mining activities in the North West comprise approximately 479 mining licences for surface mines and 118 mining licences for underground mines, including both operational and non-operational mines (DMRE 2017). In 2019 it was estimated that the mining sector directly contributed 8.3% of national GDP and employed 460,015 people in South Africa (MCSA 2020). In the North West, the mining industry contributes approximately 33.8% to the total industrial gross value added (GVA) (NWDC 2021). The industry accounts for 14.5% of formal employment (122,000 jobs) in the province and 32.7% of national mining employment (NWDC 2021).

There is variation in the percentage GVA contribution and formal employment across the North West's four districts (Table 4). Bojanala Platinum District makes the highest percentage contribution to GVA and formal employment within the region's mining industry, at 54.3% and 27.1% respectively (NWDC 2021). The Ngaka Modiri Molema District makes the lowest percentage contribution to GVA and formal employment of the region's mining industry, at 6.8% and 1.7 % respectively (NWDC 2021).

Table 4: District contributions to GVA and employment

	Percentage contribution to the total industries GVA (MCSA 2020) and (NWDC 2021)	Percentage contribution to formal employment (MCSA 2020) and (NWDC 2021)
Bojanala Platinum	54.3	27.1
Dr Kenneth Kaunda	13.6	3.9
Dr Ruth Segomotsi Mompati	8.3	2.2
Ngaka Modiri Molema	6.8	1.7
North West	33.8	14.5
South Africa	8.3	2.8

c Sensitivity

The types of commodity mined is one of the main factors that make the mining industry of the North West more sensitive to the impacts of changing temperature and rainfall patterns due to climate change. Platinum and gold operations require large amounts of water for exploration, drilling, dust suppression, cooling and extractive metallurgy processes (Ndlovu 2018). The North West is already a water-stressed province, and growth in the mining industry will place further stress on its water resources. The restrictions placed on gold and platinum operations will result in a decrease in their mineral output, and this will reduce their contribution to the province's economy.

Rising temperatures also pose health hazards to employees. They face an increased risk of contracting communicable diseases and exposure to heat-related illnesses. Mine workers diagnosed with silicosis, HIV and active pulmonary tuberculosis will be more sensitive to the health impacts of climate change.

Stakeholder perspectives

The majority of stakeholders viewed the province's mining as having **high sensitivity** to climate change. Reasons cited included:

- Water scarcity.
- Platinum and gold mining operations require large amounts of water for exploration, drilling, dust suppression, cooling and extractive metallurgy processes.
- Low rainfall affects water intensive processes detrimentally. The abrupt rain pattern also dampens raw materials making it expensive to de-water and extract minerals.
- Reliance on water in various mining activities.
- The sensitivity will continue to be high as more underground water is used and there are less rains.
- Water scarcity and usage will increase sensitivity.
- Increased cost of water and power will impact negatively on mining economics and sustainability.
- Need for considerable amounts of water.
- Water can be recycled, and heat/ventilation is controlled.
- The mining industry is already managing the temperature impacts well and it would not be difficult to step up the measures if need be.
- The mining industry is less sensitive to climate change impacts compared to other sectors such as rural environments, waste management etc.. If the impact is drought the mining industry generally has excess water. If it's flooding it is easier for mitigation measures to be put in place.
- Occupational exposure requirements in mining environments for heat or cold stress etc.
- Rising temperatures.
- A lack of emphasis on rehabilitating mined sites leads to dust pollution and loss of topsoil and ability of the ecosystem to sequester carbon. Poor recycling leads to excessive waste going to landfill.
- Unrehabilitated mining sites are one of the factors that increase the sensitivity of this sector.
- Effect of heavy rains and floods.
- Increased extreme weather is likely to create significant operational challenges to the mining industry.
- Mining sector needs to do self-reflection on its own effect on climate change.
- Migrant mine workers often live in shockingly poor conditions because they prefer to send their earnings home, or their families live in terrible conditions. These communities will be very vulnerable to climate change unless these mining houses are held responsible. The smaller mining houses need to be regulated here.
- The majority of companies in this sector are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security. Vulnerable communities in rural areas are most affected. Mining is an energy and water-dependent economic sector, mostly inundated by low-income and high unemployment levels in the surrounding communities.

d Adaptive Capacity

Mining operations vary considerably in size, capacities and resources and thus have varying adaptive capacities. Mining operations in the North West have a low adaptive capacity to temperature-related impacts of climate change. Ventilation and heat insulation technologies that are used to decrease high-temperature conditions are expensive. These technologies make use of electricity and water, which are resources that are already gravely affected by climate change.

The National Department of Minerals and Energy represents mining. Mining is a significant economic activity in the province and South Africa which creates considerable employment and profit. Mining companies can potentially draw on their considerable financial resources to adapt to climate change impacts and challenges. The numerous industry bodies can also support access to information, knowledge and help capacity building of mining operations to address climate change challenges. Examples include:

- Mining Industry Association of Southern Africa
- Minerals Council South Africa
- Southern African Institute of Mining and Metallurgy
- The Association of Mine Managers
- The Council for Geoscience
- The Geological Society of South Africa
- The Mine Health and Safety Council
- The Mining Qualifications Authority
- Occupational Health in the South African Mining Industry

Stakeholder perspectives

The majority of stakeholders viewed the province's mining as having **medium to high capacity** to respond to climate change. Reasons cited included:

- The big mining houses and their sustainability teams have been working on climate change strategies for some time now.
- Mining companies are increasingly adapting their mining methods and technologies to address climate change and have the institutional capacity to adapt.
- It depends on the size and type of the mining operation and financial capacity. Companies with high financial turn-over will be able to adapt better than smaller ones, for example turning to mining technologies that use less water.
- The mining sector is well established and has the resources to respond to any impacts likely to be experienced.
- Adequate resource capacity (skills, knowledge, expertise, financial) and investment/sustainability performance reporting KPIs and initiatives.
- Platinum group metals are doing well so technological solutions will be implemented.
- Profitability of sector.
- Private ownership of mines
- Technologies used in the mines.
- Mining sector may not be serious about its effect on the climate and is more concerned with the bottom line.

- Green technologies will impact adversely on the profits of the mining industry as they are expensive.
- Poor climate change policy and adaptation in the mining industry.
- Lack of infrastructure such as roads can lead to lack of response.
- Mining sector is one of the major polluters and has a significant impact on the environment.
- The North West is already a water-stressed province, and growth in the mining industry will place further stress on its water resources.
- Air quality offsets projects afford the mines to expand capital projects for greening the surrounding communities and reduce dust emissions and air pollution by budgeting for 'cleaner' processes.
- The mining sector has created an environment which is conducive to high influx of unskilled labourers. This leads to a large range of social ills including unemployment, teenage pregnancies, crime and gangsterism. This leads to a variety of factors which impact on the environment.

Summary

The mining sector is of **Medium Concern** due to the following reasons:

- **Exposure:** The North West has a large mining industry. The main commodities mined in the North West are diamonds, gold and platinum-group metals. The mining industry contributes approximately 33.8% to the total industrial GVA of the province and 14.5% of formal employment (NWDC 2021).
- **Impacts:** Mining is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in temperature and rainfall patterns affect water availability for mining operations
 - Increases in temperature lead to increases in the number of very hot days and disrupts mining operations because of poor working conditions.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's mining sector as having high sensitivity to climate change. Key sensitivity factors include reliance on water supply for operations and the impact of extreme weather events.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's mining as having medium adaptive capacity to respond to climate change. In particular, it was noted that the technological and financial resources are available to respond to climate change impacts.

5.4 Infrastructure and Utilities

5.4.1 Water Supply

a Impacts

More frequent flooding and drought events are projected under all future climate scenarios considered by the Long-Term Adaptation Scenarios Flagship Research Programme (Ziervogel et al. 2014). As an already water-stressed province, water resources in the North West will thus be increasingly impacted by climate change (Edokpayi et al. 2020). As with many other provinces, the North West has faced persistent droughts in recent years, with particularly severe drought conditions experienced in 2014/15, and into the summer of 2015/16 (NWDEDECT 2018).

Various hazards associated with climate change can negatively affect the water sector in the North West with the following impacts:

- Increases in rainfall variability, average temperatures, and the frequency and severity of droughts will likely reduce surface water runoff in the North West and may cause changes in run-off patterns (and the timing of seasonal high and low water flows).
- Increases in average temperature are likely to increase evaporation rates in the North West, which can reduce water levels in dams, rivers, streams, and wetlands (Ziervogel et al. 2014; Botai et al. 2016).
- Increases in average temperatures, rainfall variability and in the frequency and severity of flood events may decrease water quality and increase water pollution due to erosion, runoff from rainfall events, and greater frequency and severity of algal blooms (NWREAD 2016b; Edokpayi et al. 2020).
- Increases in the frequency and severity of extreme weather events, such as intense storms and flooding, may also impact water infrastructure (NWREAD 2016b).

b Exposure

Freshwater resources are classified into three sources: surface water, return flow and groundwater. For surface water, important river systems in the North West and on its boundaries include the Crocodile West, Groot Marico, and Vaal River systems (NWDEDECT 2018). Water from these river systems is used for agriculture (including irrigation), domestic, mining, and industrial purposes (NWDEDECT 2018). The Crocodile West and Vaal River systems receive water from Gauteng in the form of stormwater and the outputs of Gauteng's wastewater treatment works (NWDEDECT 2018). Reduced water levels and periods of seasonal low stream flows typically occur during the "dry season" (NWDEDECT 2018; NWREAD 2016b).

Groundwater in the North West is used for agricultural irrigation and is also the main source of water for a number of settlements in the province (NWDEDECT 2018). Groundwater flowing to the surface as springs or "eyes" is also the source of several rivers in the North West, e.g. the Groot Marico, Mooi and Molopo rivers (NWREAD 2016b).

c Sensitivity

In the North West, potable water is lost to leaks as a result of old infrastructure, a lack of maintenance, insufficient operational capacities and management (NWREAD 2016b). Surface water and groundwater are negatively affected by agricultural runoff, mining effluent, failing wastewater treatment works and pollution. (NWREAD 2016b; NWDEDECT 2018). Water supply is also sensitive to the disruption of water infrastructure by climate change related extreme weather events (NWREAD 2016b). Water quality is affected by warmer temperatures (such as a decline in biochemical oxygen demand [BoD] or a slight decrease in pH levels) (NWREAD 2016b).

Water quality in the North West is severely negatively affected by poorly treated effluent from wastewater treatment works in the North West and Gauteng, acid mine drainage, over abstraction of water and land degradation (NWDEDECT 2018). The most recent report on wastewater treatment works in South Africa (the *2014 Green Drop Report*), found that in the 2012/2013 municipal financial year, 23 of the wastewater treatment works in the North West were reported to be at critical risk and a further seven were at high risk, the two lowest classifications (DWS 2016). These water quality issues make the ecological condition of rivers and wetlands worse, they

reduce ecosystem goods and services, they directly and indirectly affect human health, and they increase sensitivity to the effects of climate change (NWREAD 2016b; NWDEDECT 2018; Kretzmann et al. 2021). The severity of and full implications of this remain hidden as there is a lack of up-to-date, credible data on the operations of waste water treatment works (WWTWs) and water treatment works in South Africa (Kretzmann et al. 2021).

The distribution of households by source of water in 2016 in the North West is set out in Table 5 (Statistics SA 2018).

Table 5: Breakdown of households in the North West Province by main water source in 2016 (Statistics SA 2018)

Water Source	Bojanala	Ngaka Modiri Molema	Dr Ruth Segomotsi Mompoti	Dr Kenneth Kaunda	North West
Borehole in the yard	77,318	56,894	22,370	9,518	166,100
Borehole outside the yard	56,326	22,052	8,579	8,517	95,473
Flowing water/stream/river	3,787	1,751	376	365	6,279
Neighbours tap	87,128	71,419	9,195	3,745	171,488
Other	32,317	10,680	1,386	4,045	48,428
Piped (tap) water inside the dwelling/house	328,582	153,445	63,815	333,008	878,850
Piped (tap) water inside yard	755,411	266,372	118,505	348,552	1,488,841
Piped water on community stand	97,821	132,297	117,893	9,208	357,220
Public/communal tap	114,486	105,610	88,398	23,586	332,080
Rain-water tank in yard	10,061	2,222	278	27	12,587
Spring	234	254	205	304	996
Water-carrier/tanker	91,812	65,684	28,121	1,946	187,563
Well	1,864	431	236	0	2,531
Total	1,657,147	889,111	459,357	742,821	3,748,436

The North West's mining and agriculture sectors consume large amounts of water, and many communities also rely on groundwater for consumption and irrigation (NWREAD 2016b). The adverse effects of acid mine drainage have been recorded in the province and the Vaal and Crocodile River systems of South Africa are among the major national water sources affected by acid mine drainage. To date, attempts at reducing acid mine drainage have had limited impact (Edokpayi et al. 2020). These issues all increase the sensitivity of the water supply sector in the North West to the projected impacts of climate change.

In several parts of the North West, including the Tosca Dolomitic Aquifers and the Vryburg, Delareyville and Schweizer-Reneke areas, where dolomitic aquifers occur, groundwater has and is being used at an unsustainable rate (NWDEDECT 2018). This over-extraction reduces water security in these areas, especially, in times of drought, and makes such areas more sensitive to climate change (NWDEDECT 2018). Furthermore, the over-extraction of groundwater negatively affects some surface water flows in the province as groundwater is the source of several rivers in the North West (NWREAD 2016b).

The sensitivity of the water sector in the North West to the projected impacts of climate change is being increased further through unsustainable rates of water use, the poor state of wastewater treatment works, aged water infrastructure, agricultural runoff, mining effluent, invasive alien species, land degradation (including poor land-use management and land-use change), and pollution.

Stakeholder perspectives

The majority of stakeholders viewed the province's water supply as having **high sensitivity** to climate change. Reasons cited included:

- Drought.
- Higher temperatures which will reduce water levels.
- Western portion of South Africa will be a hot spot if temperature increases and will also be one of a few areas of the world that is likely to become dryer.
- If water resources (dams etc.) dry up and there is no water, you can have the best infrastructure in the world, but you cannot make water if it does not exist.
- Over abstraction.
- Irrigation.
- Overgrazing.
- Land degradation.
- High temperatures.
- Effects of agricultural runoff.
- Effect of mining effluent and acid mine drainage.
- Chronic pollution.
- Overuse of groundwater, the usage of water in the mining sector and contaminated water resources due to pollution (untreated sewage and solid waste).
- Poor water quality and incremental surface water discharges that lead to the increased manifestation of invasive species (e.g. water hyacinth in Hartbeespoort dam) due to poor local development control/management, ineffective regulation enforcement and poor water quality create susceptibility/instability of the existing economic and social infrastructure around these river systems to sustain proper resource management and efficiency.
- The spread of invasive alien species.
- Lack of management in water sector.
- Poor management at local government level.
- Municipal infrastructure in Madibeng, Rustenburg and Koster failing, resulting in sewage flowing into rivers.
- Poorly managed wastewater treatment plants.
- Inability to improve and manage water infrastructure.
- Lack of skills to manage water resources.
- No plans or lack of implementation of available plans.
- Lack of data available in the water sector.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.

d Adaptive Capacity

The North West has a relatively well-established water supply system consisting of dams, reservoirs, pipelines, and water treatment works (NWDEDECT 2018). Yet, existing water resources are often poorly managed, with many households still lacking access to clean water. The adaptive capacity of the water sector is undermined by unsustainable rates of water use, poorly managed and maintained wastewater treatment works, aged water infrastructure, leaks, agricultural runoff, mining effluent, acid mine drainage, invasive alien species, land degradation (including poor land-use management and land-use change), and pollution.

Various initiatives are underway in the province that could support adaptive capacity. These include water conservation and water demand management, water restrictions, water awareness-raising programmes, rainwater harvesting and invasive alien species removal programmes like the Working for Water programme (NWREAD 2016b). Additional programmes include the Working for Wetlands programme (with approximately 50 interventions implemented in the North West annually), dam remediation programmes and the Municipal Asset Maintenance Programme to decrease water loss. These maintenance programmes, however, require additional funding and roll-out (NWREAD 2016b).

The effective implementation of water policy and plans will help support adaptive capacity of the water supply sector in the long term. This includes the implementation of water management plans such as the initiatives outlined in the second National Water Resources Strategy (NWREAD 2016b; DWA 2013).

Water supply will also be enhanced through the R1,2 billion Pilanesberg scheme expected to provide an additional 100 million litres of water per day for the benefit of municipalities and mines (DWA 2013). The National Department of Water and Sanitation, in conjunction with the National Treasury, has a Water Services Infrastructure Grant that municipalities may access to assist them in the provision of basic water and sanitation facilities to municipalities that do not have access to basic water services.

Stakeholder perspectives

The majority of stakeholders viewed the province's water supply as having **low capacity** to respond to climate change. Reasons cited included:

- Many sectors, if not all, require the use of water, so it's very critical that this resource be properly managed and protected, and climate change will exacerbate water problems that we currently have in the province. There is a need to use water sparingly.
- Being a water scarce province.
- The province being already under significant stress.
- There are already water shortages throughout the North West province, especially at schools. Even the suburbs of Rustenburg, the mining capital, often have water interruptions which have increased in the last 10 years. Schools around Sunrise View complain that the water tastes strange and causes diarrhoea.
- Climate change affects rainfall adversely, South Africa depends on annual rainfall for human and animal freshwater needs.
- Unsustainable rates of water usage.

- Agriculture contributing to over-abstraction.
- Insufficient alien invasive removal programmes.
- No to little monitoring and management of groundwater resources are taking place e.g., municipalities using boreholes to extract water for municipal use are not monitored nor maintained.
- Water management for increased extreme weather is poor in the country and in the province.
- Most of these factors are under the management of government or semi government spheres and implementation is therefore difficult.
- Poor management of water in the province.
- Lack of groundwater management in many municipalities which are utilising groundwater for rural water supply.
- Lack of critical technical skills in the municipalities to operate and manage the water infrastructure.
- Lack of transfer of institutional knowledge and background.
- Financial constraints to kick-start new projects to ensure adequate and constant water supply from dams/reservoirs.
- Corruption.
- Lack of political will.
- Lack of rain.
- Incompetence.
- Aging infrastructure.
- Poor water treatment.
- A lack of water awareness campaigns and programmes.
- Pollution of rivers by mining activities and effluent from wastewater treatment works.
- There is adequate regional economic viability to balance and improve the high economic and social development needs around these river systems.
- A lack of infrastructure that is designed to cope with extreme weather to ensure harvesting of water resources during extreme rainfall to compensate for extreme droughts.
- Most of these factors are under the management of government or semi government spheres and implementation is therefore difficult.

Summary

The water supply sector is of **High Concern** due to the following reasons:

- **Exposure:** Important River systems in the North West include the Crocodile West, Groot Marico, and Vaal River systems. Water from these river systems is used for agriculture (including irrigation), domestic, mining, and industrial purposes (NWDEDECT 2018).
- **Impacts:** Water supply is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Changes in rainfall patterns result in changes in spatial/geographic distribution of water
 - Increasing temperatures and rainfall variability reduces water availability and results in many households experiencing a high degree of water stress

- Warmer temperatures result in changes in water quality such as a decline in biochemical oxygen demand (BoD) or slight decreases in pH levels, salinisation and sedimentation
- Disruption of water infrastructure by climate change-related extreme weather events
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's water supply as having high sensitivity to climate change. Key sensitivity factors include:
 - North West is a water scarce province
 - Increased temperatures reduce water quality and quantity
- **Adaptive Capacity:** The majority of stakeholders viewed the province's water supply as having low adaptive capacity to respond to climate change. In particular, it was noted that the North West is a water scarce province and there is poor management of water resources in the province.

5.4.2 Energy Supply

a Impacts

Climate change impacts the energy sector in a number of ways:

- The energy sector is closely linked to temperature and predicted increases in temperature and severe heat waves will directly impact energy demand with an increased requirement for cooling, such as the use of air conditioning.
- Drought can have a significant impact on coal-powered energy production, which is water intensive.
- Increased storms and flash floods will impact energy supply infrastructure.
- Economic growth, combined with increased temperatures and severe heat waves, will lead to a growing demand for electricity in the North West and at the same time, reduced water supply and stress on water resources will impact energy production, particularly water-intensive coal power (NWREAD 2016a).

b Exposure

The North West province uses an estimated 12% of South Africa's available electricity and is the fourth largest electricity consumer in the country (NWDEDECT 2018). Over 85% of South Africa's energy requirements in urban and peri-urban areas are fulfilled by coal-powered electricity, supplied by Eskom (Akinbami, Oke, and Bodunrin 2021; Pollet, Staffell, and Adamson 2015). In rural areas, where the majority of the province's population resides, households mainly use wood, paraffin and charcoal for cooking and paraffin and candles for lighting. The number of households with access to electricity in the province has increased in recent years from 73% in 2011 to 81% in 2016 (NWDEDECT 2018). Energy supply infrastructure is also exposed to damage from extreme weather events and disasters (NWREAD 2016a).

The distribution of households with or without access to electricity in 2016 in the North West is set out in Table 6 (Statistics SA 2018).

Table 6: Breakdown of households in the North West Province by main source of electricity in 2016 (Statistics SA 2018)

Electricity Source	Bojanala	Ngaka Modiri Molema	Dr Ruth Segomotsi Mompati	Dr Kenneth Kaunda	North West
Battery	243	92	86	35	455
Connected to other source which household is not paying for	5,903	965	447	2,180	9,495
Connected to other source which household pays for	28,530	6,078	3,802	10,017	48,427
Generator	1,080	390	160	401	2,031
In-house conventional meter	122,954	48,980	40,719	112,480	325,133
In-house prepaid meter	1,363,691	767,400	372,520	576,544	3,080,156
No access to electricity	126,079	62,546	36,204	38,014	262,842
Other	7,095	2,340	4,495	2,946	16,875
Solar home system	1,574	318	926	203	3,020
Total	1,657,149	889,109	459,359	742,820	3,748,434

c Sensitivity

The energy sector is sensitive to the predicted impacts of climate change, particularly disruption from climate change-related extreme weather events, such as intense storms and wildfires, which impact on energy supply infrastructure (NWREAD 2016a).

South Africa's majority coal-powered energy production is water intensive, as are nuclear power plants where water is used for cooling. Effects that indicate the climate sensitivity of the water supply include changes in water availability for cooling in power plants, which will negatively impact the efficiency of power production, with more cooling required in extremely warm temperatures.

Stakeholder perspectives

The majority of stakeholders viewed the province's energy as having **high sensitivity** to climate change. Reasons cited included:

- Higher temperatures demand more energy for cooling purposes.
- Being sensitive to excessive heat and cold weather as it adds pressure on the grid as people use more electricity to get relief from severe conditions.
- Being dependent on extracting and using fresh water to produce energy, with less available water.
- Being a water scarce province.
- Reliance on water.
- Lack of management.
- Eskom infrastructure not being maintained.
- There is no consequence management taking place due to non-compliance.
- Poor infrastructure and maintenance.
- Being dependent on mining.
- Being dependent on extracting fossil fuel.
- Mining will threaten habitats and ecosystems.
- Gradual movement away to cleaner energy sources, process picking up pace.

- The province not having yet moved into at least 60% renewable energy resource to lessen the reliance on Eskom which uses coal to produce electricity.
- Coal is not a finite resource and it's polluting the atmosphere.
- Coal-electricity energy driver and domestic heating dependency is a high greenhouse gas and carbon dioxide (CO²) emission driver.
- Energy supply shortages and interruptions impact on business sustainability.

d Adaptive Capacity

At the national and provincial levels there is an increasing focus on the diversification of energy production away from predominantly coal to growing the supply of energy from renewables (Akinbami, Oke, and Bodunrin 2021). This will have considerable adaptation and mitigation benefits in the North West. Less water-intensive renewable energy production will reduce pressure on water resources and help to support adaptation in the water sector. A renewable energy strategy has been developed for the province which aims to improve the environment and alleviate energy poverty (NWDEDECT 2012).

Numerous renewable energy supply options have also been proposed and developed for the province (NWDEDECT 2012) and the North West has considerable solar power potential. Until recently, the province had only one solar PV project, the RustMo1 Solar Farm, located in Buffelspoort, Rustenburg. This 7-MW peak-plant started energy production in 2013. However, five new solar PV projects were approved under the Renewable Energy Independent Power Producer Procurement Programme and the province now has a total of five utility-scale plants (Table 7). These are South African owned and provide power to the national grid and provide benefits to surrounding local communities through local economic development programmes (Darrol 2021; Akinbami, Oke, and Bodunrin 2021).

Table 7: Solar PV projects in the North West

Solar PV Project Name and Location	Capacity
RustMo1, Rustenburg Local Municipality	7 MW
De Wildt Solar, Brits, Madibeng Local Municipality	50 MW
Bokamoso Solar, Maquassi Hills Local Municipality	67.9 MW
Zeerust Solar Power Station, Zeerust, Ramotshere Moiloa Local Municipality	75 MW
Waterloo Solar Park, Vryburg, Naledi Local Municipality	75 MW

Despite considerable investment in solar energy, coal remains the main source of energy for the North West and the rest of South Africa (Akinbami, Oke, and Bodunrin 2021).

Stakeholder perspectives

The majority of stakeholders viewed the province's energy as having **medium to high capacity** to respond to climate change. Reasons cited included:

- Additional energy requirements (power stations etc.) will need water – the North West is a water scarce province.
- Energy supply to the province is almost exclusively from outside the province.
- Financial constraints can prevent capacity to respond.

- Growing population and new settlements cause the lack of response.
- Inadequate clean energy development projects and mechanisms support high capital expenditure of these projects coupled with complicated regulatory framework to enable alternative energy production.
- Solar installation is still moving slowly without sufficient subsidisation.
- Independent power producers provide much potential to use solar energy.
- Increased solar energy options are available.
- Decrease in regulation of the energy sector will easily overcome this problem.
- Energy is the biggest carbon emitter and the worst CO₂ emitter in SA.
- The reliance of coal to produce energy thus contributes to increased levels of greenhouse gas emissions.
- Eskom is totally non-compliant with the Veld and Forest Fire Act No 101 of 1998. Their lines are not properly maintained and cause major fires in all parts of the province.
- Fossil fuel-based energy needs to be eliminated.

Summary

The energy supply sector is of **Medium Concern** due to the following reasons:

- **Exposure:** The North West uses an estimated 12% of South Africa's available electricity. The number of households with access to electricity in the province increased from 73% in 2011 to 81% in 2016 (NWDEDECT 2018).
- **Impacts:** Energy supply is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Disruptions in energy supply as a result of damage to energy supply infrastructure during climate change-related extreme weather events
 - Increase in demand for air conditioning in warmer temperatures
 - Changes in water availability for cooling in power plants
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's energy supply as having high sensitivity to climate change. Key sensitivity factors include:
 - Reliance on water supply for activities
 - Reliance of fossil fuels for energy generation
 - Poor infrastructure and maintenance.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's energy supply as having a medium to high adaptive capacity to respond to climate change. In particular, it was noted that while fossil fuels are still being used in electricity generation, there is a slow movement toward clean energy production.

5.4.3 Transportation

a Impacts

The transport sector fulfils critical social and economic functions in society. Key sectors such as agriculture are highly dependent on a well-functioning transport sector and road network (Eisenack et al. 2012; IDB 2020). Many transport services are strongly influenced by weather conditions, and transport interruptions, such as those caused by severe weather events, can incur high social and economic costs.

Higher temperatures combined with greater diurnal range (the difference between day and night temperatures) and more intense rainfall, flooding and hail events are likely to increase the rate of depreciation of transport networks, vehicles and infrastructure (including roads, bridges, highways and stormwater drainage) across the province (NWREAD 2016a; Moretti and Loprencipe 2018; IDB 2020).

Roads and infrastructure are also vulnerable to the impact of wildfires which are predicted to increase across the province.

Climate change impacts, such as increased rainfall and extreme storm events, will increase the overall annual cost of the transportation system and the costs to its users. The increased annual cost of climate impacts to South Africa's national road network is predicted to be as high as USD 96 million in 2030, USD 229 million in 2050, and USD 390 million in 2090, under no adaptation scenarios (IDB 2020).

b Exposure

The North West's road network is relatively well developed with key highways and an increasing number of paved roads. As a largely rural province, much of the road network remains unpaved. The North West's road network consists of a total of 5,088 km paved roads and 14,655 km unpaved roads, totalling a road network of approximately 19,743 km (PMG 2016). Bojanala District has the largest paved network of 1,787 km, while Dr Ruth Segomotsi Mompati District has the largest unpaved network consisting of approximately 6,364 km (PMG 2016).

Approximately 76% of the country's total freight tonnage is transported by road, with the remainder transported predominantly by rail. However, the past two decades have seen a steady decrease in rail's contribution to freight transport (IDB 2020). Export produce relies on sea freight that is serviced by road, and this is of particular importance for the North West which produces agriculture for local, national, and international markets.

c Sensitivity

Adequate and reliable road networks are central to building adaptive capacity, particularly for isolated rural communities. When road networks are disrupted, access to hospitals, schools and employment opportunities are directly affected. The transport sector's infrastructure, operations and demand are all sensitive to climate change impacts. Transport systems are increasingly sensitive to climate impacts and disasters since adaptation has not yet been adequately mainstreamed into the current design and construction of roads, bridges and storm-water systems (Le Roux 2021).

Most road construction does not account for changes over time in weather and climate conditions, with designs often based on weather patterns from the mid-20th century and the assumption of an unchanging climate (IDB 2020). This increases the sensitivity of road systems to predicted changes in localised temperatures, precipitation and run-off in warmer global climates. Drainage manuals still often refer to historical rainfall data for development, without adequately considering future climate change impacts on flood and run-off calculations (Le Roux 2021).

Heat waves and higher temperatures increase the sensitivity of transportation infrastructure such as bridges through the thermal expansion of paved surfaces and joints, more rapid deterioration of materials (e.g., protective cladding) as well as the buckling of rail systems and cracking of roads

causing potholes. Excessive rain events also contribute to potholes, with damage further exacerbated if repairs are not timeous, contributing to the maintenance costs of the road network. The Long-Term Adaptation Scenarios project identified the North West as the second-most at-risk province for flood-related damage to bridges and dams due to increased floods from climate change (NWREAD 2016b).

The North West's extensive dirt roads are particularly sensitive to erosion and landslides during high rainfall events and flooding (NWREAD 2016b). Wide-scale investments are required in the province and nationally to improve conditions of deteriorating transport and road infrastructure to withstand the impacts of climate change (IDB 2020).

Stakeholder perspectives

The majority of stakeholders viewed the province's transportation as having **high sensitivity** to climate change. Reasons cited included:

- Severe climate change effects like storms and heat that can damage transport infrastructure severely.
- Rural ecosystem services are sensitive to poor water infrastructure and poor roads infrastructure.
- Will lead to increased CO² over the long term.
- Depends on local municipalities doing maintenance.
- Depends on local municipalities working for water being monitored after alien invasive plant clearing is done.
- Poor infrastructure.
- Poorly constructed roads with poor quality materials used for construction.
- Poor maintenance of roads.
- Limited capacity
- Changes can still be made to adapt transport infrastructure to climate change.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security. Vulnerable communities in rural areas are most affected.

d Adaptive Capacity

Transport systems and infrastructure are central to urban and rural functions for everyday and emergency conditions, and thus need to be adaptive to the increasing disasters and hazards in the context of climate change (Moretti and Loprencipe 2018).

Despite strong evidence that proactive adaptation measures, such as changes to design and materials, have considerable cost-savings in the long run (such as decreased maintenance and more robust infrastructure linked to less economic and social disruption), there are considerable financing challenges for pre-emptive adaptation from the local to the national scale, particularly due to the high cost of road construction and maintenance and pressing immediate development demands (IDB 2020).

Despite the constraints, a number of upgrade projects are underway in the province and increasing investment is forthcoming for transport infrastructure, as envisaged in South Africa's Infrastructure Investment Plan (that is currently being developed) (DPWI 2020; PMG 2020) and the Rural Roads Upgrade Programme (NWREAD 2016a). For example, two routine road maintenance projects recently commissioned, and valued at R116 million, for Naledi Local Municipality will not only support climate adaptation but will also have co-benefits by creating economic opportunities and livelihood diversification for the next three years (SANRAL 2020). Infrastructure development has been identified as an important catalyst for revitalising the South African economy post Covid-19, with the transport sector allocated considerable investment and projects under South Africa's Infrastructure Investment Plan (that is currently being developed) (DPWI 2020; PMG 2020).

Stakeholder perspectives

The majority of stakeholders viewed the province's transportation as having **medium capacity** to respond to climate change. Reasons cited included:

- Transport sector is adaptable and various means of transport are available.
- Little to no rail transport that can take pressure off the road network leading to increased road transport (trucks, taxis etc.) for the foreseeable future.
- New technologies are available.
- Electric vehicles are not an option due to cost and large distances.
- The province and the country at large are lacking the necessary infrastructure.
- Lack of funding.
- Lack of capacity.
- In the previous rainy season, stormwater drains that had been unmaintained in numerous parts of the North West caused flooding.
- Lack of implementation.
- Road construction is expensive.
- Adequate national transport and stormwater in urban development. However, most parts of the rural area's ecosystem services are affected by inadequate rural infrastructure and transportation of goods and services.
- The Department of Public Works, SANRAL, Transnet, and the Airports Company South Africa, being non-compliant with the Veld and Forest Fire Act 101 of 1998.
- Control of alien invasive plants needs to be attended to.
- Water scarcity for building roads.
- Water scarcity for materials.
- Effect of heat stress on infrastructure.
- Moving forward we need to construct roads/bridges that will be able to withstand extreme weather conditions because times have changed, we are already experiencing climate change.

Summary

The transportation sector is of **High Concern** due to the following reasons:

- **Exposure:** The North West's road network is relatively well developed with key highways and an increasing number of paved roads. As a largely rural province, much of the road network remains unpaved.
- **Impacts:** Transportation is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Increases in heavy rainfall can cause erosion of dirt roads and landslides causing road blockages
 - Roads and bridges buckling and cracking in warmer temperatures
 - Disruption of transportation infrastructure by climate change-related extreme weather events.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's transportation as having high sensitivity to climate change. Key sensitivity factors include:
 - Poor quality of existing infrastructure
 - Effects of disaster events on transport infrastructure.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's transportation as having medium adaptive capacity to respond to climate change. In particular, it was noted that there was little consideration of climate change effects in the design and construction, and poor maintenance of infrastructure.

5.4.4 Waste Management

a Impacts

Climate change impacts can potentially affect waste management processes and sites in a number of ways including:

- Disruption and damage to on-site building facilities such as weighbridges and leachate collection systems due to flooding and extreme storm events.
- Increased flooding from surface water, groundwater and drainage can lead to disruption of supporting infrastructure such as road and rail.
- Increased temperature could affect landfill degradation rates as well as leachate production and composition.
- Slope instability and subsidence risk due to drying out of soils followed by rapid wetting resulting from heavy rainfall events.

The extent to which these potential impacts affect waste management sites and processes is dependent on site-specific issues (Environment Agency UK 2003; Ackerman 2000; DEA 2018b; NWDEDECT 2018).

b Exposure

There are 68 waste disposal sites in the North West (as of July 2021), 53 of which are municipal owned, while the other 15 are privately owned (Moselakgomo 2021). Of the 53 municipal waste disposal sites in the province, 25 are operational (22 are licensed, 2 are in the process of being licensed, and 1 was refused a license based on a Section 24G decision) and 28 have been earmarked for closure (15 waste disposal sites are closed and 13 are operating towards closure) (Moselakgomo

2021). Of the 15 privately owned waste disposal sites, 5 are operational and 10 have been earmarked for closure or are closed (Moselakgomo 2021).

There are 23 transfer stations and 8 buy-back centres for supporting recycling and recovery processes in the province, and 10 treatment facilities, 7 of which use thermal treatment for the disposal of health care risk waste and 3 are composting facilities for organic waste (DEA 2018a).

The province has 178 licensed waste management activities and various methods of refuse removal (Table 8) (DEA 2018a; Statistics SA 2018). The majority (87%) of urban households have their waste collected by local authorities or private companies, while only 6% dispose of their waste at their own or communal dump site (DEA 2018a). In rural areas, the majority of households dump their waste at their own waste site or at a communal waste site, while 33% have their waste collected by local authorities or private company (DEA 2018a).

Table 8: Breakdown of households in the North West Province by method of refuse removal in 2016 (Statistics SA 2018)

Method of Refuse Removal	Bojanala	Ngaka Modiri Molema	Dr Ruth Segomotsi Mompati	Dr Kenneth Kaunda	North West
Communal container/central collection point	22,473	2,536	1,107	10,013	36,129
Communal refuse dump	46,900	32,252	8,944	19,533	107,629
Dump or leave rubbish anywhere (no rubbish disposal)	52,723	28,340	18,935	19,968	119,965
Other	22,916	12,156	3,890	9,312	48,273
Own refuse dump	449,049	483,230	263,072	69,641	1,264,993
Removed by local authority/private company/community members at least once a week	987,716	314,649	156,452	602,554	2,061,371
Removed by local authority/private company/community members less often than once a week	75,371	15,946	6,957	11,801	110,075
Total	1,657,148	889,109	459,357	742,822	3,748,435

c Sensitivity

Despite increasing legislative requirements, most municipal plans do not address all the relevant waste management impacts and issues, with some municipalities having unrealistic objectives, while others have not been formally approved and adopted, or not included in Integrated Development Plans (NWDEDECT 2018).

Out of 68 waste disposal sites in the North West, 38 have been identified for closure or are closed due to being unsuitably located, detrimental to the environment or near their end of life (DEA 2018a). The high number of waste disposal sites in the North West that have been identified for closure or are closed poses a significant challenge for adaptation in the waste management sector (DEA 2018a). The predominant practice of relying on landfills for disposing of solid waste is unsustainable, both ecologically and financially, and challenges are intensified under climate change. Landfill sites occupy large land areas due to their direct footprint combined with pollution

buffer areas. Their operational lifespan is often less than 50 years and despite rehabilitation, the land is often left sterile and bare (NWDEDECT, 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's waste management as having **medium to high sensitivity** to climate change. Reasons cited included:

- Need to improve waste services and infrastructure development for waste recycling and disposal facilities.
- Lack of funding.
- Lack of capacity.
- Capacity constraints, both human and financial.
- Lack of planning.
- Even with available plans there's lack of capacity to implement them.
- Shortages of fleets.
- Increased population.
- No waste minimisation education being done at schools or in the local press.
- Increased pollution of strategic resources such as water.
- Waste can increase pollution and damage health and the environment causing a vicious circle.
- Government Departments, Eskom, Transnet, SANRAL, SOEs, Municipalities, Corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998.
- Non-compliance with waste-related legislation.
- Non-compliance of landfill sites increases the sensitivity of this sector.
- The predominant practice of relying on landfills for disposing of solid waste is unsustainable, both ecologically and financially.

d Adaptive Capacity

The increase in waste management legislation over the past decade can help support the sector's adaptive capacity:

- The National Environmental Management Act: Waste Act (Act 59 of 2008), as amended, regulates waste management to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation, and for securing ecologically sustainable development.
- The National Waste Management Strategy, 2020 (NWMS) (DEFF 2021) was published in early 2021 and is a legislative requirement of the Waste Act. The purpose of this strategy is to give effect to meeting the objectives outlined in the Waste Act. The principal aim of the National Waste Management Strategy is to reduce environmental impacts associated with poor waste management. The strategy utilises the following three pillars: waste minimisation; effective and sustainable waste services; compliance, enforcement and awareness (DEFF 2021).
- The 2016 North West Province Integrated Waste Management Plan is in place and has eight principal goals:

Goal 1: Institutional and planning matters, Goal 2: Minimum service standards, Goal 3: Minimisation, re-use, recycling and recovery of waste, Goal 4: Landfill management, Goal 5: Waste Information system, Goal 6: Rural waste management, Goal 7: Education and awareness, Goal 8: Monitoring compliance, enforcement, and remediation.

The North West Provincial Government has developed a Rural Waste Management Strategy to address service delivery in rural areas and overcome challenges presented by the province's dispersed spatial distribution (NWDEDECT, 2018). The North West Department of Economic Development, Environment, Conservation and Tourism has initiated various stakeholder engagement platforms to support partnerships with external stakeholders, including the commercial agricultural sector, agri-business and environmental sectors, focussing on issues of implementation of the sector priorities and resolutions (NWDEDECT, 2018). There are several capacity-building and awareness-raising programmes underway that can help support adaptive capacity. For example, waste minimisation and disposal awareness programmes and training are being undertaken in schools, higher learning education facilities and communities (DEA 2018a).

Stakeholder perspectives

The majority of stakeholders viewed the province's waste management as having **low capacity** to respond to climate change. Reasons cited included:

- Lack of knowledge.
- Lack of skills and planning tools.
- Landfill sites being insufficient.
- Existing landfill sites being poorly managed.
- Many municipalities are under administration resulting in poor management of the waste sector.
- Most of these factors are under the management of government or semi government spheres and implementation is therefore difficult. Government should create a conducive environment for the private sector to implement.
- It is important that waste must be managed properly to reduce environmental impacts and emissions. There is a need to have plans or strategies to reduce, reuse and recycle waste.
- This sector is a disaster as it adversely affects many sectors.
- A lack of will to implement available plans. It is important that waste must be managed properly to reduce environmental impacts and emissions. There is a need to have plans or strategies to reduce, reuse and recycle waste.

Summary

The waste management sector is of **High Concern** due to the following reasons:

- **Exposure:** There are 68 waste disposal sites in the North West (as of July 2021), 53 of which are municipal owned, while the other 15 are privately owned (Moselakgomo 2021). Of the 53 municipal waste disposal sites in the province, 25 are operational and 28 have been earmarked for closure or are closed (Moselakgomo 2021). Of the 15 privately owned waste disposal sites, 5 are operational and 10 have been earmarked for closure or are closed (Moselakgomo 2021).

- **Impacts:** Waste management is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Intense rainfall events wash waste into streams, rivers and stormwater systems, increasing blockages in these systems and distributing waste into the aquatic environment
 - Damage to waste management facilities and disruption of waste management services as a result of extreme weather events.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's waste management as having high sensitivity to climate change. Key sensitivity factors include:
 - Non-compliance with waste legislation
 - Unsustainable disposal of waste at landfills.
- **Adaptive Capacity:** The majority of stakeholders viewed the province's waste management as having low adaptive capacity to respond to climate change. In particular, it was noted that there is a lack of financial and human resources to adequately manage waste in the province.

5.5 Public Health and Safety

5.5.1 Human Health

a Impacts

Various hazards associated with climate change will negatively impact human health in a number of ways (NWREAD 2016a). This includes:

- Increased average temperatures that can result in heat stress, exacerbate existing chronic health conditions, cause dehydration, trigger heat strokes and increase the presence of pests and disease vectors (like mosquitos).
- Drought reducing food security and increasing water-borne diseases.
- Flood events causing effluent overflow, which in turn can cause water-borne diseases.
- Adversely impacting air quality, as higher temperatures result in heightened levels of allergens and harmful air pollutants. Increased temperatures can create increased ozone, which is a harmful air pollutant.
- Extended hot days/warm seasons can result in longer pollen seasons which can result in heightened allergies and asthma episodes which can decrease productivity and quality of life.

b Exposure

It is estimated that the North West has a population of 4,108,816 people or 6.89% of the population of South Africa (Statistics SA 2020b). The average life expectancy in the North West, based on the 2016 to 2020 period, is 65 years for women and 58.6 years for men (Statistics SA 2020b). For both women and men, this is slightly lower than the average life expectancy for South Africa as a whole. The top five leading causes of death in the North West in 2017 were (Statistics SA 2020b):

- Tuberculosis;
- Hypertensive diseases;
- Other forms of heart disease;

- Influenza and pneumonia; and
- Diabetes mellitus.

Exposure to particulate matter (PM) is a major concern for air quality and human health for the province. In the North West, PM emanates from mine tailings (68,310 tonnes per annum), industrial emissions (43,026 tonnes per annum) and domestic fuel utilisation in dense low-income settlements (1,176 tonnes per annum) (Table 9) (NWDEDECT 2018). Domestic fuel use is of particular concern in terms of threats to human health due to the immediacy of human exposure. Exposure to the following pollutants are of concern (in order of severity): PM₁₀, SO₂ (sulphur dioxide), NO_x (nitrogen oxides), lead and benzene (NWDEDECT 2018). There are episodes of high PM concentrations throughout the province, yet this has deteriorated over the past decade. There have been repeated National Ambient Air Quality Standards (NAAQS) PM exceedances at 4 out of 7 monitoring stations between 2015-2017 (NWDEDECT 2018).

Table 9: Summary of atmospheric emissions for North West Province by source) (NWDEDECT 2018, pg 35)

Sector	Pollutant (Tonnes Per Annum or TPA)							
	PM ₁₀	PM _{2.5}	SO ₂	NO _x	CO ₂	Benzene	Lead	Total
Listed activities	16,653		53,901	42,722	7,720	2	88	121,086
Boilers	154		1,948	192	154			2,448
Vehicles			981	8,271	7,018	9	400	16,679
Domestic fuel burning	1,176		120	153				1,449
Biomass burning	7,215	4 694	304	3,390	56,505			72,108
Agriculture	6,643	1 200		946				8,789
Livestock	334	72						406
Denuded land	195	29						224
Mining (tailings)	68,310							68,310
Landfills	10					28		38
WWTW (VOCs)						76		76
Total	100,690	5,995	57,254	55,674	71,397	115	488	291,613

c Sensitivity

Age is one of the key factors that makes the population of the North West more sensitive to the health impacts of climate change, with children under five and the elderly over 60 more sensitive to climate-related health stressors. In the North West in 2020, there were estimated to be 401,845 children (9.78% of the total population) under the age of five and 368,848 adults over the age of 60 (8.97% of the total population) (Statistics SA 2020b). An increasing proportion of the North West's population is vulnerable to climate change impacts, due to the aggregate increase in elderly people residing in the province (Statistics SA 2012).

Higher levels of air pollution, which are typical of urban areas as well as urban land-use practices will likely increase the sensitivity of urban populations and areas to climate change (Le Roux, Van Huyssteen, et al. 2019). Non-compliance with the PM National Ambient Air Quality Standards (NAAQS) poses a direct threat of respiratory disease to people living in low-income, high-density settlements and in rural areas where domestic fuels are still widely utilised (NWDEDECT 2018).

Children and the elderly are particularly vulnerable, as well as those suffering from pre-existing conditions such as asthma, tuberculosis or other respiratory diseases (NWDEDECT 2018). The Waterberg-Bojanala is a National Environmental Management: Air Quality Act priority area and it includes the Bojanala Platinum District Municipality. The Air Quality Management Plan for the Waterberg-Bojanala Priority Area was finalised in 2015 (Government Notice No. 1207 of 2015) (NWDEDECT 2018).

Stakeholder perspectives

The majority of stakeholders viewed the province's human health as having **medium to high sensitivity** to climate change. Reasons cited included:

- A higher proportion of younger people.
- Increased death rates as a result of extreme events.
- Damage to health facilities/infrastructure when there are floods.
- A greater impact on people in rural areas, compared to those in urban areas.
- Most people in rural areas are still far from health services and do not have adequate access to primary healthcare services. Covid-19, TB and HIV prevalence has increased the exposure risks to these facilities and services.
- Lack of human resources.
- Lack of availability of basic needs.
- No political will to ensure quality service to the community it serves.
- Government departments, Eskom, Transnet, SANRAL, SOEs, municipalities, corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.
- Diseases related to air pollution and sewage infected water are on the increase and public health facilities are already struggling.

d Adaptive Capacity

There is considerable variability in the capacity of the health system in the various districts of the North West to respond to the health impacts of climate change (Table 10). In particular, Bojanala Platinum District Municipality has a low adaptive capacity, with the lowest percentage of hospital beds and ideal clinics. Dr Kenneth Kaunda District Municipality has a high adaptive capacity, with the highest percentage of hospital beds and ideal clinics. An ideal clinic is defined as a clinic with good infrastructure, adequate staff, adequate medicines and supplies, good administrative processes, and sufficient adequate bulk supplies.

Table 10: Key statistics on health facilities and access to medical aid

	Hospital beds per 10,000 uninsured population (Massyn et al. 2020)	Percentage of clinics with ideal clinic status (Massyn et al. 2020)	Percentage of individuals who were members of medical aid schemes in 2017
Bojanala Platinum	5	37.3%	14%
Dr Kenneth Kaunda	30.7	90%	12.8%
Dr Ruth Segomotsi Mompati	11.2	71.7%	7.3%
Ngaka Modiri Molema	14.2	55.6%	9.7%
Average for North West	12.9	56.2%	11.9%
Average for South Africa	16.8	54.9%	15.4%

Regarding air quality and emissions, there has been an improvement in data monitoring over the past decade and there are 7 provincial monitoring stations, as well as others that are placed in priority areas. The National Environmental Management: Air Quality (Act 39 of 2004) includes regulations to define Listed Activities, Atmospheric Emissions Licences and Minimum Emissions Standards (NWDEDECT 2018). Air quality standards are vital in air quality management, as they stipulate tolerable concentrations for air pollutants (NWDEDECT 2018). South Africa utilises the NAAQS for pollutants and can be used to identify air quality problems across the province and identify where specific interventions are required to address the causes of non-compliance (NWDEDECT 2018). The provincial Air Quality Management Plan is in place and districts across the province have also developed Air Quality Management Plans that are being finalised and implemented. The National Department of Environment, Forestry and Fisheries is developing a strategy to address domestic PM emissions and indoor air pollution in dense low-income settlements (NWDEDECT 2018). The aim is to support a coordinated approach for implementing efforts to ensure ambient air quality in dense low-income settlements' compliance with NAAQS and meet the Constitutional requirement of the right to air that is not harmful to people's health and well-being (section 24 of the Constitution of South Africa) (NWDEDECT 2018). There are various other tools such as IQAir's air quality index web tool (Figure 13) that can be used in understanding the province's air quality state and supporting adaptation strategies. IQAir's air quality index web tool is the world's largest free real-time air quality information platform and can be accessed online: <https://www.iqair.com/us/south-africa>.

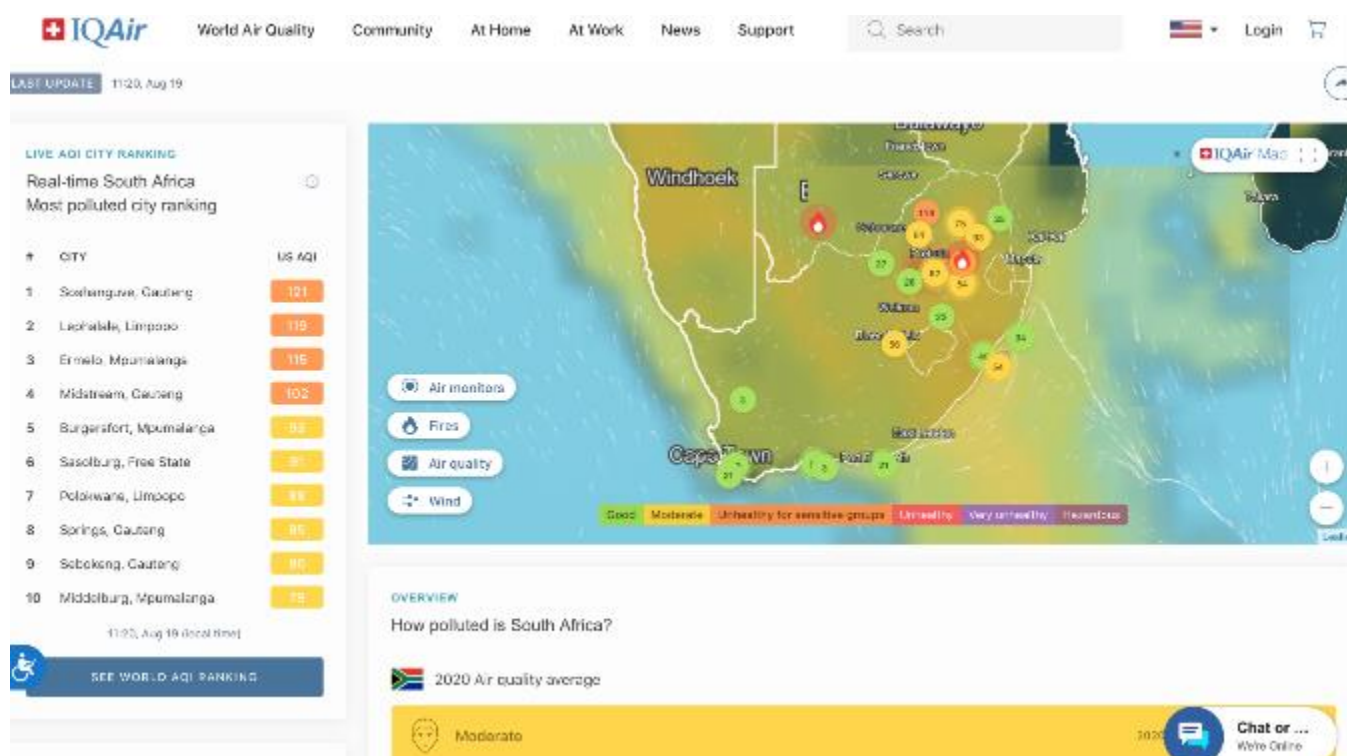


Figure 13: Screenshot of the IQ Air web tool showing the Real-time South Africa – most polluted cities ranking

Stakeholder perspectives

North West Climate Risk and Vulnerability Assessment Report (Ref: Contract No: 83368487)

The majority of stakeholders viewed the province's human health as having **medium capacity** to respond to climate change. Reasons cited included:

- Basic health services and practitioners are in place; however, sites are not well administered or managed.
- No political will to ensure quality service to the community it serves.
- Lack of human resources.
- The human race is extremely adaptive.
- Older people suffer more.
- Vulnerable people being mostly susceptible to adverse climate changes.
- Lack of infrastructure especially in rural areas.
- Technology measures being in place to mitigate impacts - however it will come at a financial cost and the North West is predominantly poor. No national grants/tax incentives and rebates/discounts etc. in place for ordinary citizens/households to convert to greener/solar energy.
- More can be done in areas where population and pollution are higher, as they have more access to resources.
- There is loss of life due to extreme climate changes, such floods and heat waves.

Summary

The human health sector is of **High Concern** due to the following reasons:

- **Exposure:** The North West has a population of approximate 4,108,816 people. Women have an average life expectancy of 65 years and men an average life expectancy of 58.6 years (Statistics SA 2020b).
- **Impacts:** Human health is expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Drought could lead to dehydration, lowered food security (due to less access to adequate nutrition), and an increase in water-borne disease (from more users using limited water supplies, increasing the risk of contamination)
 - Flood events can cause effluent overflow which in turn can cause an increase in water-borne diseases
 - Increases in temperature can result in heat stress which can exacerbate existing chronic health conditions, cause dehydration, result in heat strokes and increase the presence of pests
 - The pattern of increasing extreme rainfall events and rising temperatures favour the geographical expansion of the borders of vector-borne diseases such as malaria, dengue fever and yellow fever.
- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's public health as having medium sensitivity to climate change. Key sensitivity factors include:
 - Insufficient basic services and primary health care
 - Increased deaths as a result of disaster events.

- **Adaptive Capacity:** The majority of stakeholders viewed the province’s human health as having medium adaptive capacity to respond to climate change. In particular, it was noted that vulnerable members of communities will be more susceptible to climate changes affects, especially in rural areas.

5.5.2 Disasters Resulting from Extreme Weather Events

South Africa’s Disaster Management Act (No. 57 of 2002) and Disaster Management Amendment Act (No. 16 of 2015) (Republic of South Africa 2002, 6; 2015, 4) define a “disaster” as:

“a progressive or sudden, widespread or localised natural or human-caused occurrence which–

- a) *causes or threatens to cause–*
 - i. *death, injury or disease;*
 - ii. *damage to property, infrastructure or the environment; or*
 - iii. *significant disruption of the life of a community; and*
- b) *is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their own resources”.*

Disasters resulting from extreme weather are likely to increase in the North West due to predicted changes in the climate. The province is prone to heatwaves and droughts and floods are also a regular occurrence. Predictions show that climate change in the North West is likely to result in higher evaporation rates, more frequent and intense droughts and heatwaves, storm and flood events, as well as more wildfires (NWDEDECT 2018; NWREAD 2016a).

a Impacts

Hazards associated with climate change can influence disasters and disaster-related events in the following ways:

- Floods are the most frequently recorded disaster in South Africa – between 1980 and 2010 there were 77 major floods with over 1,000 deaths recorded (CSIR 2019). Flooding is likely to increase under predicted climate change.
- Temperature increases are likely to increase the risk of veld and wildfires, especially in the eastern parts of the province (NWREAD 2016a). The predicted increase in heatwaves and heat stress could lead to increased disaster situations.
- Climate change could lead to an increase in drought and extremes which adversely affect agriculture, livestock, energy demand and supply, as well as water security (CSIR 2019).
- Predicted increases in average temperatures and the number of very hot days, as well as in rainfall variability, are projected to increase evaporation rates and the duration and effect of dry spells, which will likely increase the risk, likelihood and severity of wildfires in the North West (NWREAD 2016b).

The annual average number of fire-danger days has been projected for the period 2021-2050 under the RCP8.5 scenario (Figure 14) (CSIR 2019). The calculations were based on climatic conditions and did not consider the availability of fuel loads (CSIR 2019).

Figure 14 shows that by 2050, under the RCP 8.5 scenario, the province is projected to experience a significant number of high fire-danger days per annum (CSIR 2019). The projected number of high

fire-danger days in the North West by 2050, under the RCP 8.5 scenario, are higher than much of eastern South Africa but lower than part of western South Africa (CSIR 2019).

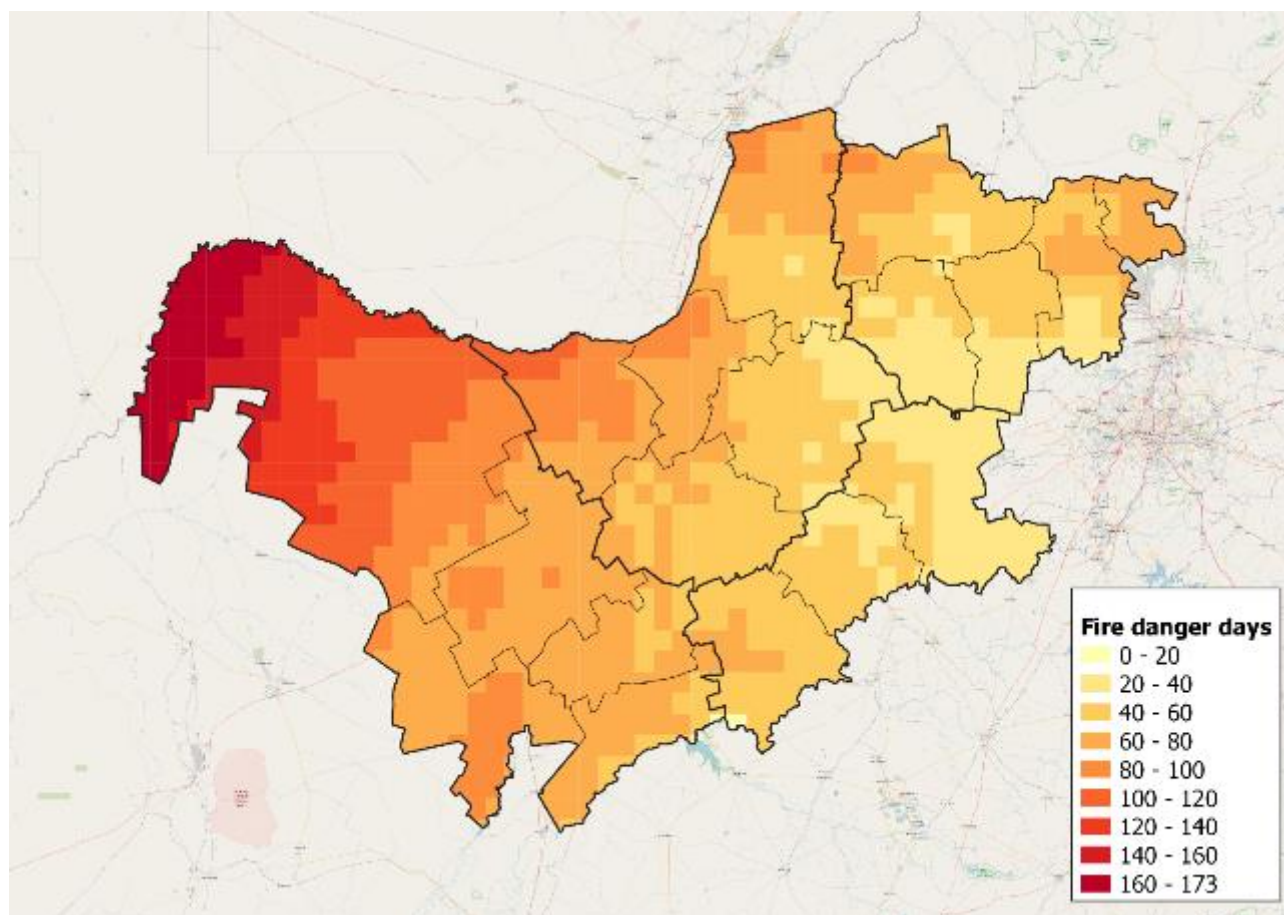


Figure 14: Projected number of high fire-danger days per year in the North West for the period 2021-2050 under the RCP8.5 scenario (CSIR 2019)

b Exposure

Infrastructure, building stock, livelihoods and key sectors across the North West are thus variously exposed to disaster events and impacts resulting from climate change and extreme weather. Examples include:

- Fire frequency: Across the province fires are already intense and fire regimes characteristic of South Africa's major ecosystems, such as grasslands, are predicted to increase in frequency as a result of climate change. Extreme storm events are also predicted to increase across the North West (NWREAD 2016a).
- Infrastructure: The North West is ranked as the second most at-risk province for damage to dams and bridges from increased flooding due to climate change (NWDEDECT 2018).
- Housing and settlements: There are increasing flood risks as more people, property and infrastructure are exposed to flood hazards, with climate change acting as a hazard multiplier. There are also considerable populations living in flood-prone areas in both urban and rural settings in the North West (CSIR 2019). Informal dwellings on risk-prone land are highly exposed to heatwaves, floods, and wildfires.

c Sensitivity

Age is a key factor influencing the North West's sensitivity to disaster events. Children under five years of age are particularly vulnerable to the impacts of disaster events. Children are physiologically more vulnerable to heat stress and to extreme disaster events such as flooding. The elderly (people over 60 years of age) are also particularly vulnerable to disaster events.

In the North West, informal settlements are growing in urban areas, with housing for low-income urban dwellers built unsustainably on marginal, risk-prone land (NWDEDECT 2018). The lack of infrastructure and services in settlements like these increases their sensitivity to extreme events. Impoverished households that are uninsured are often without resources to repair or replace their homes or property following a disaster (NWDEDECT, 2018).

An important proxy for identifying sensitivity to climate change and disaster events is whether a household lives in an informal or formal housing structure. The breakdown of households by type of main dwelling in 2016 is shown in Table 11 (Statistics SA 2018). In 2016, most households in the North West lived in formal dwellings, and the Bojanala District had the highest proportion of informal dwellings of any district municipality in the province in 2016 (Statistics SA 2018). The Bojanala District is thus a key area of sensitivity for disaster risk and climate change impacts.

Table 11: Breakdown of households in the North West Province by type of main dwelling in 2016 (Statistics SA 2018)

Dwelling Type	Bojanala	Ngaka Modiri Molema	Dr Ruth Segomotsi Mompati	Dr Kenneth Kaunda	North West
Caravan/tent	96	62	36	70	264
Cluster house in complex	2,227	409	97	1,325	4,058
Flat or apartment in a block of flats	4,447	2,254	429	10,485	17,615
House/flat/room in backyard	60,692	17,639	6,527	10,823	95,682
House or brick/concrete block structure on a separate stand or yard or on a farm	355,277	200,011	103,796	179,066	838,150
Informal dwelling (shack; in backyard)	71,153	14,011	3,985	12,385	101,534
Informal dwelling (shack; not in backyard; e.g., in an informal/squatter settlement or on a farm)	92,379	15,350	5,375	14,905	128,010
Other	10,030	3,762	1,126	3,617	18,535
Room/flatlet on a property or larger dwelling/servants quarters/granny flat	4,062	1,926	979	1,615	8,582
Semi-detached house	1,647	686	1,011	1,977	5,323
Townhouse (semi-detached house in a complex)	3,369	259	1,430	2,563	7,621
Traditional dwelling/hut/structure made of traditional materials	5,583	13,576	2,274	1,712	23,146
Unspecified	181	29	37	-	247
Total	611,143	269,974	127,102	240,543	1,248,767

Agriculture is also highly sensitive to changes in temperature, rainfall and extreme events as crop growth is directly linked to these. Drought and floods have negative implications for agricultural livelihoods across the province and are likely to intensify over the short to long term as climate change impacts manifest and extreme weather and disaster events increase. Subsistence farmers

are particularly vulnerable as evidenced in the 2013 drought when the provincial Disaster Risk Management Centre received over 6,000 relief applications from subsistence farmers (eNCA 2013).

Stakeholder perspectives

The majority of stakeholders viewed the province's disaster resulting from extreme weather as having **high sensitivity** to climate change. Reasons cited included:

- There is willingness to respond, but resources are sadly lacking.
- Sensitivity will differ depending on areas.
- An independent audit of these risks is needed.
- High rural population that does not have the quality of disaster management.
- Government departments, Eskom, Transnet, SANRAL, SOEs, Municipalities, Corporates and the majority of landowners are non-compliant with the Veld and Forest Fire Act 101 of 1998, which leads to loss of life, livelihoods and food security.
- Inadequate infrastructure development and water availability to protect, support and sustain rural areas and population in droughts and floods.
- People lose their life during extreme weather conditions, and this increases the sensitivity.

d Adaptive Capacity

Proactive disaster risk management can support adaptive capacity and can decrease the vulnerability of communities, their lives, assets and livelihoods.

1) Early warning systems

The National Disaster Management Centre has developed several early warning systems relating to floods and drought including the Integrated National Early Warning System (INEWS) and South African Flash Flood Guidance (SAFFG) system. There is increased knowledge about the likely outcome of floods and how to act on early warning to support decision-making and reduce the vulnerabilities of livelihoods and infrastructure (NWDETECT 2018). However, further development and improvement is required, particularly for severe weather and pest infestation events and to ensure timeous communication with potentially affected populations, especially in informal settlements and rural areas (Poolman et al. 2015).

2) Disaster frameworks and structures

The North West Provincial Department of Cooperative Governance and Traditional Affairs is responsible for disaster management and for implementing the National Disaster Management Framework at the provincial level. To support its adaptive capacity, the province has developed a number of disaster management frameworks and structures. These include a provincial disaster risk management centre in Mahikeng (covering droughts, severe weather conditions, floods, veld fires and diseases), the disaster risk management advisory forum, an inter-departmental disaster risk management committee, a volunteer disaster management unit and a disaster risk management plan. However, climate change considerations are not yet adequately mainstreamed into these policy frameworks and structures (NWREAD 2016a). The National Department of Agriculture, Land Reform and Rural Development has implemented an early warning system to provide extreme weather warnings to farming communities and undertakes research and education campaigns and training to support disaster responses and risk management (NWREAD

2016a). Additionally, the Early Warning Unit in the Climate Change and Disaster Management Directorate of DALRRD compiles and disseminates monthly advisories to farming communities.

Local government is the key sphere for the implementation of disaster risk reduction and management, yet most local municipalities across South Africa adopt a reactive approach to disaster management and face a range of challenges relating to inadequate financing, a lack of political will, inadequate community participation and communication and insufficient skilled and trained personnel (NWREAD 2016a).

Stakeholder perspectives:

The majority of stakeholders viewed the province's disasters resulting from extreme weather as having **low capacity** to respond to climate change. Reasons cited included:

- Lack of human resources.
- More financial and human resources are needed.
- Infrastructure and resources must be given to fire protection agencies as they are able to manage wildfire, but this is not happening.
- Good structures are in place but capacity to implement should be addressed.
- Availability of infrastructure and financial resources in different areas.
- Disaster Risk Management Centres normally fall under the District Municipality – however many municipalities are under administration.
- Most of these factors are under the management of government or semi government spheres and implementation is therefore difficult.
- Lack of water availability capacity.
- Inadequate infrastructure development.
- It takes time for damaged infrastructure to be fixed or rebuilt.
- Lack of coordinated approach on disaster risk reduction
- Floods are already happening because infrastructure is not maintained, flood lines are ignored during building and alien invasive plants are allowed to proliferate.
- The department responsible for the sector is not implementing sufficiently to protect the citizens of the country.
- It is important to have measures in place to respond once we experience extreme weather patterns.

e Summary

The Disasters Resulting from Extreme Weather Events is of **High Concern** due to the following reasons:

- **Exposure:** Climate change is likely to lead to increased disaster situations in the province (NWREAD 2016a).
- **Impacts:** Disasters resulting from extreme weather are expected to experience a number of climate change impacts, in particular, stakeholders highlighted, *via* an online survey, the following impacts as being of most concern:
 - Floods
 - Droughts
 - Wildfires

- **Sensitivity:** The majority of stakeholders who participated in an online consultation event for this report viewed the province's disasters resulting from extreme weather as having high sensitivity to climate change. Key sensitivity factors include:
 - Increased temperatures will lead to increased fire risk
 - Lack of disaster management in rural areas
 - Poor infrastructure development to protect from disaster events.
- **Adaptive Capacity:** The stakeholders viewed the province's disasters resulting from extreme weather as having medium adaptive capacity to respond to climate change. In particular, it was noted that there are disaster management plans in place, however, there is a lack of coordination from the relevant departments to respond to disaster events.

6 Conclusion

This Climate Change Risk and Vulnerability Report identifies the four key climate change hazards that threaten South Africa's North West province; and analyses the province's core economic, social, and environmental sectors to better understand how climate change will impact on the families, communities and people of the North West province. Drawing on evidence, the report identifies rising temperatures, increasing rainfall variability, increasing periods of drought, and increasing storms and flooding events as the key climate change hazards facing the North West.

To appreciate how these hazards will affect different sectors, the report documents the exposure to climate change of each sector; the impacts on sectors as a result of climate change; the sensitivity of each sector to climate change and finally the capacity of each sector to adapt to climate change.

The report records high levels of concern for the future of important sectors in the face of a changing climate. Ecosystems, rural livelihoods, water supply, waste management, human health, transport and disaster management are all sectors of high concern in the North West. Urban livelihoods, agriculture, tourism, mining and energy supply are all sectors of medium concern.

Despite its relatively small population of approximately 3,75 million people, or 7% of the national population, North West plays an important role in the national and global economy. Its large mining industry provides 50% of the world's platinum and the province welcomes South Africans and international guests to its world-class provincial parks and world heritage sites. Its significant agricultural sector makes an important contribution to national food security, the export sector and rural livelihoods. The province's ability to respond and adapt to climate change in these and other sectors is of national and international significance.

This report identifies the major risks to the province in the face of climate change and its key vulnerabilities. Safeguarding the unique and important cultural, environmental and economic assets of the province for future generations is a collective responsibility. While responding to climate change is by no means the only challenge that faces the province, the threat it presents will undoubtedly magnify many others.

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8 Annexure: Municipality Vulnerability Indexes

8.1 Socio-Economic Vulnerability Index

Social inequalities are the factors that affect the susceptibility and coping mechanisms of communities and households. Indicators for social vulnerability attempt to consider the sensitivity, response and recovery from the impacts of natural hazards. The CSIR Green Book has developed a socio-economic vulnerability index that is measured on a scale from 1 (low vulnerability) to 10 (high vulnerability) and is comprised of the following indicators:

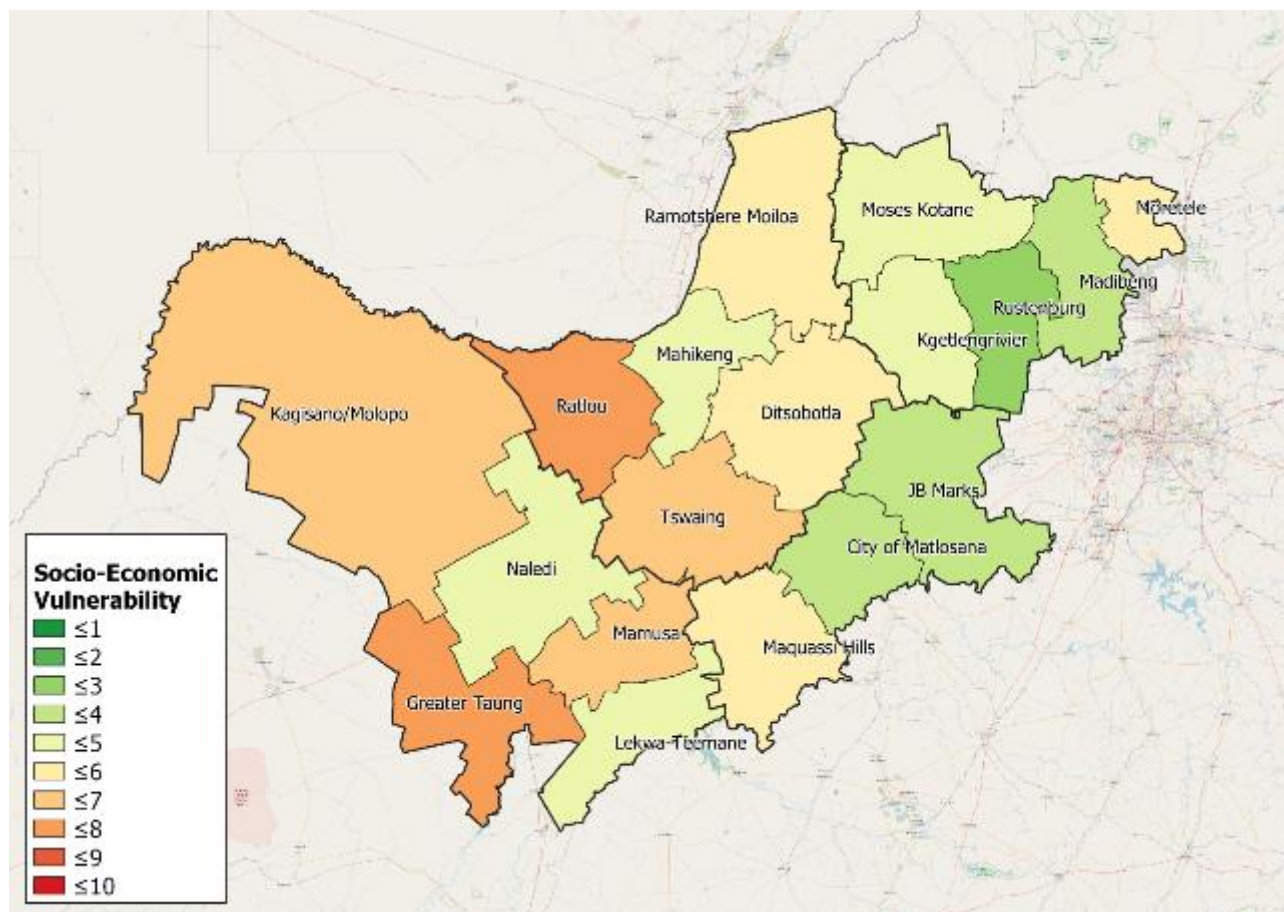
- Household composition
 - Age dependency
 - Female-/child-headed households
- Income composition
 - Poverty level
 - Unemployment
- Education
 - Literacy rate
 - Level of education
- Health
 - Child mortality
- Access to basic services
 - Electricity access
 - Water access
 - Sanitation
 - Refuse removal
- Safety and security
 - Reported violent crimes

The table below shows the score of each municipality in the North West on the Socio-Economic Vulnerability Index developed by the CSIR Green Book.

Municipality	Socio-Economic
Ratlou	7.58
Greater Taung	7.01
Kagisano/Molopo	6.96
Tswaing	6.29
Mamusa	6.04
Ramotshere Moiloa	5.75
Maquassi Hills	5.63
Moretele	5.48
Ditsobotla	5.35
Lekwa-Teemane	4.76
Mahikeng	4.55
Naledi	4.5
Moses Kotane	4.49
Kgetlengrivier	4.45
Madibeng	3.73

City of Matlosana	3.35
JB Marks	3.17
Rustenburg	2.32

The Socio-Economic Vulnerability Index is visually presented in the figure below.



8.2 Environmental Vulnerability Index

Environmental vulnerability describes the vulnerability and risk to the natural environment and the impacts on the ecological infrastructure of which surrounding settlements are dependent. The environmental risk of an area includes ecosystems, habitats, physical and biological processes (reproduction, diversity, energy flows, etc). The CSIR Green Book has developed an Environmental Vulnerability Index that is measured on a scale from 1 (low vulnerability) to 10 (high vulnerability) and is comprised of the following indicators:

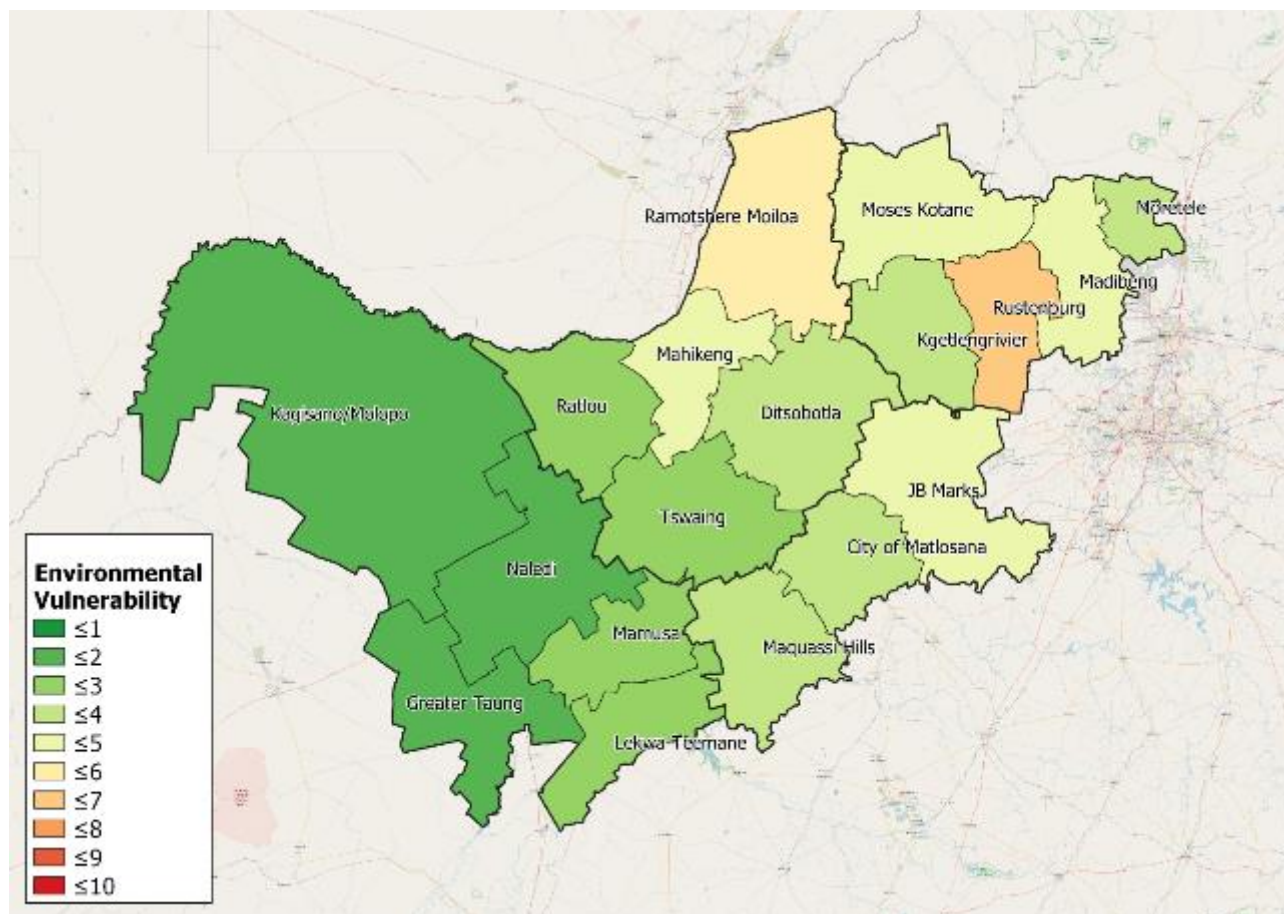
- Human influence of the environment
 - Degraded/eroded/desertified area
 - Urban encroachment
- Ecological infrastructure
 - Protected areas
 - Conservation areas
 - Critical biodiversity areas

- Ecological support areas
- Water resources
 - Groundwater supply
 - Surface water supply
 - Wetland areas
- Health
 - Air quality
- Environmental governance
 - Encroachment of protected areas
 - Distressed water catchments (based on supply/demand)

The table below shows the score of each municipality in the North West on the Environmental Vulnerability Index developed by the CSIR Green Book.

Municipality	Environmental
Rustenburg	6.19
Ramotshere Moiloa	5.57
Madibeng	4.85
Moses Kotane	4.38
JB Marks	4.16
Mahikeng	4.02
Ditsobotla	3.92
Kgetlengrivier	3.71
Moretele	3.56
Maquassi Hills	3.29
City of Matlosana	3.14
Tswaing	2.85
Mamusa	2.72
Lekwa-Teemane	2.37
Ratlou	2.12
Greater Taung	1.92
Naledi	1.68
Kagisano/Molopo	1.55

The Environmental Vulnerability Index is visually presented in the figure below.



8.3 Physical Vulnerability Index

Physical vulnerability describes the physical fabric and connectedness of settlements (buildings and infrastructure) and focuses mainly on the conditions that exist before a hazard occurs and the expected level of resulting loss. The CSIR Green Book has developed a physical vulnerability index that is measured on a scale from 1 (low vulnerability) to 10 (high vulnerability) and is comprised of the following indicators:

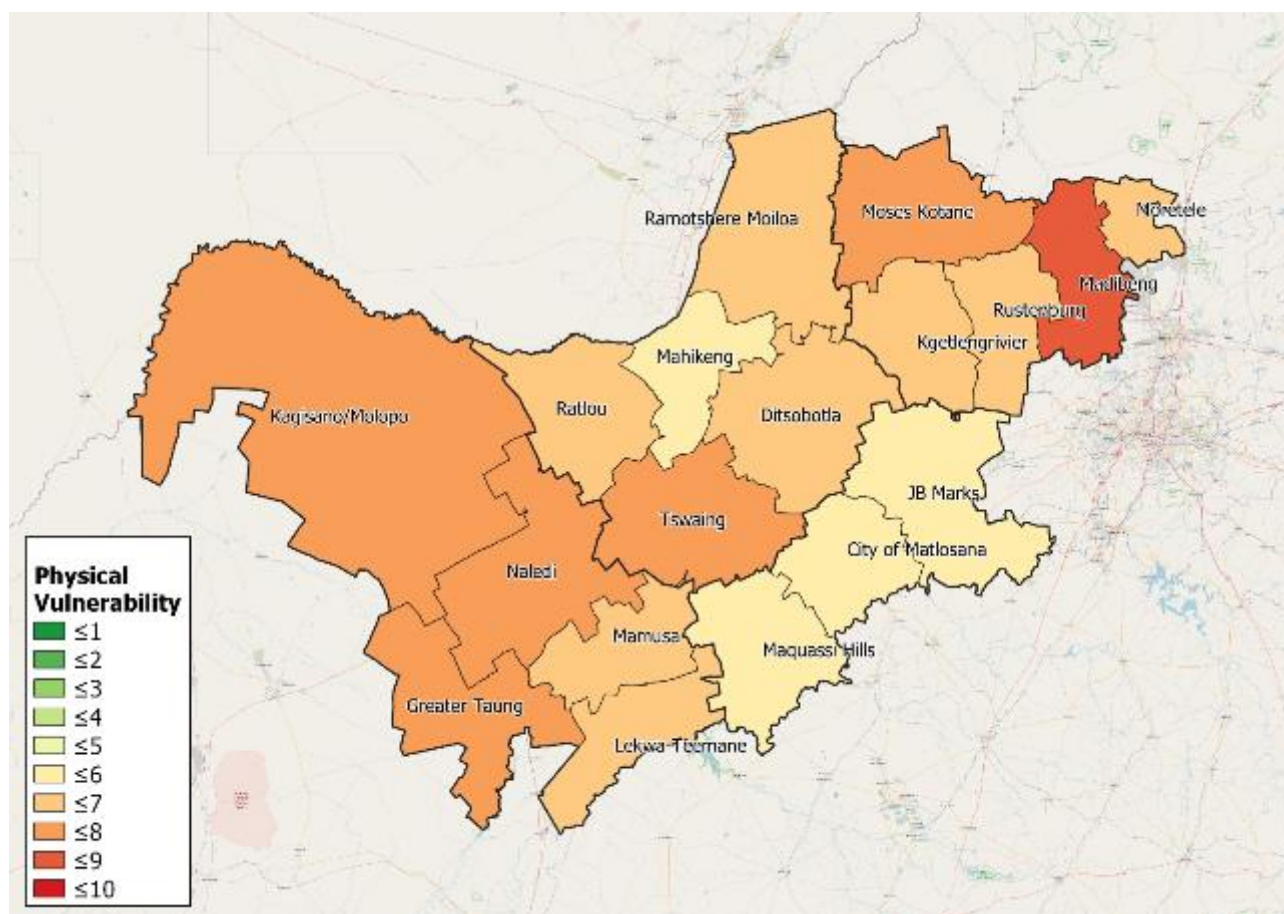
- Road infrastructure
 - Road density
- Housing type
 - Informal structures
 - Government subsidy housing
- Density
 - Population in traditional settlements
 - Footprint area in traditional settlements
- Accessibility within the local municipality
 - Accessibility indicator

The table below shows the score of each municipality in the North West on the Physical Vulnerability Index developed by the CSIR Green Book.

Municipality	Physical
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Madibeng	8.17
Moses Kotane	7.92
Greater Taung	7.43
Kagisano/Molopo	7.43
Naledi	7.41
Tswaing	7.01
Mamusa	6.87
Rustenburg	6.8
Ramotshere Moiloa	6.74
Kgetlengrivier	6.57
Ditsobotla	6.45
Moretele	6.24
Lekwa-Teemane	6.21
Ratlou	6.13
JB Marks	6
Mahikeng	5.81
Maquassi Hills	5.15
City of Matlosana	5.06

The Physical Vulnerability Index is visually presented in the figure below.



8.4 Economic Vulnerability Index

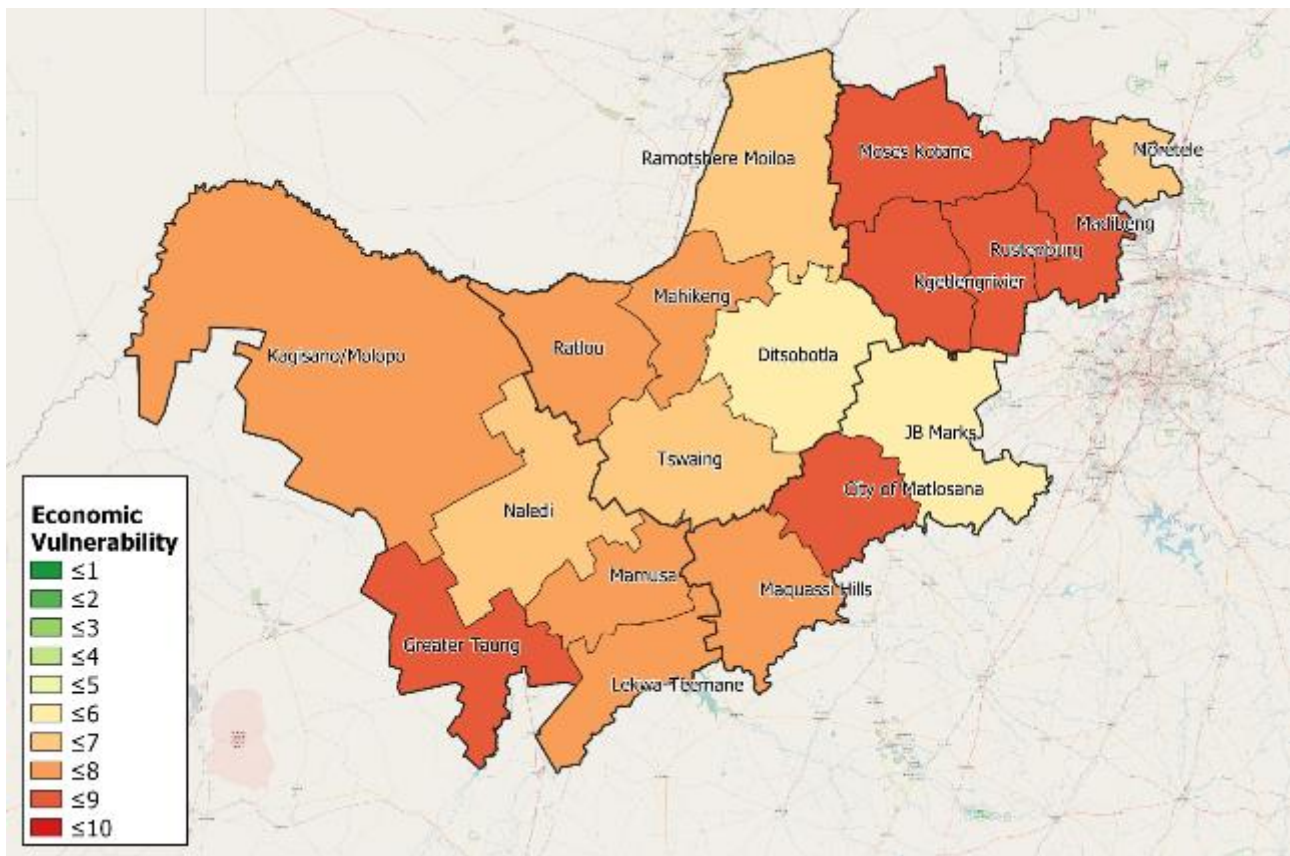
Economic vulnerability describes the potential risks posed by hazards on economic assets and processes. Potential hazards can include job losses, increased poverty and interruptions in business activities. The CSIR Green Book has developed an economic vulnerability index that is measured on a scale from 1 (low vulnerability) to 10 (high vulnerability) and is comprised of the following indicators:

- Diversification
 - Economy dependent on agriculture, forestry, and fisheries
 - Economy dependant on mining
- Size of economy
 - GDP per capita
 - GDP production (relevant to national)
- Labour force
 - Unemployed or discouraged work seekers in economically active population
 - Unemployed females in economically active population
- GDP growth/ decline pressure
 - GDP change (2011 relative to 1996)
- Inequality
 - Gini co-efficient
 - Population earning no income

The table below shows the score of each municipality in the North West on the Economic Vulnerability Index developed by the CSIR Green Book.

Municipality	Economic
Greater Taung	8.52
Rustenburg	8.49
City of Matlosana	8.48
Kgetlengrivier	8.46
Moses Kotane	8.18
Madibeng	8.04
Mamusa	7.96
Kagisano/Molopo	7.92
Mahikeng	7.84
Lekwa-Teemane	7.58
Ratlou	7.34
Maquassi Hills	7.02
Ramotshere Moiloa	6.86
Naledi	6.65
Tswaing	6.45
Moretele	6.39
JB Marks	5.98
Ditsobotla	5.14

The Economic Vulnerability Index is visually presented in the figure below.



8.5 Rural Vulnerability Index

Following the above 4 CSIR Green Book vulnerability indexes, an additional index was developed that more adequately reflects the vulnerability in municipalities with most households living in rural areas. Indicators of rural vulnerability focus on the exposure, sensitivity, and adaptive capacity of rural communities to the various climate risks. The rural vulnerability index is measured on a scale from 1 (low vulnerability) to 10 (high vulnerability) and is comprised of the following indicators using StatsSA census data from 2011.

- Exposure
 - Density
- Sensitivity
 - Type of dwelling
 - Source of water
 - Toilet facility
 - Refuse disposal
 - Electricity for cooking, heating, and lighting
- Adaptive capacity
 - Employment status
 - Agriculture
 - Access to internet

The table below shows the score of each municipality in the North West on the Rural Vulnerability Index.

Municipality	Rural
Ratlou	4.15
Greater Taung	3.96
Kagisano/Molopo	3.85
Ramotshere Moiloa	3.82
Tswaing	3.77
Madibeng	3.74
Maquassi Hills	3.73
Ditsobotla	3.70
Moretele	3.67
Mamusa	3.54
Kgetlengrivier	3.48
Moses Kotane	3.26
Lekwa-Teemane	3.19
Naledi	3.18
Mahikeng	3.03
Rustenburg	2.88
City of Matlosana	2.67
JB Marks	2.50

The Rural Vulnerability Index is visually presented in the figure below.

