Bojanala Platinum District Municipality

Climate Risk Profile Report based on the GreenBook

April 2024

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Authors:	Daleen Lötter, Amy Pieterse, Chantel Ludick & Lethabo Chilwane
Project lead:	Amy Pieterse (CSIR)
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Acronyms

°C	Degree Celsius
AFF	Agriculture, Forestry, and Fisheries
AR5	Fifth Assessment Report
CABLE	CSIRO Atmosphere Biosphere Land Exchange model
CCAM	Conformal-cubic atmospheric model
CDRF	Climate and Disaster Resilience Fund
CMIP5	Coupled Model Intercomparison Project 5
CoGTA	Department of Cooperative Governance and Traditional Affairs
CRVA	Climate Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
BPDM	Bojanala Platinum District Municipality
DEA	Department of Environmental Affairs
DM	District Municipality
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EcVI	Economic Vulnerability Index
EnVI	Environmental Vulnerability Index
GCM	General circulation model
GRiMMS	Groundwater Drought Risk Mapping and Management System
GVA	Gross Value Added
GDP	Gross Domestic Product
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
km	Kilometre
l/p/d	Litres Per Person Per Day
LM	Local Municipality
MAR	Mean Annual Runoff
mm	Millimetre
NDMC	National Disaster Management Centre
PVI	Physical Vulnerability Index
RCP	Representative Concentration Pathways
SCIMAP	Sensitive Catchment Integrated Modelling and Prediction
SDF	Spatial Development Framework
SEVI	Socio-Economic Vulnerability Index
SPI	Standardised Precipitation Index
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013)
THI	Temperature Humidity Index
WMAs	Water Management Areas
WMO	World Meteorological Organisation
WRYM	Water Resources Yield Model

WUI	Wildland-Urban Interface

Glossary of Terms

Adaptation actions	A range of planning and design actions that can be taken by local government to adapt to the impacts of climate change, reduce exposure to hazards, and exploit opportunities for sustainable development (CSIR, 2019).
Adaptation planning	The process of using the basis of spatial planning to shape built-up and natural areas to be resilient to the impacts of climate change, to realise co-benefits for long-term sustainable development, and to address the root causes of vulnerability and exposure to risk. Adaptation planning assumes climate change as an important factor while addressing developmental concerns such as the complexity of rapidly growing urban areas, and considers the uncertainty associated with the impacts of climate change in such areas – thereby contributing to the transformational adaptation of urban spaces. Adaptation planning also provides opportunities to climate proof urban infrastructure, reduce vulnerability and exploit opportunities for sustainable development (National Treasury, 2018; Pieterse, 2020).
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" (IPCC, 2022, p. 2899).
Climate change adaptation	"In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2022, p. 2898).
Climate change mitigation	"A human intervention to reduce emissions, or enhance the sinks, of greenhouse gases (GHGs)" (IPCC, 2022, p. 2915). The goal of climate change mitigation is to achieve a reduction of emissions that will limit global warming to between 1.5°C and 2°C above preindustrial levels (Behsudi, A, 2021).

Climate hazards	Climate hazards are a sub-set of natural hazards and a grouping of hydrological, climatological, and meteorological hazards. This includes the spatial extent and frequency of, among others, floods, fires, and extreme weather events such as extreme rainfall and extreme heat. Sometimes referred to as hydrometeorological hazards. The potential occurrence of a climate hazard may cause loss of life, injury, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2022). Climate hazards can increase in intensity and frequency with climate change (Pieterse et al., 2023).
Climate risk	Risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and a hazard. Relevant adverse consequences include those on "lives and livelihoods, health and well-being, economic and sociocultural assets, infrastructure and ecosystems" (IPCC, 2022, p. 144). In the IPCC's 6th Assessment Report, it is confirmed that risks may result from "dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system" (IPCC, 2022, p. 132).
Coping capacity	"The ability of people, institutions, organizations and systems, using available skills, values, beliefs, resources and opportunities, to address, manage, and overcome adverse conditions in the short to medium term" (IPCC, 2022, p. 2904).
Disaster risk reduction	"Denotes both a policy goal or objective, as well as the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard or vulnerability; and improving resilience" (IPCC, 2022, p. 2906).
Exposure	Exposure implies the physical exposure of elements to a climate hazard. It is defined as 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 [by climate hazards]" (IPCC, 2022, p. 2908).
Mainstreaming	The process of integrating climate change adaptation strategies and measures into existing planning instruments and processes as opposed to developing dedicated adaptation policies and plans (Pieterse et al., 2021).

Resilience	"The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation" (IPCC, 2022, pp. 2920–2921).
Sensitivity	"The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)" (IPCC, 2022, p. 2922).
Vulnerability	Vulnerability is defined as the "propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including, sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2022, p. 2927). Vulnerability refers to the characteristics or attributes of exposed elements, i.e., elements that are exposed to potential climate-related hazards. Vulnerability is a function of sensitivity and (coping or adaptive) capacity (Pieterse et al., 2023).

1. Introduction

This Climate Risk Profile report, as well as the accompanying Climate Change Adaptation Plan, were developed specifically for Bojanala Platinum District Municipality (BPDM), to support its strategic climate change response agenda. Both documents are primarily informed by the GreenBook, which is an open-access online planning support system that provides quantitative scientific evidence in support of local government's pursuit in the planning and design of climate-resilient, hazard-resistant settlements. The GreenBook is an information-dense resource and planning support system offered to South African local governments to better understand their risks and vulnerabilities in relation to population growth, climate change, exposure to hazards, and vulnerability of critical resources. In addition to this, the GreenBook also provides appropriate adaptation measures that can be implemented in cities and towns, so that South African settlements are able to minimise the impact of climate hazards on communities and infrastructure, while also contributing to developmental goals (See Green Book l Adapting settlements for the future).

The purpose and strategic objectives of the Climate Risk Profile and the Adaptation Plan are to:

- Build and further the climate change response agenda,
- Inform strategy and planning in the district and its local municipalities,
- Identify and prioritise risks and vulnerabilities,
- Identify and prioritise climate interventions and responses, as well as
- Guide and enable the mainstreaming of climate change response, particularly adaptation.

The Climate Risk Profile report provides an overview of the unique climate change needs and risks of the district based on the science, evidence, and information from the GreenBook. Climate change trends, hazards, and vulnerabilities are spatially mapped for the district, its local municipalities, and settlements. Finally, the report identifies the major risks that need to be prioritised and sets out adaptation goals to further inform the adaptation plan and its implementation.

1.1. Approach followed

The approach used in the GreenBook, and the Climate Risk Profile is centred around understanding climate-related risk. Climate-related risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and the occurrence of a climate hazard (see Figure 1). "Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, and services (including ecosystem services, ecosystems and species)" (Chen, et al., 2021, p. 64). The components of risk are dynamic. Climate hazards are driven by natural climate variability and anthropogenic climate change. Human activity contributes to Greenhouse Gas emissions that increase temperatures, which in turn affects changes in the occurrence of climate hazards such as drought, flooding, coastal flooding, and heat extremes. Planned as well as unplanned development and growth of our settlements drive the exposure of people, as well as the built- and natural environment to climate hazards. Vulnerability includes the inherent characteristics that make systems sensitive to the effects and impacts of climate hazards. Municipal risk is driven by vulnerability and exposure to certain climate-related hazards.

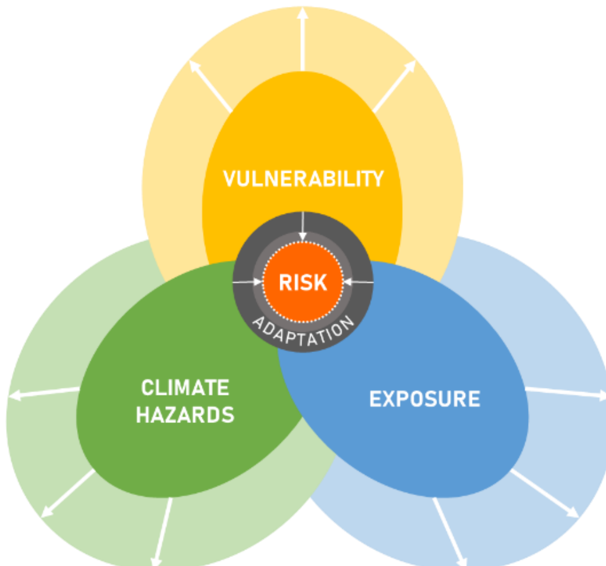

Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

To understand climate risk across the municipal area, the exposure of settlements to certain climate hazards and their vulnerability are unpacked. In this Climate Risk Profile report multiple vulnerability indices are provided on the municipal and settlement level, as well as variables for the current and future projected climate. Climate-related hazards such as drought, heat extremes, wildfire and flooding and the impact of climate on key resources are also set out for the district and its municipalities.

All information contained in this report is based on the GreenBook, unless otherwise specified. Information and data were derived using GIS analysis and modelling techniques using secondary data and is not based on local surveys. Additional information to this report is available for local municipalities through the GreenBook Municipal Risk Profile Tool. Municipalities are encouraged to consider both the information available in this report and on the Municipal Risk Profile tool to understand their risk profile. Access the GreenBook and its various resources and tools here: https://greenbook.co.za/

1.2. Policy framework

There are various regulatory and legislative requirements for climate change response [planning] in South Africa, at local government level. For instance, the Disaster Management Amendment Act of 2015, which aims to provide measures to reduce disaster risks through climate change adaptation and the development of early warning systems, requires each organ of state, provincial government and municipality to identify measures for, as well as indicate plans to invest in, disaster risk reduction (DRR) and climate change adaptation. The Spatial Planning and Land Use Management Act, No. 16 of 2013 (SPLUMA) outlines five principles intended to guide spatial planning, land development and land use management at all levels of planning, including local government level. Amongst them are the principles of (1) spatial resilience, which encourages “flexibility in spatial plans, policies and land use management systems, to ensure sustainable livelihoods in communities most likely to suffer the impacts of economic and environmental shocks” – some of which may be induced by the impacts of climate change, and (2) spatial sustainability, which sets out requirements for municipal planning functions such as spatial planning and land use management to be carried out in ways that consider protecting vital ecosystem features such as agricultural land, i.e., from both anthropogenic and natural threats, including the impacts of climate change, as well as in ways that consider current and future costs of providing infrastructure and social services in certain areas (e.g., uninformed municipal investments may lead to an increase in the exposure of people and valuable assets to extreme climate hazards).

Furthermore, the National Climate Change Response White Paper – which outlines the country's comprehensive plan to transition to a climate resilient, globally competitive, equitable and low-carbon economy and society through climate change adaptation- and mitigation, while simultaneously addressing the country's key priorities, including job creation, poverty reduction, social equality and sustainable development, amongst others – identifies local governments as critical role players that can contribute towards effective climate change adaptation through their various functions, including “[the] planning [of] human settlements and urban development; the provision of municipal infrastructure and services; water and energy demand management; and local disaster response, amongst others.” (Republic of South Africa, 2011, p. 38). The Climate Change Bill (B9-2022) takes it further by setting out institutional arrangements for climate change response. Section 7. (1) of the Bill requires that all organs of state affected by climate and climate change align their policies, programmes, and decisions to ensure that the risks of climate change impacts and associated vulnerabilities are considered. Local government is a key player in climate change response as a facilitator and implementer to achieve effective climate response. The Bill requires that district intergovernmental forum to serve as a Municipal Forum on climate change that coordinates climate response actions and activities in its respective municipality. The Bill also sets out requirements for each district municipality to undertake a climate change needs assessment and a climate change response implementation plan. The Climate Risk Report and related Adaptation Plan, provided here, meet most of these requirements and provide the essential information needed by the district municipality to fulfil its obligations in terms of the Bill.

The National Climate Change Adaptation Strategy outlines several actions in support of climate change adaptation, that are applicable at municipal level, including the development and implementation of adaptation strategies and vulnerability reduction programmes targeting communities and individuals that are most at risk to the impacts of climate change; the development of municipal early warning systems; as well as the integration of climate change adaptation measures into municipal development plans and relevant sector plans. The National Climate Risk and Vulnerability Assessment Framework – which is aimed at all actors, including local governments – guides the development and review of climate risk and vulnerability assessments (CRVAs) to enable alignment, aggregation and comparison across all CRVAs, in an effort to inform an integrated and effective climate change adaptation response across all scales and sectors.

1.3. District Municipal context

The Bojanala Platinum District Municipality (BPDM) is one of four district municipalities in the North West province and comprises five local municipalities of Kgetleng Rivier, Madibeng, Moses Kotane, Moretele and Rustenburg. It is bordered by the Waterberg District Municipality to the north, Dr Kenneth Kaunda District Municipality to the south, City of Tshwane Metro to the east, West Rand District Municipality to the south - east, and Ngaka Modiri Molema District Municipality to the west. The District makes up approximately a quarter of the total population in the North West Province. Compared to North West's average annual growth rate (1.97%), the growth rate in Bojanala Platinum's population at 2.64% was slightly higher than that of the province.

The Gross Domestic Product (GDP) was around R137.3 billion in 2018 with the mining sector being the largest within Bojanala Platinum District Municipality accounting for R 71.5 billion or 52.1% of the total GVA in the district municipality's economy (Bojanala Platinum District IDP, 2022). The District holds the largest Platinum Group Metal reserves in the country and the country holds 80% of the world’s reserves. Community services, finance and trade are the other large contributors. Agriculture contributes the least to the economy of Bojanala Platinum District Municipality.

The District’s major employing sectors are the mining sector which created 120 000 formal employment opportunities in the District. The trade sector is the second largest employer contributing 82 300 jobs to the labour force, while community services contributed 73 300 jobs. The unemployment rate is 27.6 %, with 437 000 people employed from a working age population of 617 000 people (Bojanala Platinum District IDP, 2022).

Based on the 2022 Census (StatsSA, 2022) Bojanala has a total population of 1 624 144. Within this population, young children (0-14 years) make up 26,3% of the total population. The working-age population (15-64 years) accounts for 67,7%, while the elderly (65+ years) constitute 5,9%. The district's dependency ratio is reported at 47,6 with a sex ratio of 103,3 Education indicators reveal that 5,5% of individuals aged 20 and above have no formal schooling, while 6,9% have attained higher education qualifications. With regards to housing, the district hosts 531 492 households, with an average household size of 3,1. Formal dwellings dominate the housing landscape, representing 84,2% of the housing stock. Sanitation and waste management services are accessible, with 54,1% of formal dwellings equipped with flushing toilets connected to sewerage, and 57,5% receiving weekly refuse disposal services. Moreover, 41,6% of households enjoy access to piped water within their dwellings, while 94,1% have electricity for lighting.

Large parts of the Bojanala Platinum District Municipality are characterized by high levels of biodiversity. The District falls largely within the Savanna and Grassland biomes. The Marikana Thornveld, Rand Highveld Grassland and Springbokvlakte Thornveld are classified as endangered, while the Central Sandy Bushveld and Moot Plains Bushveld that are located across all five local municipalities are classified as vulnerable ecosystems. The Magaliesberg Mountain Range is an important water source area that supports human settlement north of the range, such as Rustenburg, as well as agriculture, e.g. Buffelspoort Dam (North West Biodiversity Sector Plan, 2015).

BPDM municipal area is approximately 18 333km² in extent and spread over former homeland areas, commercial farms, towns, and semi-urban areas, with large areas of land under the custodianship of traditional authorities. The major cities/towns are Brits, Derby, Hartbeesfontein, Hartbeespoort, Koster, Madikwe, Marikana, Mooinooi, Phatsima, Rustenburg, Swartruggens, Tlhabane and Mogwase. The area also symbolises the resettlement and separate development policies of the old apartheid years.

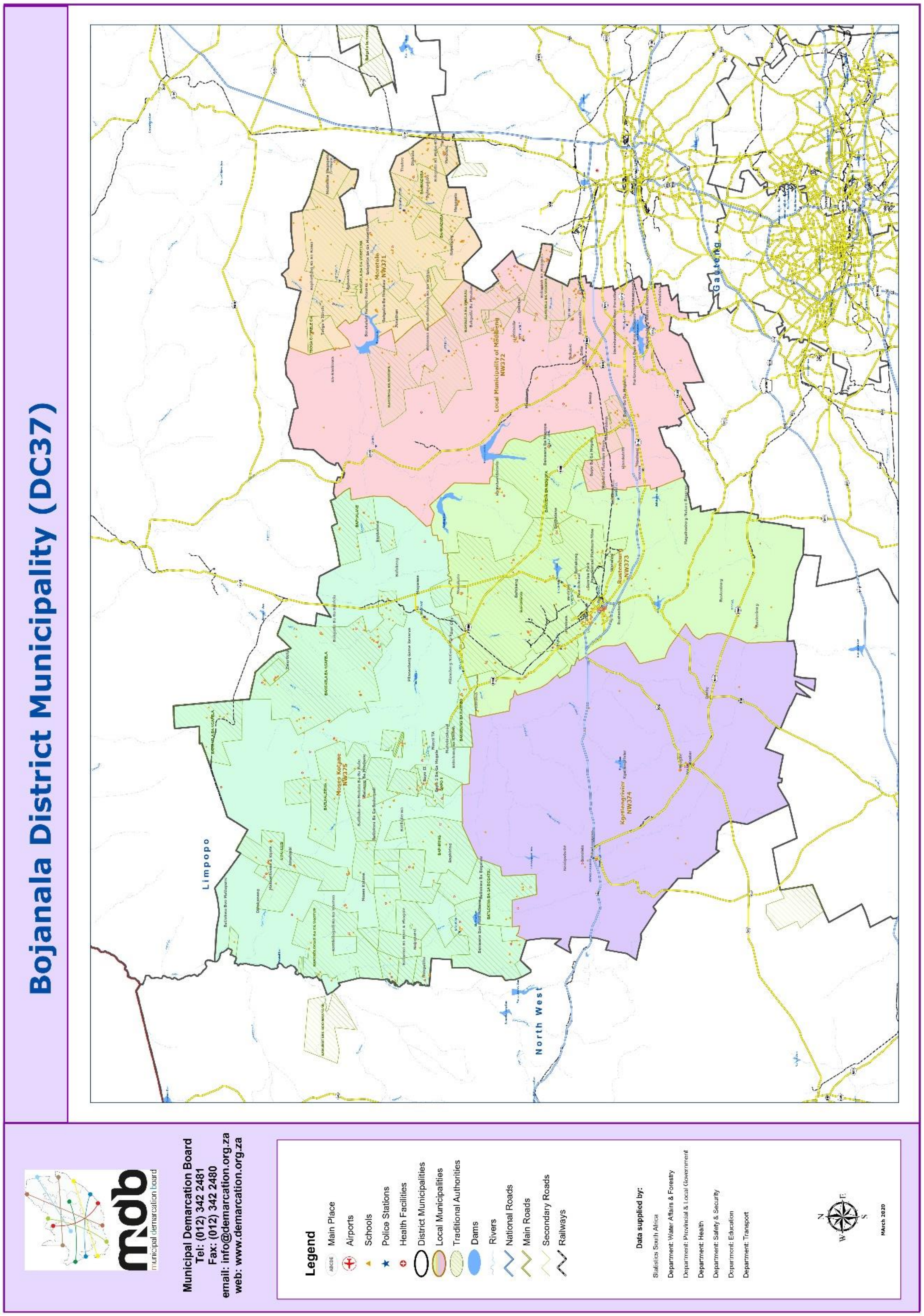

Figure 2: Bojanala Platinum District Municipality (Municipal Demarcation Board, 2022), with Local Municipalities shaded in different colours

2. Baseline and future climate risk

This section starts with an overview of vulnerability and population change projections, unpacking the components of vulnerability on both the municipal and settlement level as well future population pressures. Thereafter the current and future climate is discussed in terms of temperature and rainfall across the District. Current as well as future exposure to drought, heat, wildfire, and flooding are set out. The impact of climate on key resources such as water and agriculture are also discussed for the municipalities in the District. Together this information provides an overview of current and future climate risk across the Bojanala Platinum District to inform responsive planning and adaptation.

2.1. Vulnerability and population change

There are many factors that influence the vulnerability of our municipalities and settlements, some of which are unpacked in the following section. The current vulnerabilities for the Bojanala Platinum District, its local municipalities, and settlements are profiled using a framework which sets out indicators that can be used to profile the multi-dimensional and context-specific inherent vulnerability of settlements and municipalities in South Africa. The framework describes and quantifies, where possible, the inherent vulnerability of people, infrastructure, services, economic activities, and natural resources by setting out context and location-specific indicators that were specifically designed to support vulnerability risk assessments of South African municipalities. Population changes drive vulnerability into the future, and therefore population growth and decline of settlements across the District are projected to 2050. Spatial population projections are integral in determining the potential exposure and vulnerability of a population to hazards.

2.1.1. Municipal vulnerability

Municipal vulnerability is unpacked in terms of four vulnerability indices, each of which are described below and in Table 1, the vulnerability scores are provided for each of the municipalities in Bojanala Platinum District.

The Socio-Economic Vulnerability Index (SEVI) shows the vulnerability of households living in the municipality with regards to household composition, income composition, education, mobility, health, access to basic services, access to social government services, political instability, and safety and security of households. A high vulnerability score indicates municipalities that house a high number of vulnerable households with regards to their ability to withstand adverse shocks from the external environment.

The Economic Vulnerability Index (EcVI) speaks toward the economic resilience of the municipality, and considers economic sector diversification, the size of economy, labour force, the GDP growth/decline pressure experienced in the municipality, as well as the inequality present in the municipality. The higher the economic vulnerability the more susceptible these municipalities are to being adversely affected by external shocks.

The Physical Vulnerability Index (PVI) relates to the built environment and the connectedness of the settlements in the local municipality. It is a composite indicator that considers road infrastructure, housing types, the maintenance of the infrastructure, densities, and general accessibility. A high physical vulnerability score highlights areas of remoteness and or areas with structural vulnerabilities.

The Environmental Vulnerability Index (EnVI) highlights municipalities where there is a high conflict between preserving the natural environment and accommodating the growth pressures associated with population growth, urbanisation, and economic development. The index considers the human influence on the environment, the amount of ecological infrastructure present that needs protection, the presence of critical water resources, environmental health, and environmental governance. A high vulnerability score highlights municipalities that experience increasing pressure relating to protecting the environment and allowing land use change due to growth pressures.

Each Local Municipality in the Bojanala Platinum District is provided a score out of 10 for each of the vulnerability indices. A score higher than 5 indicates an above national average, and a score lower than 5 indicates a below national average for vulnerability. Scores are provided for both 1996 and 2011, where a lower score in 2011 compared to 1996 indicates an improvement and a higher score indicates worsening vulnerability. Trend data are only available for Socio-Economic Vulnerability and Economic Vulnerability

Table 1: Vulnerability indicators across Bojanala Platinum District Municipality for 1996 to 2011

MUNICIPALITY CODE	MUNICIPALITY	SEV96	SEV11	Trend	EVI96	EVI11	Trend	PV	Trend	EV	Trend
NW374	Kgetlengrivier	6.13	4.45	↘	7.28	8.46	↗	6.57	↗	3.71	No Trend
NW372	Local Municipality of Madibeng	5.47	3.73	↘	5.60	8.04	↗	8.17	↗	4.85	No Trend
NW371	Moretele	6.16	5.48	↘	6.17	6.39	↗	6.24	↘	3.56	No Trend
NW375	Moses Kotane	5.87	4.49	↘	7.36	8.18	↗	7.92	↗	4.38	No Trend
NW373	Rustenburg	5.08	2.32	↘	6.22	8.49	↗	6.80	↘	6.19	No Trend

Socio-economic vulnerability has decreased (improved) across all LMs between 1996 and 2011. All LMs however experienced an upward trend in economic vulnerability. Rustenburg and Kgetlengrivier are the two LM's which have the highest economic vulnerability in the District. Rustenburg LM has the 2nd highest economic vulnerability in the North West Province. This is mainly due to its rapid population and economic growth caused by the growth in its platinum mining industry. A population growth rate of 3.0% between 2010 and 2022, high population density (an average of 210 people per square km) and rising unemployment contribute to the economic vulnerability of the Rustenburg region (IDP, 2023).

Moreover, Rustenburg also has a very high environmental vulnerability, which is the highest in the province. Rivers, watercourses, streams, dams and wetlands are under severe pressure of pollution and degradation due to mining. Mining activities also impact on soil and air quality. Alien invasive species encroachment, bush encroachment and, harvesting, poaching and trading in indigenous species also place significant pressures on biodiversity.

2.1.2. Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlements within the Bojanala Platinum District and its local municipalities, with regards to six composite indicators. This enables the investigation of the relative vulnerabilities of settlements within the district.

A high vulnerability score (closer to 10) indicates a scenario where an undesirable state is present e.g., low access to services, high socio-economic vulnerabilities, poor regional connectivity, environmental pressure or high economic pressures. An indicator of growth pressure, providing a temporal dimension (15-year trend), was added to show which settlements were experiencing growth pressures on top of the other dimensional vulnerabilities up until 2011.

The Socio-Economic Vulnerability Index comprises of three indicators (and eight variables) that show the vulnerability of households occupying a specific settlement with regards to their (1) household composition (household size, age dependency, female/child headed household), (2) income composition (poverty level, unemployment status, and grant dependency of the households), as well as (3) their education (literacy and level of education).

The Economic Vulnerability Index comprises of five variables grouped into three indicators that highlight the economic vulnerability of each settlement with regards to (1) its size (GDP per capita and GDP production rates), (2) the active labour force (taking note of unemployed and discouraged work seekers), and (3) the GDP growth rate for the past 15 years.

The Environmental Vulnerability Index considers the footprint composition of the settlement taking the ration of built-up versus open spaces into account.

The Growth-Pressure Vulnerability Index shows the relative (1996-2011 growth rates) and anticipated pressure on settlements.

The Regional Economic Connectivity Vulnerability Index looks at the regional infrastructure of each settlement (measured through a remoteness/accessibility index), as well as the role of the town in terms of its regional economy.

The Service Access Vulnerability Index comprises of 10 variables grouped into four indictors, that show the level of services offered and rendered within a settlement and includes the settlement's (1) access to basic services (electricity, water, sanitation, and refuse removal), (2) settlement's access to social and government services (health access, emergency service access, access to schools, and early childhood development), (3) access to higher order education facilities, and (4) access to adequate housing.

A brief description of each local municipality within the district follows below. Settlement-level vulnerability is assessed within the context of a specific local municipality, comparing vulnerabilities among the settlements within that municipality rather than with settlements outside of it.

Kgetlengrivier Local Municipality

The major settlements in this municipality are Koster, Swartruggens and Derby. The settlement facing the greatest growth pressure is Swartruggens, which also has very high socio-economic vulnerability. Koster has the greatest regional connectivity vulnerability in the municipality, while Derby has the greatest service access vulnerability in the municipality.

Local Municipality of Madibeng

The major settlements in this municipality are Brits, Hartebeespoort, Letlhabile, Maboloka and Mooinooi. Brits is facing the greatest growth pressure in the municipality. Hartebeespoort has both a very high service access and economic vulnerability. Maboloka has the highest socio-economic vulnerability in the municipality, combined with a very high environmental vulnerability.

Moretele Local Municipality

This municipality is predominantly made up of traditional areas, which also faces the greatest growth pressures. The major settlements are Mogogelo, Mathibestad, Makapanstad and Lebotlwana. Lebotlwana has very high economic, socio-economic and environmental vulnerability. Lebotlwana together with Makapanstad and Mogogelo, is also subject to poor regional connectivity.

Moses Kotane

This municipality is mostly rural in nature, with over 90% of the municipality characterized by traditional areas. The two major settlements are Mogwase and Madikwe. Other smaller settlements are Ledig, Moreteletsi, Moruleng and Makgope. Madikwe faces very high economic, socio-economic, and environmental vulnerability. Ledig and Makgopa experiences the highest growth pressure in the municipality.

Rustenburg Local Municipality

The major settlements in this municipality are Rustenburg, Boitekong, Hartbeesfontein, and Marikana. Rustenburg and Boitekong experiences the highest growth in the municipality. Boitekong also faces high environmental vulnerability. Hartbeesfontein has the highest socio-economic vulnerability in the LM.

2.1.3. Population growth pressure

The core modelling components of the settlement growth model are the demographic model and the population potential gravity model. The demographic model produces the long-term projected population values at the national, provincial, and municipal scale using the Spectrum and Cohort-Component models. The spatially-coarse demographic projections were fed into the population potential gravity model, a gravity model that uses a population potential surface to downscale the national population projections, resulting in 1x1 km resolution projected population grids for 2030 and 2050. The availability of a gridded population dataset for past, current and future populations enables the assessment of expected changes in the spatial concentration, distribution, and movement of people.

Using the innovative settlement footprint data layer created by the CSIR, which delineates built-up areas, settlement-scale population projections were aggregated up from the 1 x 1 km grids of South African projected population for a 2030 and 2050 medium and high growth scenario. These two population growth scenarios (medium and high) are differentiated based on assumptions of their in- and out-migration assumptions. The medium growth scenario (Table 2) assumes that the peak of population influx from more distant and neighbouring African countries into South Africa has already taken place. The high growth scenario assumes that the peak of migrant influx is yet to happen.

Table 2: Settlement population growth pressure across Bojanala Platinum District Municipality

Population per municipality	2011	Medium Growth Scenario	
		2030	2050
Kgetlengrivier	51 041	79 107	102 207
Madibeng	475 780	699 103	871 168
Moretele	188 505	178 947	133 123
Moses Kotane	242 549	224 854	162 984
Rustenburg	549 555	852 597	1 120 701
Bojanala Platinum DM Total	1 507 430	2 034 608	2 390 183

According to the 2022 Census, the district has a current population of 1 624 144. The District's population is projected to increase by 58 % between 2011 and 2050, under a medium growth scenario. Most of this growth will take place in the settlements within Rustenburg, Kgetlengrivier and Madibeng LMs. Figure 3 depicts the growth pressures that the settlements across the district are likely to experience. The settlements that are likely to experience extreme growth pressures up to 2050, include Rustenburg, Mmakau, Klipgat, Swartruggens and Koster.

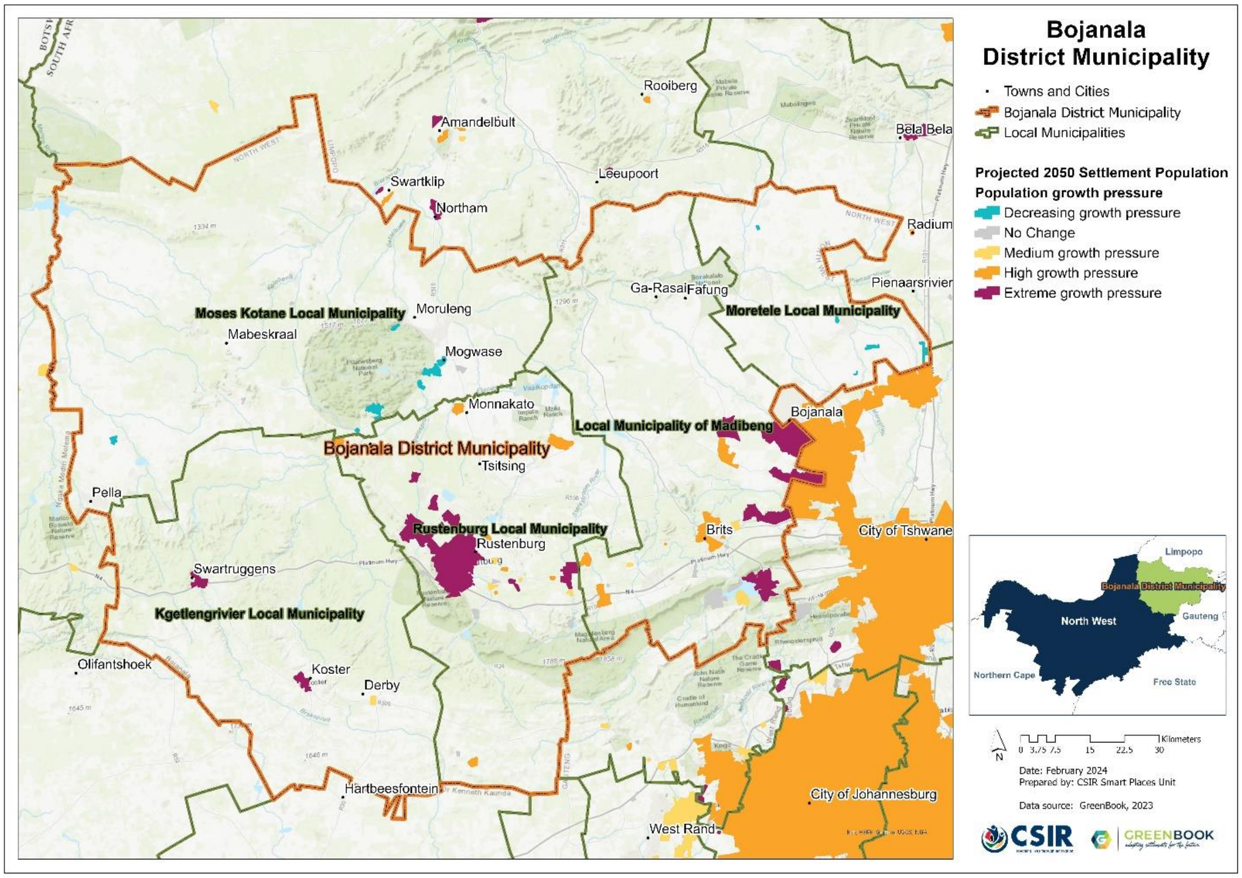

Figure 3: Settlement-level population growth pressure across Bojanala Platinum District Municipality

2.2. Climate

An ensemble of very high-resolution climate model simulations of present-day climate and projections of future climate change over South Africa has been performed as part of the GreenBook. The regional climate model used is the Conformal-Cubic Atmospheric Model (CCAM), a variable-resolution Global Climate Model (GCM) developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). CCAM runs coupled to a dynamic land-surface model CABLE (CSIRO Atmosphere Biosphere Land Exchange model). GCM simulations of the Coupled Model Inter-Comparison Project 5 (CMIP5) and the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), obtained for the emission scenarios described by Representative Concentration Pathways 4.5 and 8.5 (RCP 4.5 and RCP 8.5) were first downscaled to 50 km resolution globally. The simulations span the period 1960–2100. RCP 4.5 is a high mitigation scenario (assuming a reduction in CO_2 emissions into the future), whilst RCP 8.5 is a low mitigation scenario (assuming "business as usual" emissions).

After completion of the 50 km resolution simulations described above, CCAM was integrated in stretched-grid mode over South Africa, at a resolution of 8 x 8 km (approximately 0.08° degrees in latitude and longitude). The model integrations performed at a resolution of 8 km over South Africa offer a number of advantages over the 50 km resolution simulations:

a) Convective rainfall is partially resolved in the 8 km simulations, implying that the model is less dependent on statistics to simulate this intricate aspect of the atmospheric dynamics and physics.
b) Important topographic features such the southern and eastern escarpments are much better resolved in the 8 km resolution simulations, implying that the topographic forcing of temperatures, wind patterns and convective rainfall can be simulated more realistically.

For more information on the climate simulations, see the GreenBook Climate Change Story Map and the full technical report.

For each of the climate variables discussed below:
a) The simulated baseline (also termed “current” climatological) state over South Africa calculated for the period 1961–1990 is shown (note that the median of the 6 downscaled GCMs are shown in this case).
b) The projected changes in the variable are subsequently shown, for the time-slab 2021–2050 relative to the baseline period 1961-1990.
c) An RCP 8.5 scenario (low mitigation) is shown.

2.2.1.Temperature

The model was used to simulate average annual average temperatures (°C) for the baseline (current) period of 1961–1990, and the projected change for period 2021–2050 under a RCP8.5 mitigation scenario.

The BDM experiences average annual temperatures ranging between 16 and 20 °C, with higher averages found towards the northwestern part of the district close to the neighbouring Botswana (Figure 4). The projections show average annual temperature increases of between 2.8°C and 3.2°C across the district into the future, under a low mitigation, high emissions, scenario (Figure 5). The greatest increases are expected in the northern areas of the district with lower increases towards the south of the district.

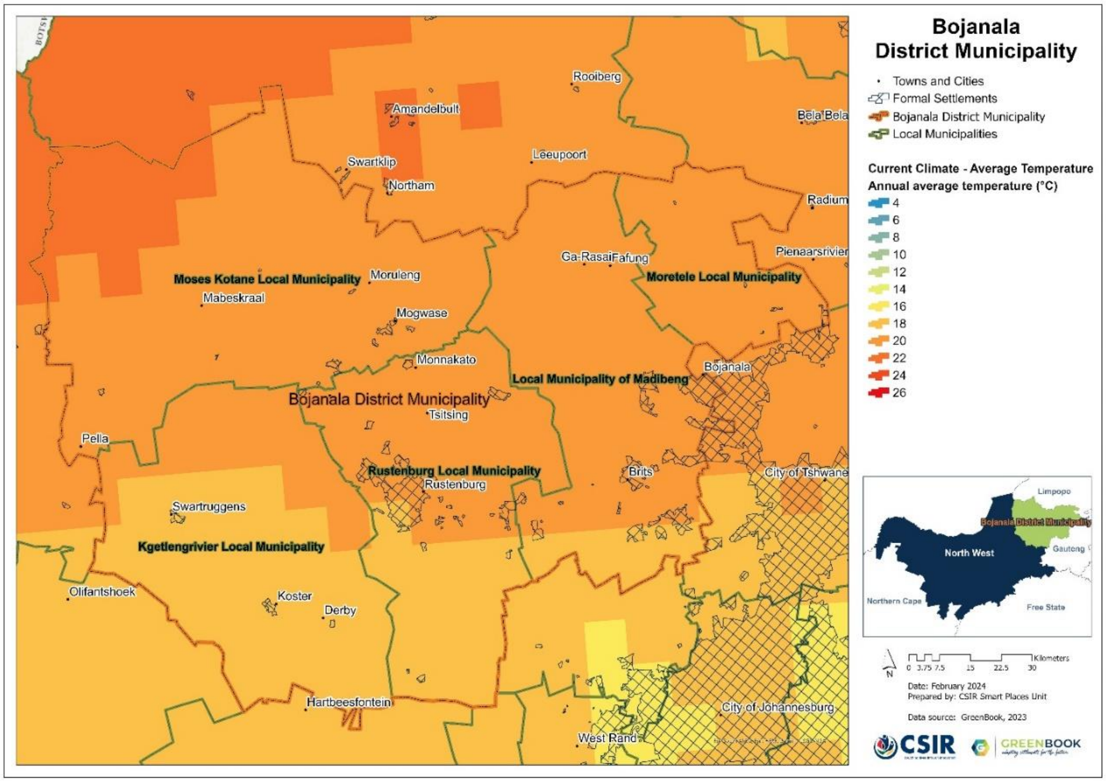

Figure 4: Average annual temperature (°C) for the baseline period 1961-1990 for Bojanala Platinum District Municipality

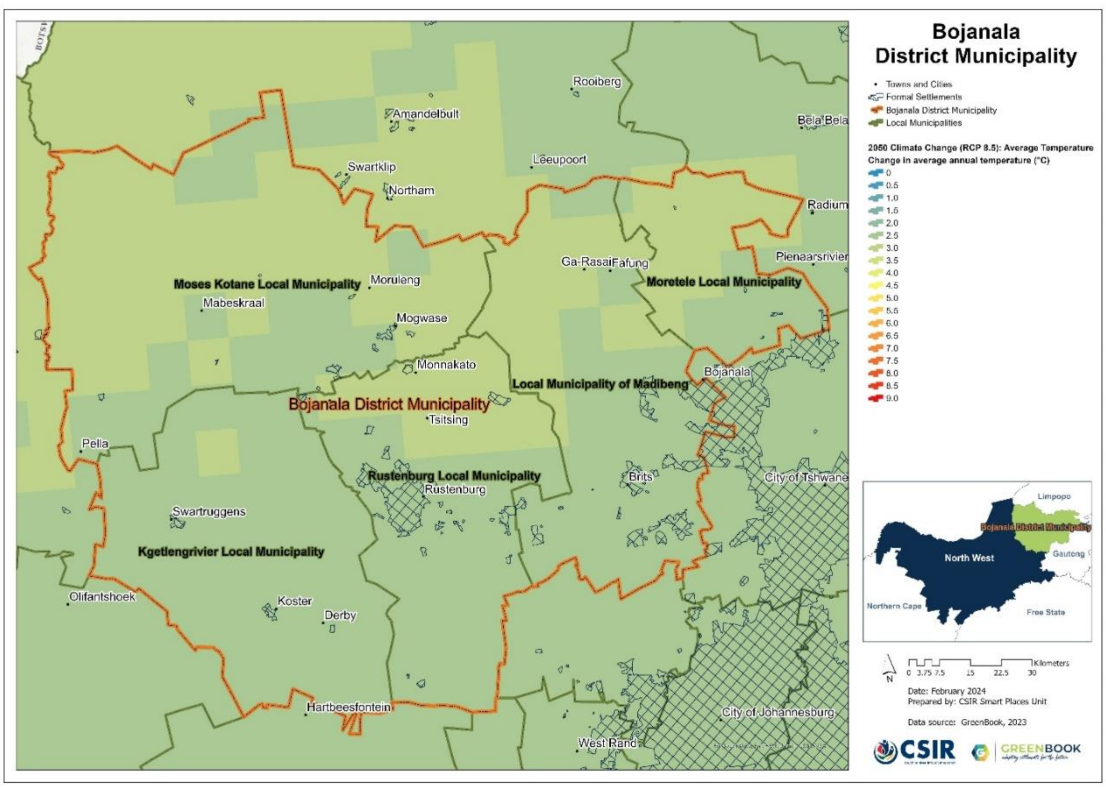

Figure 5: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for Bojanala Platinum District Municipality, assuming an RCP 8.5 emissions pathway

2.2.2. Rainfall

The multiple GCMs were used to simulate average annual rainfall (depicted in mm) for the baseline (current) period of 1961–1990, and the projected change from the baseline to the period 2021–2050 under an RCP8.5 emissions scenario. Model projections of precipitation manifest uncertain due to several factors, including model sensitivity to spatial resolution at which processes are resolved. At 8 X 8km horizontal resolution, for example, some processes (such as convective systems) that contribute to rainfall are not adequately resolved by the climate models. The precipitation projections therefore could reflect uncertainty in some locations since fine-scale processes that contribute to precipitation and its extremes are not captured. When the modelling ensemble approach used in the online GreenBook is considered, and the 10th, 50th and 90th percentiles, per grid point, agree on the directional change relative to the reference period, the signal is considered well developed and conclusive. In the case where the respective model percentiles show conflicting signs, the model ensemble manifest uncertainty and therefore reflect low confidence on which future model realisation/outcome is more likely. It is therefore critical to consider the ensemble distribution uncertainty when devising long-term adaptation strategies.

The BPDM experiences current GCM derived average annual rainfall of between 700 and 1000 mm, with higher averages found over the mountainous areas of the Pilanesburg. Lower rainfall is experienced in the northern parts of the Moses Kotane municipality towards the Limpopo province (Figure 6). Future projections show an average annual rainfall increase of up to 110 mm over parts of the Moses Kotane district, under a low mitigation, high emissions, scenario. Minor increases are projected in the eastern parts of the District (Figure 7).

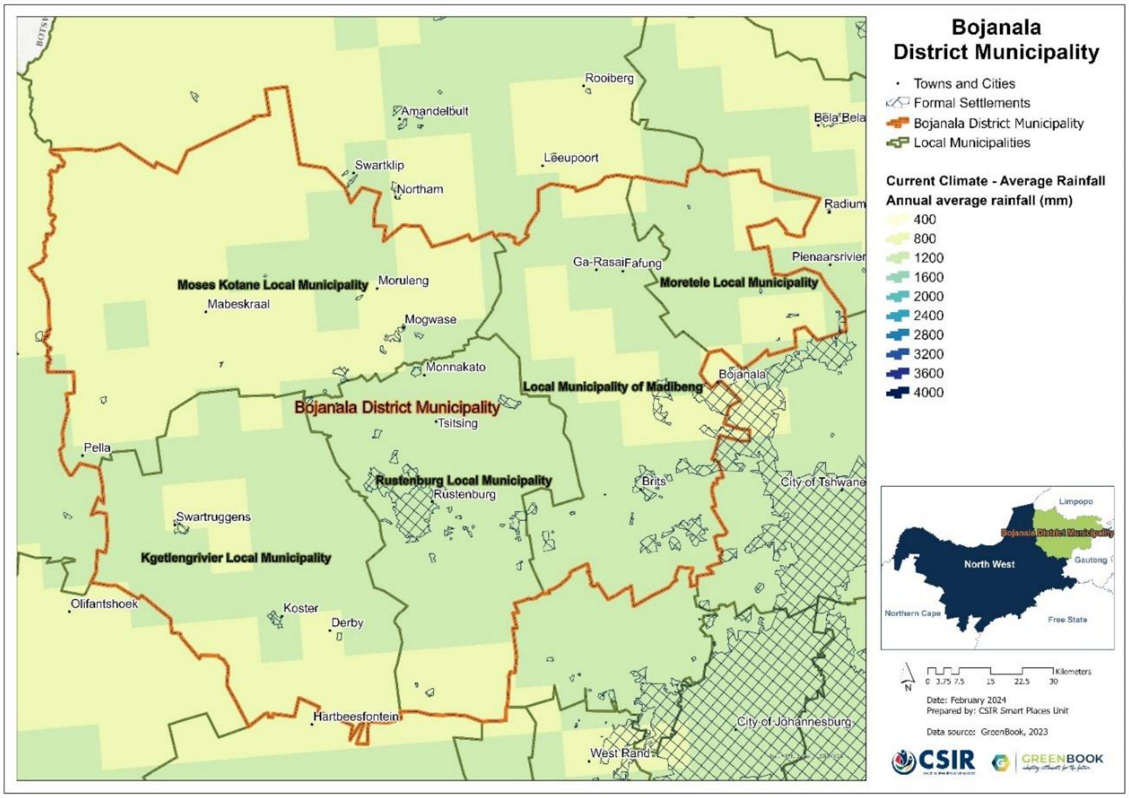

Figure 6: Average annual rainfall (mm) for the baseline period 1961-1990 for Bojanala Platinum District Municipality

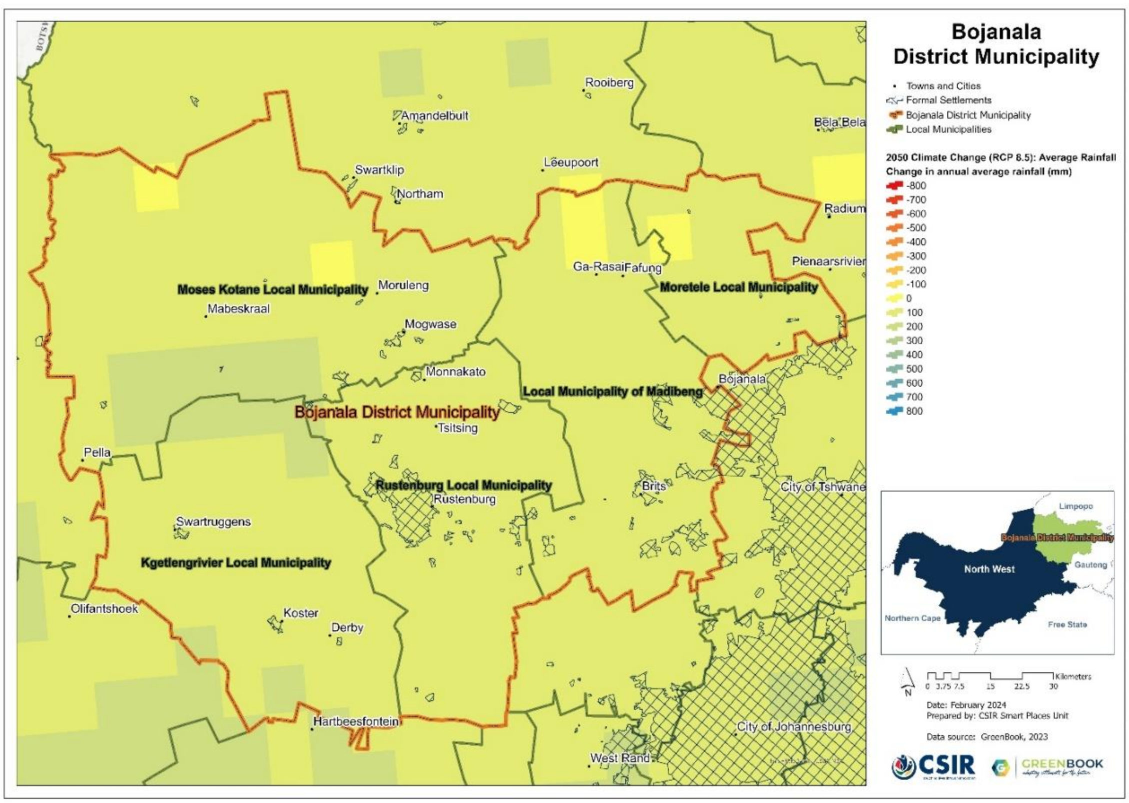

Figure 7: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for Bojanala Platinum District Municipality, assuming an RCP8.5 emission pathway

2.3. Climate Hazards

This section showcases information with regards to Bojanala Platinum District Municipality's' exposure to climate-related hazards.

2.3.1. Drought

The southern African region (particularly many parts of South Africa) is projected to become generally drier under enhanced anthropogenic forcing, with an associated increase in dry spells and droughts. To characterise the extent, severity, duration, and time evolution of drought over South Africa, the GreenBook uses primarily the Standardised Precipitation Index (SPI), which is recommended by the World Meteorological Organisation (WMO) and is also acknowledged as a universal meteorological drought index by the Lincoln Declaration on Drought. The SPI, with a two-parameter gamma distribution fit with maximum likelihood estimates of the shape and scale parameters, was applied on monthly rainfall accumulations for a 3-, 6-, 12-, 24- and 36-months base period. The SPI severity index is interpreted in the context of negative values indicating droughts and positive values indicating floods. These values range from exceptionally drier (<-2.0) or wetter (>2.0) to near-normal (region bounded within -0.5 and 0.5).

Figure 8 depicts the projected change in drought tendencies (i.e., the number of cases exceeding near-normal per decade) for the period 1995-2024, relative to the 1986-2005 baseline period, under an RCP 8.5 "business as usual" emissions scenario (RCP 8.5). A negative value is indicative of an increase in drought tendencies per 10 years (more frequent than the observed baseline) with a positive value indicative of a decrease in drought tendencies. Figure 9 depicts the projected change in drought tendencies (i.e., the number of cases exceeding near-normal per decade) for the period 2015–2044 relative to the 1986–2005 baseline period, under the low mitigation "business as usual" emissions scenario (RCP 8.5). A negative value is indicative of an increase in drought tendencies per 10 years (more frequent than baseline) into the future and a positive value indicative of a decrease. Figure 10 depicts the settlements that are at risk of increases in drought tendencies.

Near-normal drought tendencies are found across the district, and tendencies are projected to increase into the future. All settlements across the Bojanala Platinum District are at risk of drought. At the baseline, the far northern parts of the District are exposed to higher drought tendencies, which are projected to increase and expand further southwards into the future.

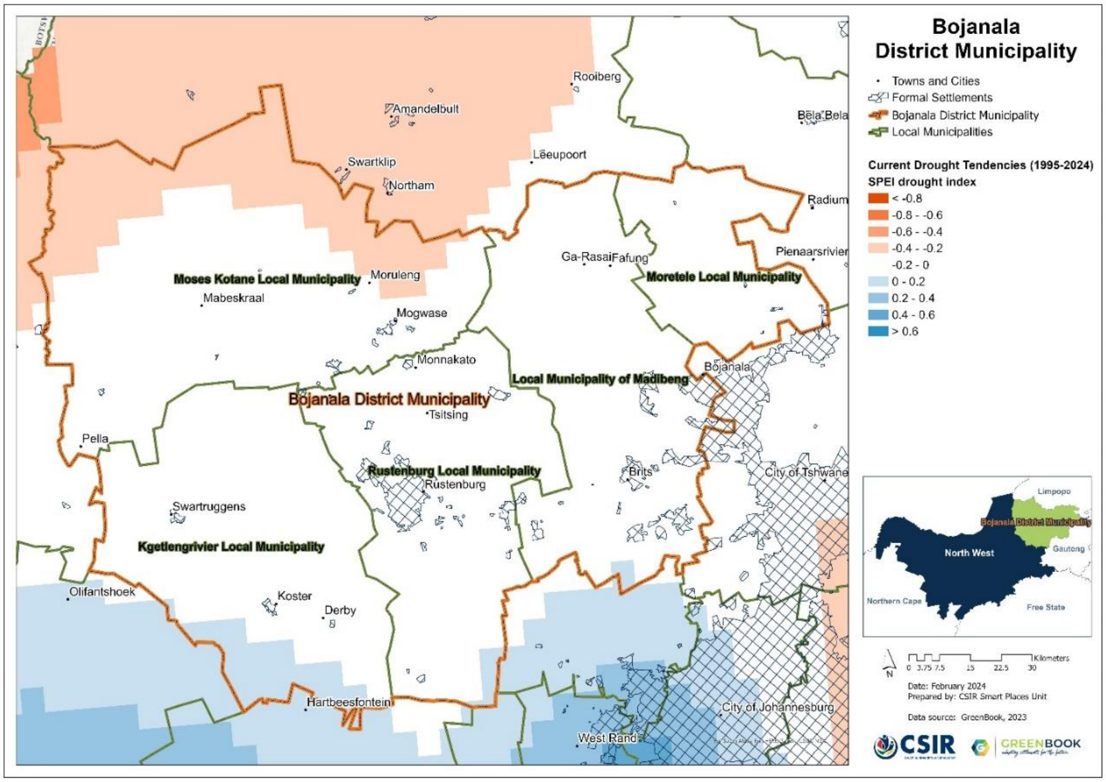

Figure 8: Projected changes in drought tendencies from the baseline period (1986–2005) to the current period (1995-2024) across Bojanala Platinum District Municipality

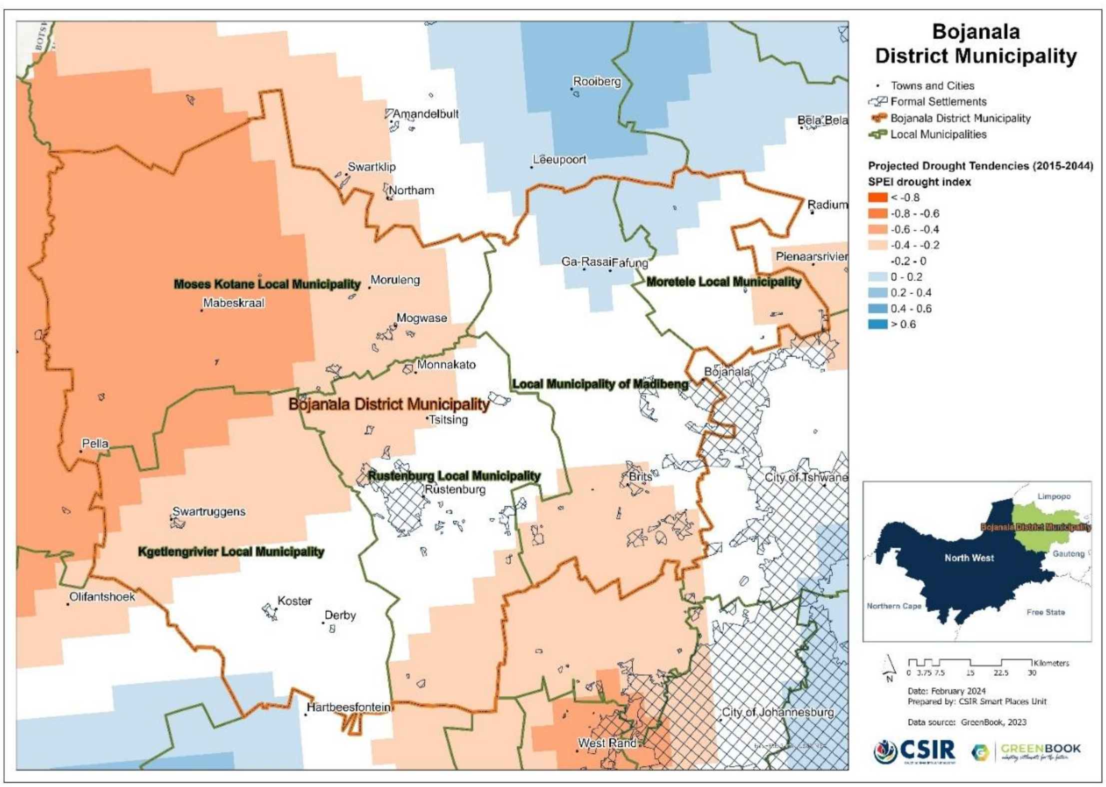

Figure 9: Projected changes in drought tendencies from the baseline period (1986–2005) to the future period 2015-2044 for Bojanala Platinum District Municipality

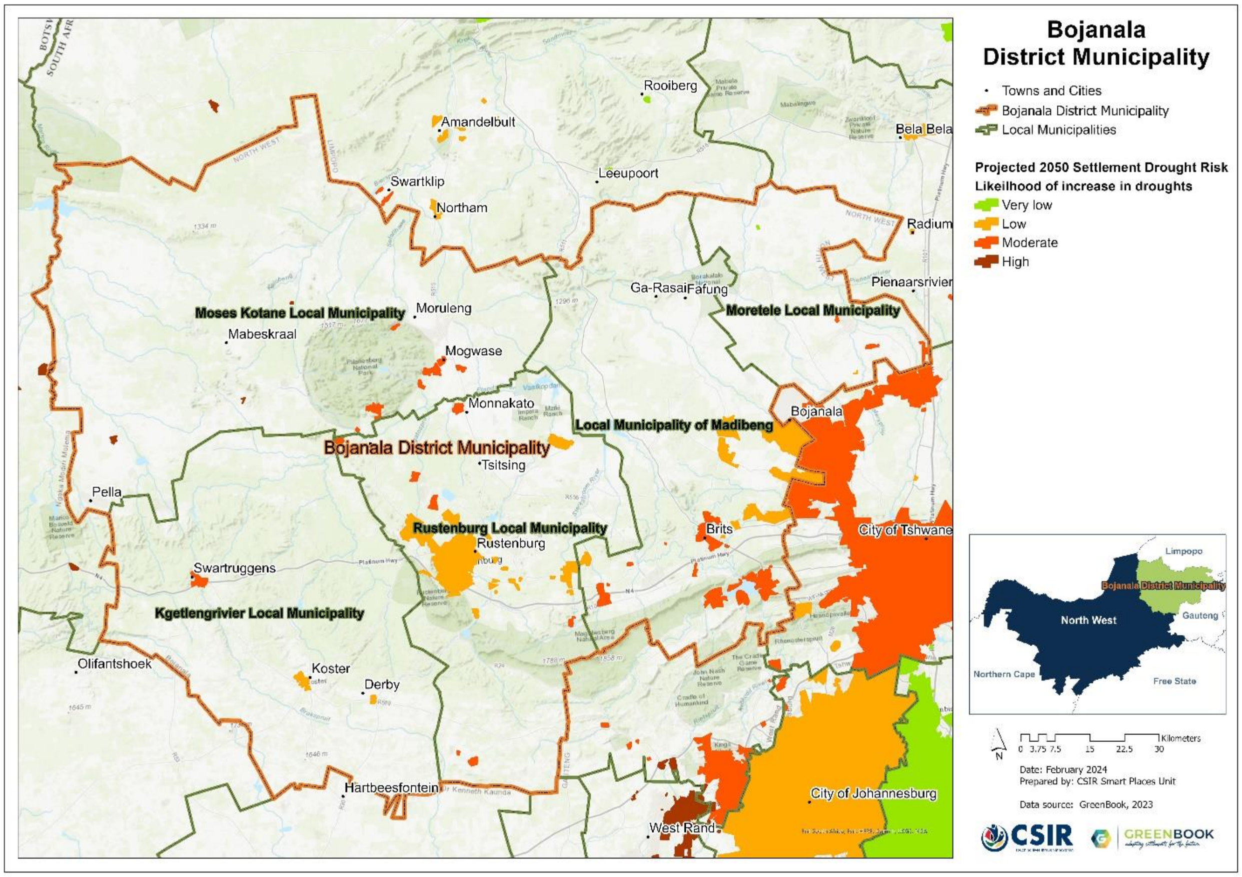

Figure 10: Settlement-level drought risk for Bojanala Platinum District Municipality

2.3.2. Heat

With the changing climate, it is expected that the impacts of heat will only increase in the future. The heat-absorbing qualities of built-up urban areas make them, and the people living inside them, especially vulnerable to increasingly high temperatures. The combination of the increasing number of very hot days and heatwave days over certain parts of South Africa is likely to significantly increase the risk of extreme heat in several settlements.

The GCMs were used to simulate bias-corrected, annual average number of very hot days, defined as days when the maximum temperature exceeds 35° C per GCM grid point for the baseline (current) period of 1961–1990 (Figure 11), and for the projected changes for period 2021–2050 (Figure 12). The annual heatwave days map under baseline conditions (Figure 13) depicts the number of days (per 8x8 km grid point) where the maximum temperature exceeds the average maximum temperature of the warmest month of the year at that location by at least 5°C for a period of at least three consecutive days. The projected change in the number of days belonging to a heatwave for the period 2021–2050 (Figure 14), assuming a "business as usual" (RCP 8.5) emissions pathway is also shown.

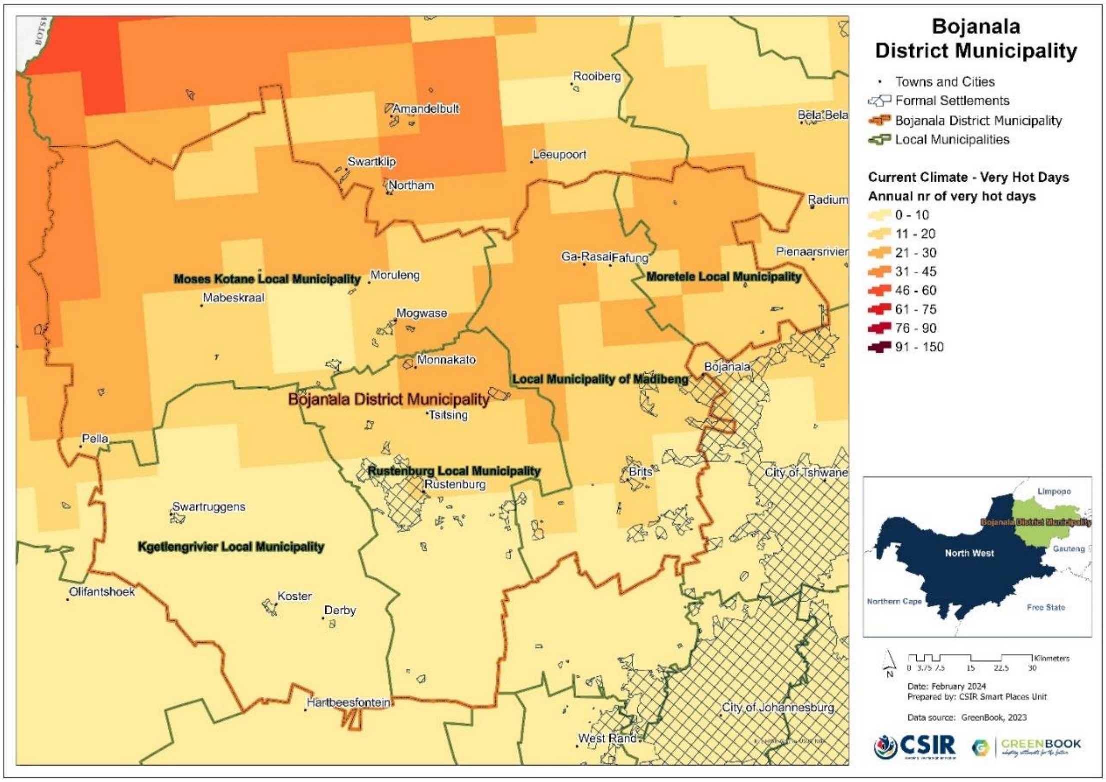

Figure 11: Annual number of very hot days under baseline climatic conditions across Bojanala Platinum District Municipality with daily temperature maxima exceeding 35°C

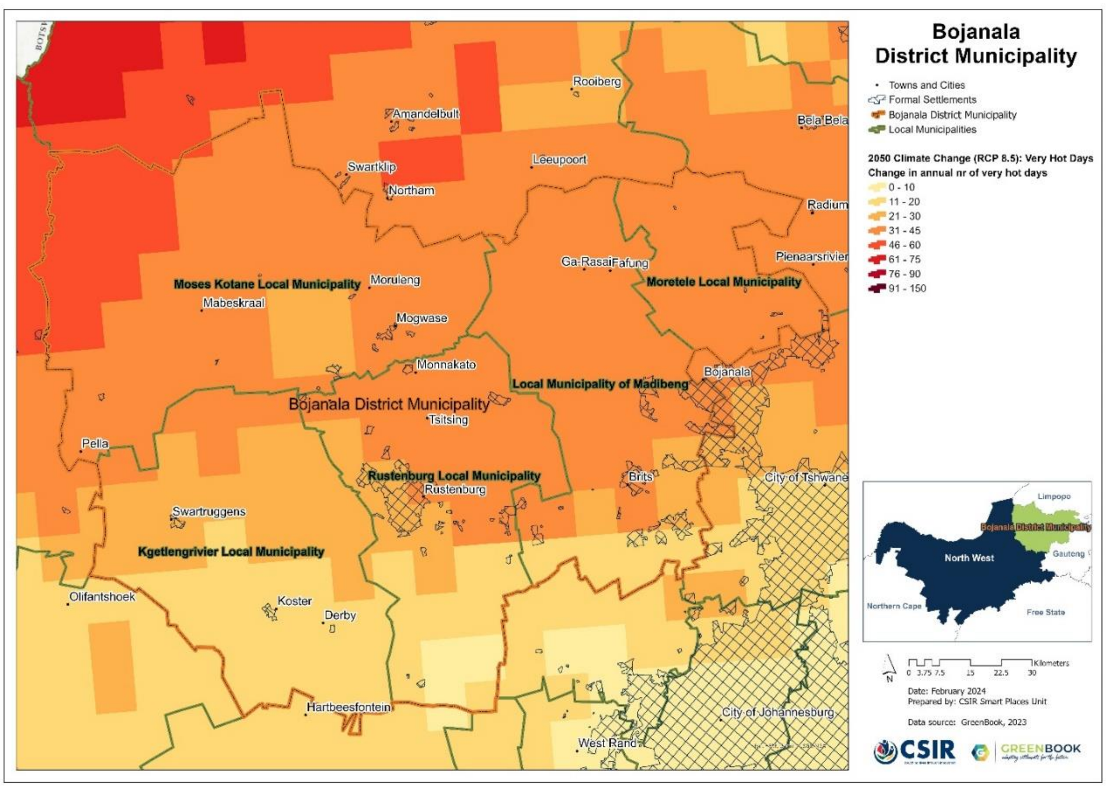

Figure 12: Projected change in annual number of very hot days across Bojanala Platinum District Municipality with daily temperature maxima exceeding 35°C , assuming and RCP 8.5 emissions pathway

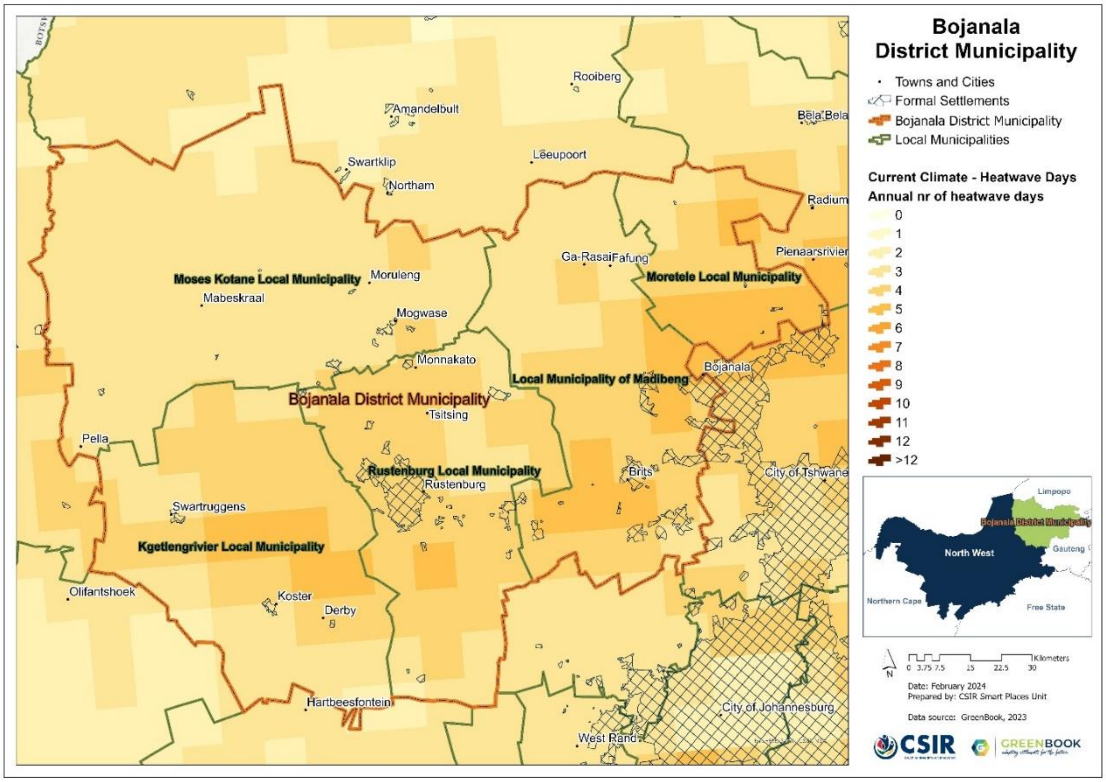

Figure 13: Number of heatwave days under baseline climatic conditions across Bojanala Platinum District Municipality

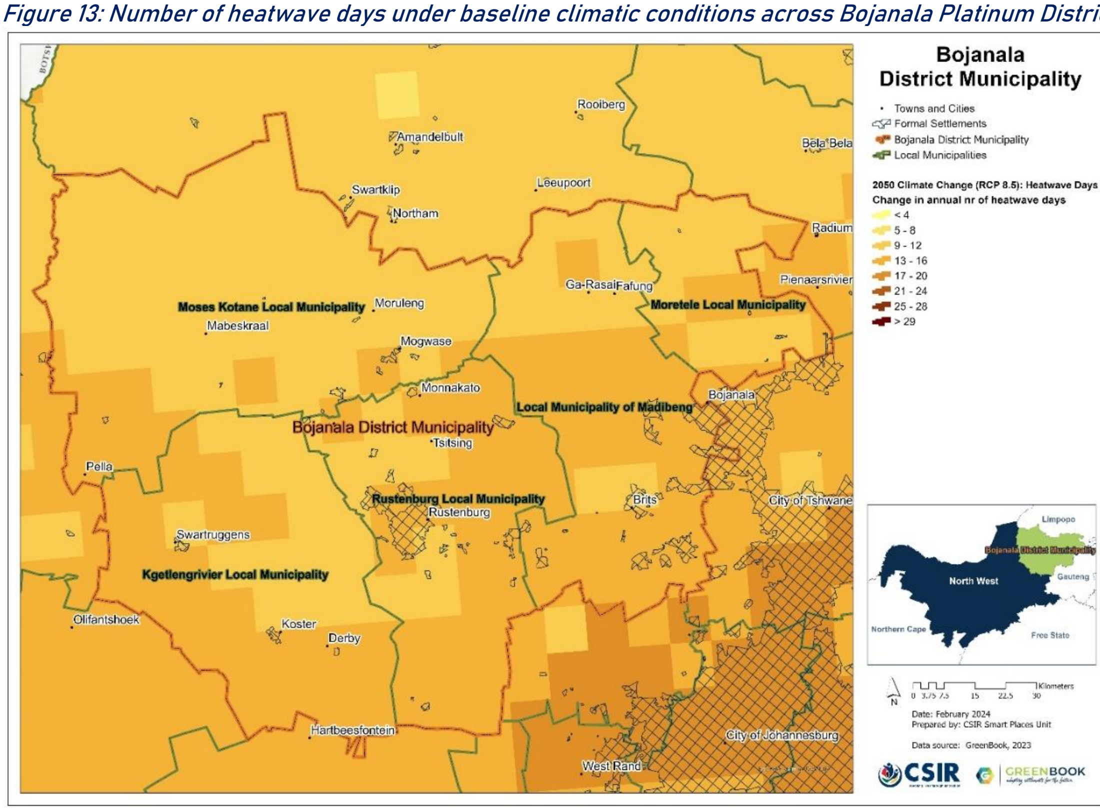

Figure 14: Projected change in annual number of heatwave days across Bojanala Platinum District Municipality, assuming an (RCP 8.5) emissions pathway

Under baseline climatic conditions, some areas over the far north of the District experience 40 to 50 very hot days annually, with daily maxima exceeding 35°C. Very hot days are more likely to be experienced in the north of the district near the border with Limpopo province. Heatwave events are more likely to take place in the central parts of the district. The number of very hot days are projected to increase in the areas that are already more likely to experience extreme heat and also expand to the south of the district. Figure 15 depicts the settlements that are at risk of increases in heat stress. Some of the settlements that are projected to be most exposed to heat stress in the future in the District include Swartruggens, Brits and Mogwase.

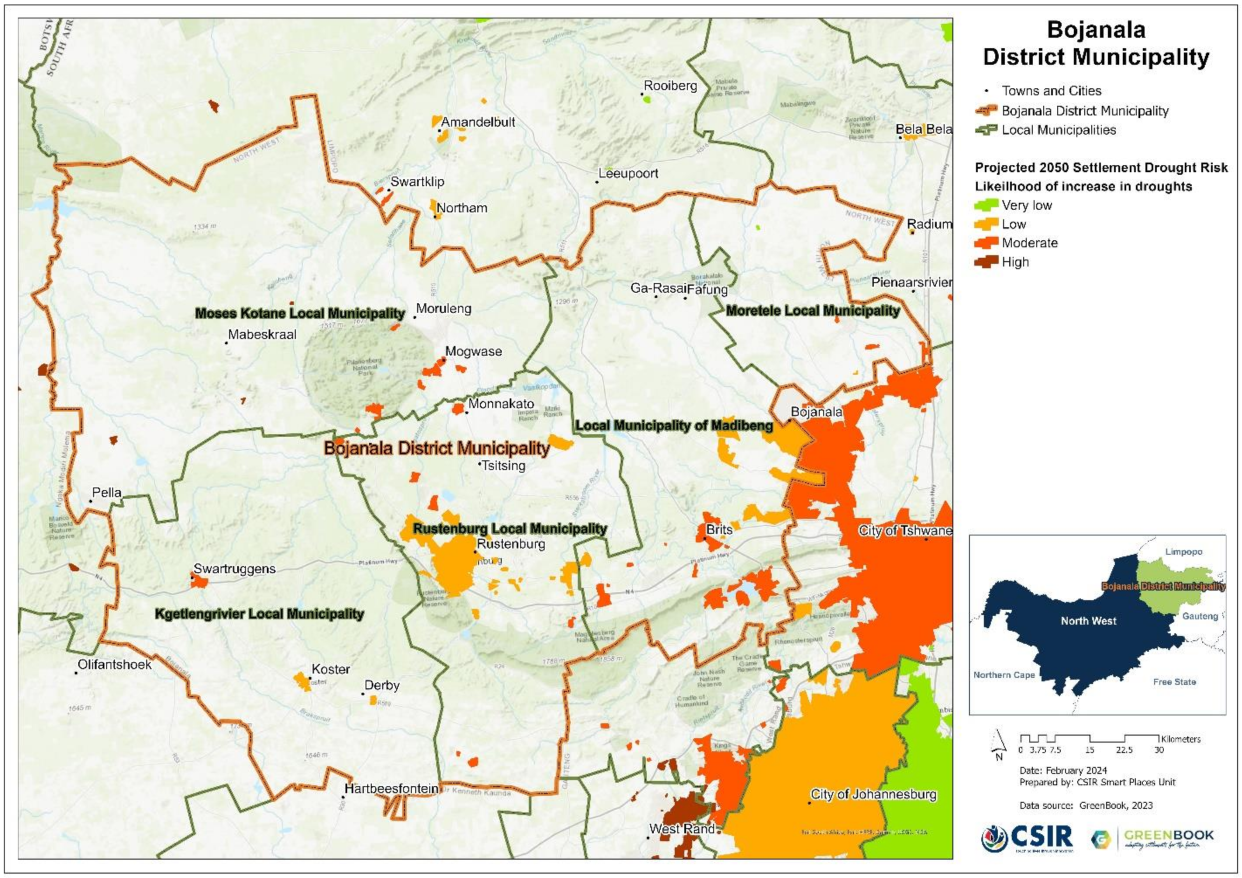

Figure 15: Settlement-level heat risk across Bojanala Platinum District Municipality

2.3.3. Wildfire

Wildfires occur regularly in South Africa and often cause significant damage. The main reasons for recurring wildfires are that we have climates with dry seasons, natural vegetation that produces sufficient fuel, and people who light fires when they should not. Much of the natural vegetation requires fires to maintain the ecosystems and keep them in good condition. At the same time fires are a threat to human lives, livelihoods, and infrastructure. More and more people, assets and infrastructure are placed on the boundary or interface between developed land and fire-prone vegetation – what we call the wildland-urban interface (WUI) – where they are exposed to wildfires. The combination of climate and vegetation characteristics that favour fires, and growing human exposure, results in significant wildfire risk across the country, especially in the southern and eastern parts.

Fire risk is determined by combining the typical fire hazard for a fire-ecotype (i.e., likelihood, fire severity) and the social and economic consequences (i.e., the potential for economic and social losses). The typical fire hazard was used to develop a plausible fire scenario for each fire-ecotype, i.e., what a typical wildfire would be like. The fire scenarios were then combined with the vulnerability to estimate the economic and social consequences. A scale was used where the likelihood was rated from 'rare' to 'almost certain' and the consequences were rated from 'insignificant' to 'catastrophic' to determine a level of fire risk which ranged from 'low' to 'high'. The risks were then summarised for all the settlements within a local authority. Changes in the fire risk in future were accommodated by adjusting either the fire scenarios or the likelihood, or both. Figure 16 depicts the likelihood and the risk of wildfires occurring in the wildland-urban interface (the boundary or interface between developed land and fire-prone vegetation) of the settlement.

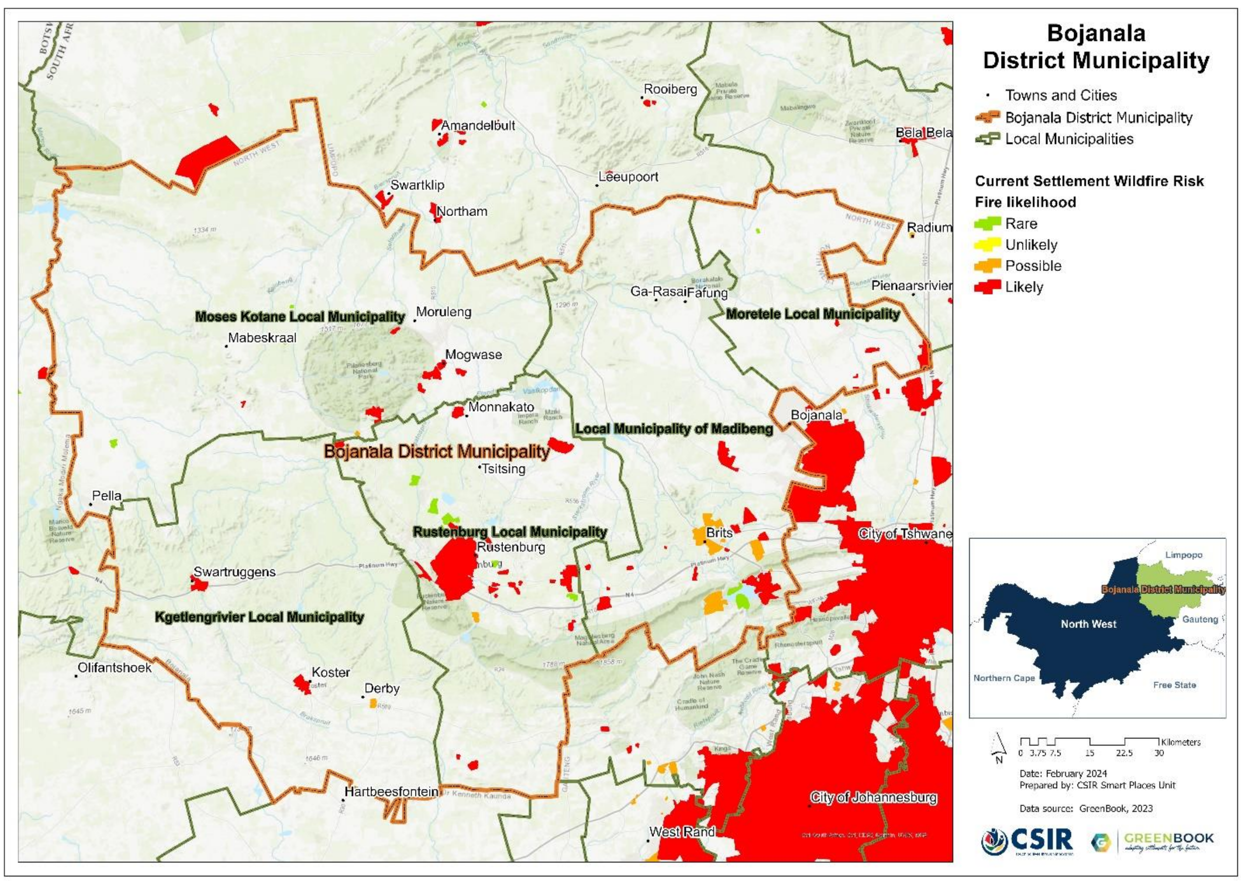

Figure 16 The likelihood of wildfires under current climatic conditions across settlements in Bojanala Platinum District Municipality

The projected number of fire danger days for an 8 x 8 km grid-point under an RCP 8.5 "business as usual" emissions scenario was calculated. A fire danger day is described as a day when the McArthur fire-danger index (McArthur 1967) exceeds a value of 24. The index relates to the chances of a fire starting, its rate of spread, its intensity, and its difficulty of suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long and short-term drought effects. Future settlement risk of wildfires is informed by the projected change in the number of fire danger days. Figure 17 depicts the settlements that could be at risk of increases in wildfires by the year 2050.

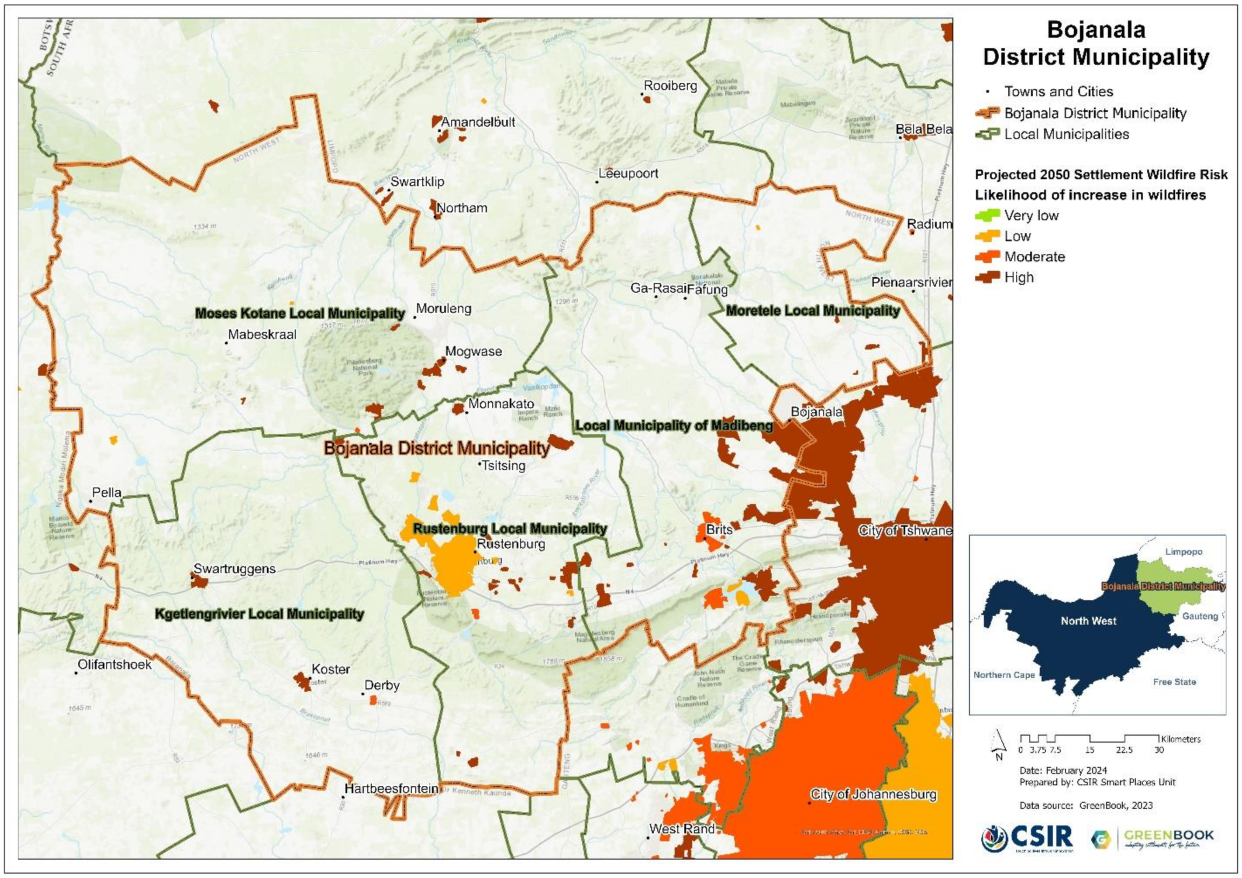

Figure 17: The likelihood of wildfires under projected future climatic conditions across settlements in Bojanala Platinum District Municipality

Most of the settlements across the district face a likely to possible likelihood to experience wildfires on their wildland-urban interface. It is projected that these settlements, could see an increase in risk of wildfires in the future. It is particularly true for settlements such as Mogwase, Swartruggens, Koster, Marikana, and Hartbeespoort.

2.3.4. Flooding

The flood hazard assessment combines information on the climate, observed floods, and the characteristics of water catchments that make them more or less likely to produce a flood. The climate statistics were sourced from the South African Atlas of Climatology and Agrohydrology, and a study of river flows during floods in South Africa (Schulze, 2008). The catchment characteristics that are important are those that regulate the volume and rate of the water flowing down and out of the catchment. The SCIMAP model was used to analyse the hydrological responsiveness and connectivity of the catchments and to calculate a Flood Hazard Index. Changes in the land cover, such as urbanisation, vegetation and land degradation, or poorly managed cultivation, reduce the catchment's capacity to store or retain water. More dynamic changes in land cover could not be considered in this analysis, such as for example, recent informal settlements that may increase exposure and risk. Additional local and contextual information should be considered to further enrich the information provided here.

Since the magnitude and intensity of rainfall are the main drivers of floods, and rainfall intensity is likely to increase into the future, it is projected that flood events are likely to increase into the future. Estimates of the extreme daily rainfall into the future were obtained from high-resolution regional projections of future climate change over South Africa. The settlements that are at risk of an increase in floods were identified using a risk matrix, which considered the flood hazard index and the projected change in extreme rainfall days from 1961-1990 to the 2050s.

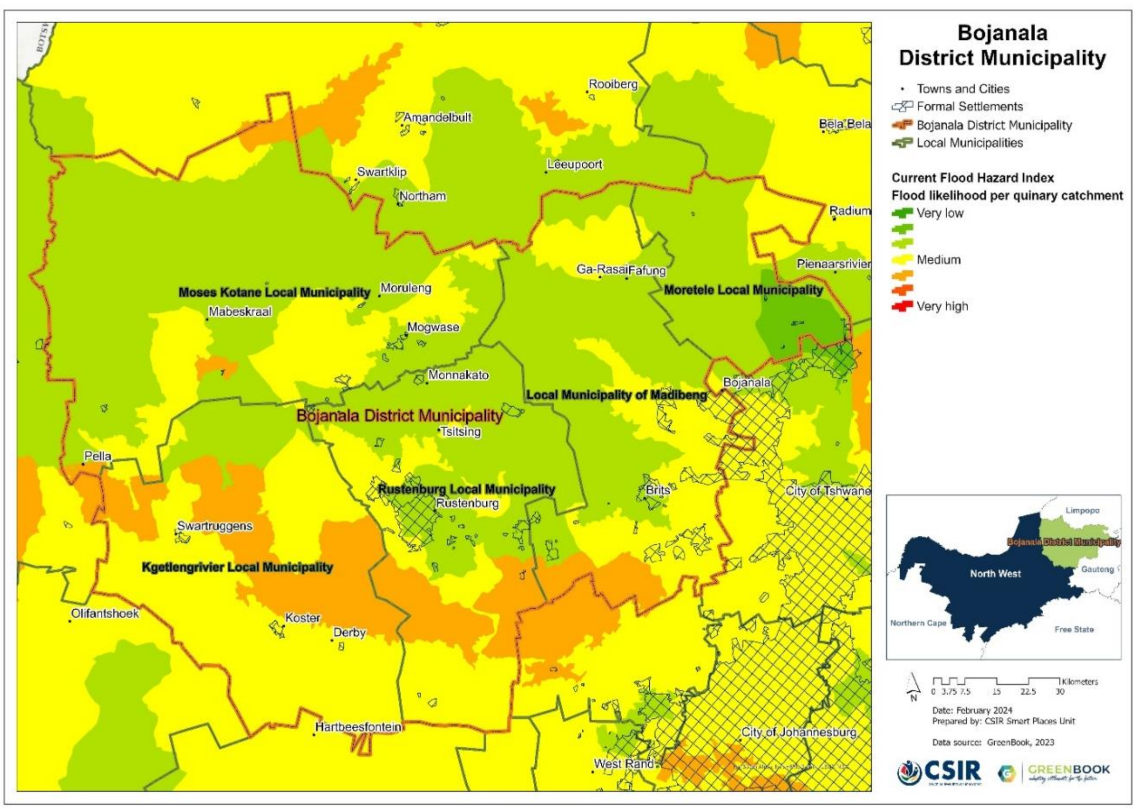

Figure 18: The current flood hazard index across Bojanala Platinum District Municipality under current (baseline) climatic conditions

Figure 18 depicts the flood hazard index of the individual Quinary catchments present or intersecting with the District. The flood hazard index is based on the catchment characteristics and design rainfall, averaged at the Quinary catchment level. Green indicates a low flooding hazard, while red indicates a high flood hazard. There is significant variation of the flood hazard index across the district. Most parts of the district have a low to medium flooding hazard, while areas in Kgetlengrivier and Rustenburg LM's that have a high flooding hazard.

Figure 19 depicts the projected change into the future in extreme rainfall days for an 8 x 8 km grid. This was calculated by assessing the degree of change when projected future rainfall extremes (e.g., 95th percentile of daily rainfall) are compared with those under the current rainfall extremes. A value of more than 1 indicates an increase in extreme daily rainfalls. Most areas of the district are predicted to experience slight increases in the number of extreme rainfall days, with areas in far south east of the Kgetlengriviere municipality that can expect a more significant increase in extreme rainfall days.

Figure 20 depicts the settlements that are at increased risk of flooding under an RCP 8.5 low mitigation (worst case of greenhouse gas emissions) scenario, and these include Swartruggens, Koster, Derby, Rustenburg and Hartbeespoort.

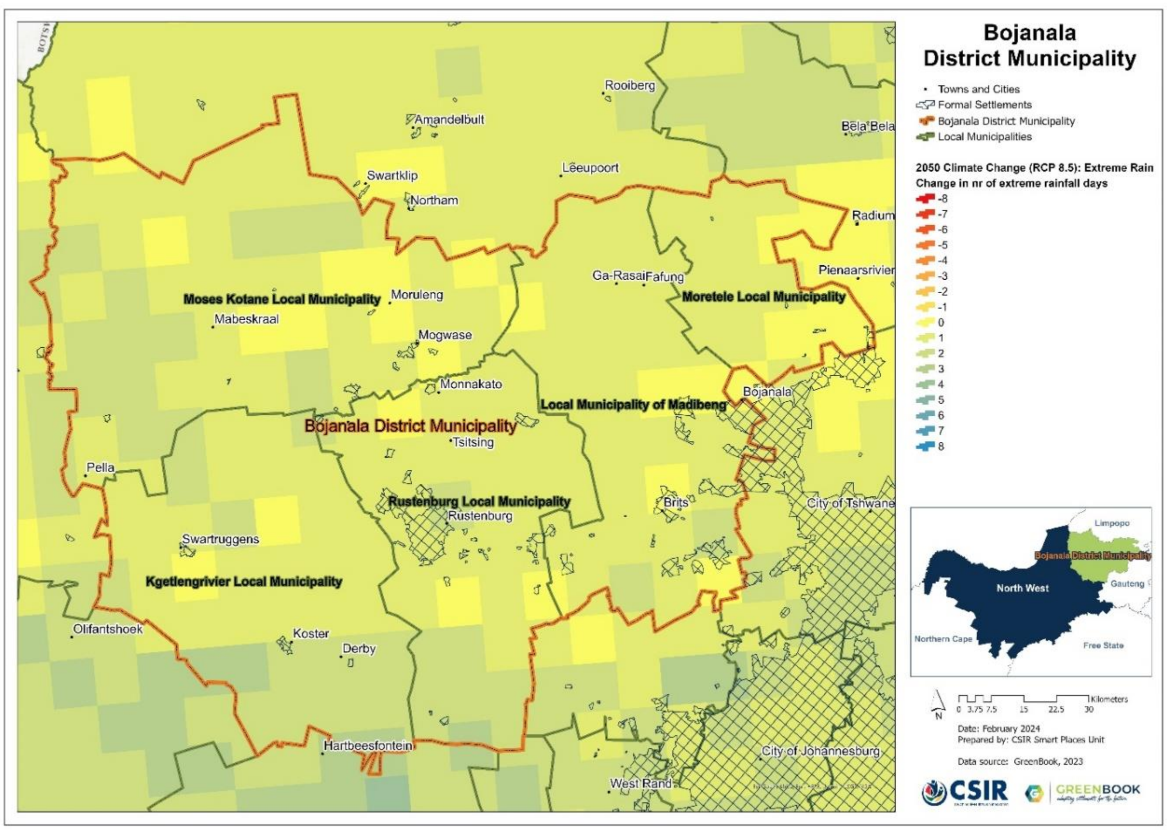

Figure 19: Projected changes into the future in extreme rainfall days across Bojanala Platinum District Municipality

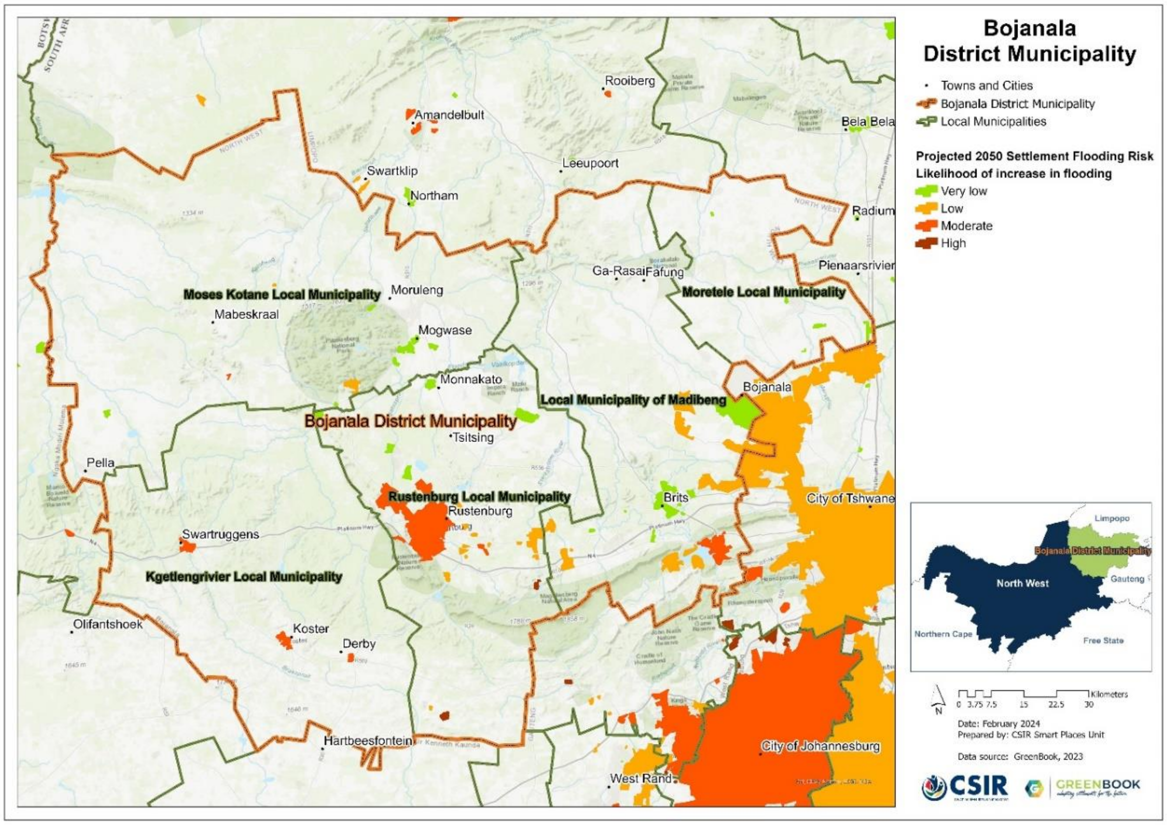

Figure 20: Flood risk into a climate change future at settlement level across Bojanala Platinum District Municipality.

1.1. Climate impacts on key resources and sectors

To understand the impact that climate change might have on major resources, this section explores the impact that climate change is likely to have on the resources and economic sectors of the Bojanala Platinum District Municipality.

1.1.1. Water resources and supply vulnerability

South Africa is a water-scarce country with an average rainfall of approximately 450 mm per year, with significant annual and seasonal variability. Rainfall also varies from over 1900 mm in the east of the country and in the mountainous areas, to almost zero in the west and northwest of the country. Conversion of rainfall to runoff is also low with an average mean annual runoff (MAR) of only 40 mm, one seventh of the global average of 260 mm per year. Runoff is even more highly variable than precipitation, both in space and time. Furthermore, demand for water is not evenly distributed, with most of the major water demand centres located far from the available water resources. This has resulted in a need to store water and to transfer water around the country to meet current and future demands.

Water availability is directly impacted by the climate and climate change. It is not just changes in precipitation that need to be considered, but also increasing temperatures that will lead to increased evaporation which could further reduce runoff and increase water losses from dams.

Increasing temperatures will also impact on water demand, particularly for irrigation, but also from urban and industrial users. This could also contribute to reduced water security if existing systems are not able to meet these increasing demands. Increasing air temperatures will also increase water temperatures and hence increase pollution and water quality risks.

To obtain a high-level first order assessment of the relative climate change risks for water supply to different towns and cities across South Africa, a general risk equation was developed to determine the current and future surface water supply vulnerability that combines both climate change and development risks (i.e., due to an increase in population and demand). The current vulnerability of individual towns was calculated based on the estimated current demand and supply as recorded across the country by the Department of Water and Sanitation's (DWS) All Towns study of 2011 (Cole, 2017). The future vulnerability was calculated by adjusting the water demand for each town proportional to the increase in population growth for both a high and medium growth scenario. The level of exposure was determined as a factor of the potential for increasing evaporation to result in increasing demands, and for changes in precipitation to impact directly on the sustainable yield from groundwater, and the potential for impacts on surface water supply. These were then multiplied by the proportion of supply from surface and groundwater for each town. Exposure to climate change risk for surface water supply was calculated in two ways. The first was by assuming surface supply was directly related to changes in streamflow in the catchment in which the local municipality was located (E1) and alternatively (E2) taking into account the potential benefits offered by being connected to a regional water supply system by using the result from a national study of climate change impacts on regional water supply derived from a high level national configuration of the water resources yield model (WRYM) that calculated the overall impacts on urban, industrial and agriculture water supply to each of the original 19 (now 9) Water Management Areas (WMAs) in South Africa.

In South Africa, groundwater plays a key strategic role in supporting economic development and sustaining water security in several rural and urban settlements that are either entirely or partially dependent on groundwater supply. Groundwater is, however, a natural resource, the availability and distribution of which are highly influenced by climate variability and change. An analysis of the impact of climate change on potential groundwater recharge was conducted for the period 2031 to 2050. The Villholth GRiMMS (Groundwater Drought Risk Mapping and Management System) formulation (Vilholth et al., 2013), which implemented a composite mapping analysis technique to produce an explicit groundwater recharge drought risk map, was adapted to formulate a series of potential groundwater recharge maps for the far-future across South Africa. Finally, the future period 2031 to 2050 was compared with the historical period 1961 to 1990.

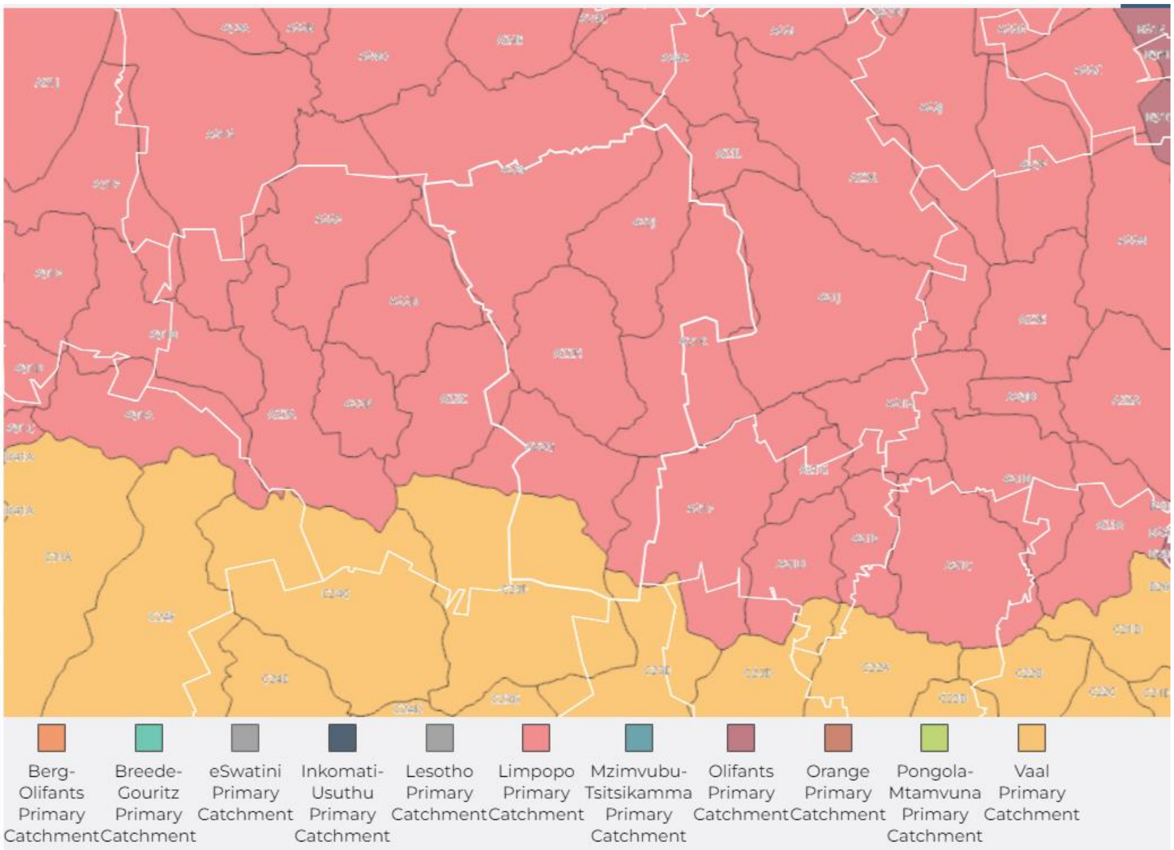

Figure 21: Quaternary catchments found in Bojanala Platinum District Municipality

Figure 23 indicates the catchment(s) related to the district. The quaternary catchments serving the district mostly include the Limpopo Primary Catchment and the Vaal Primary Catchments to the south. Figure 24 indicates where settlements get their main water supply from, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed to be groundwater dependent. In the Bojanala Platinum District, most towns are surface water dependent with a few that use a combination of surface water and groundwater sources such as Koster and Swartruggens.

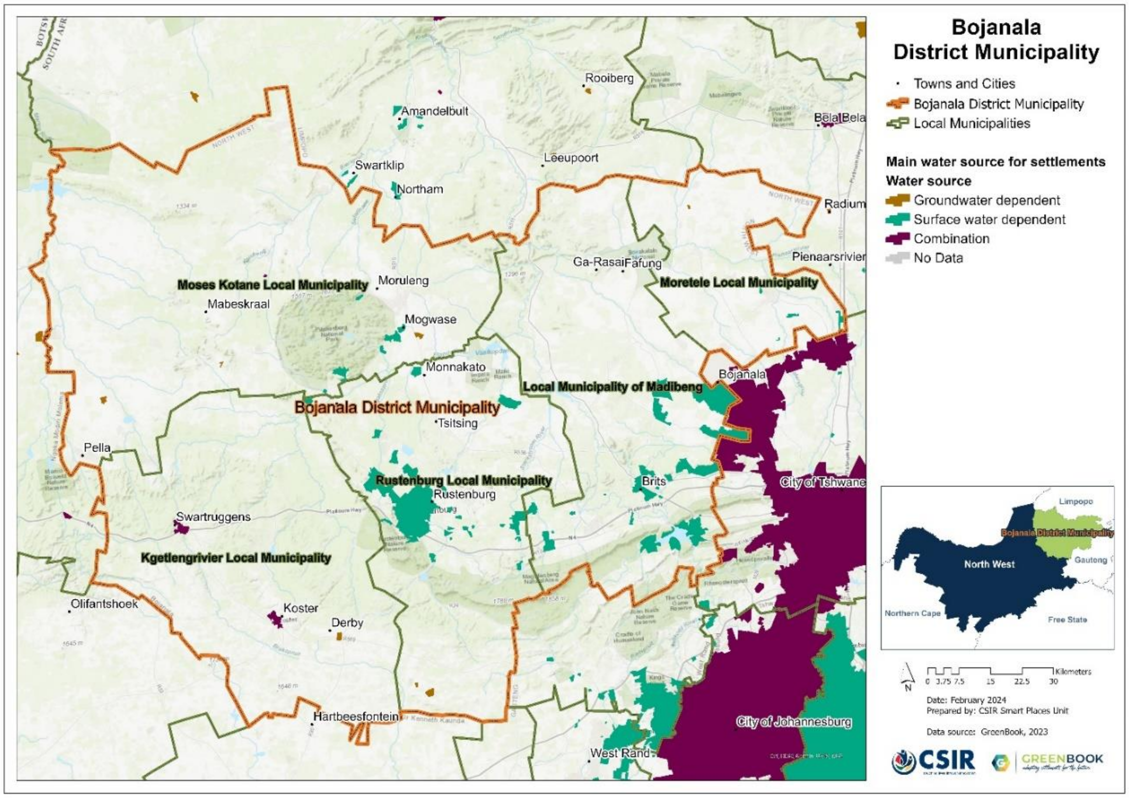

Figure 22: Main water source for settlements in the Bojanala Platinum District Municipality

Figure 25 indicates the occurrence and distribution of groundwater resources across the District Municipality, showing distinctive recharge potential zones, while Figure 26 indicates the projected change in groundwater potential. Figure 27 indicates which groundwater dependent settlements that may be most at risk of groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure into the future. Groundwater recharge potential is generally medium to high across the district under baseline climate conditions. In future it is predicted that the groundwater recharge potential will increase in most of these areas. Settlements in Kegetlengrivier LM have a moderate risk of groundwater depletion (Figure 27), considering expected pressure in terms of population growth.

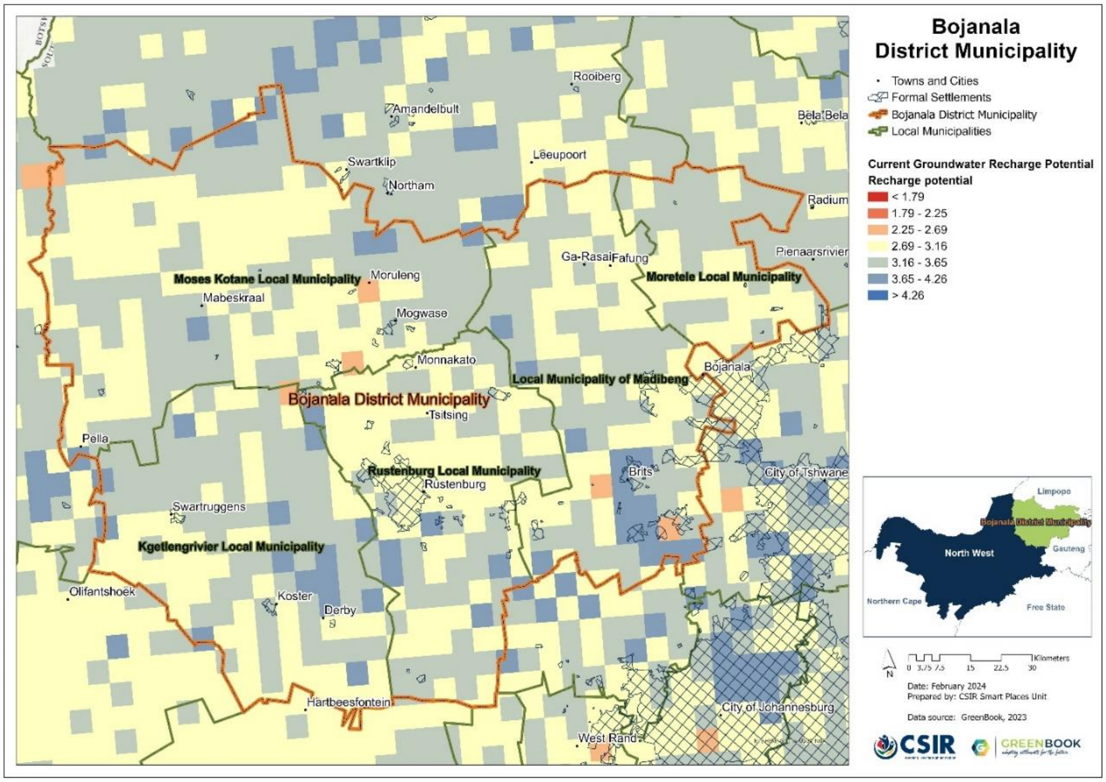

Figure 23: Groundwater recharge potential across Bojanala Platinum District Municipality under current (baseline) climatic conditions

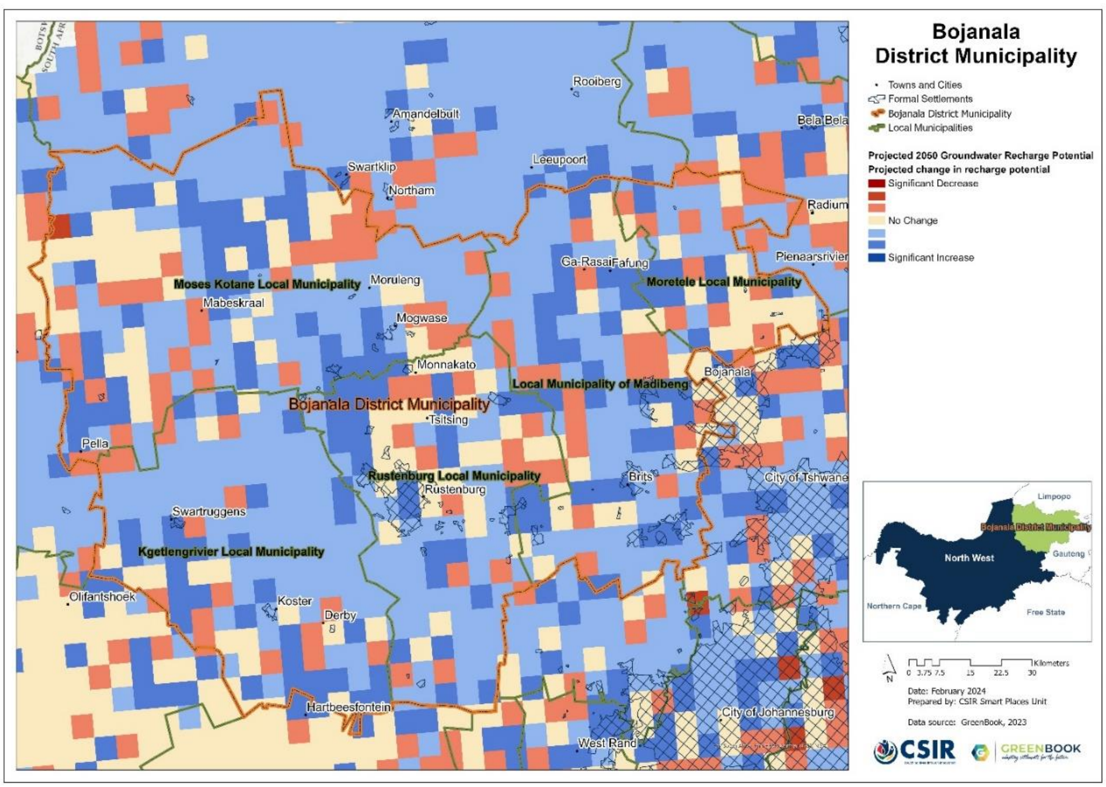

Figure 24: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across Bojanala Platinum District Municipality

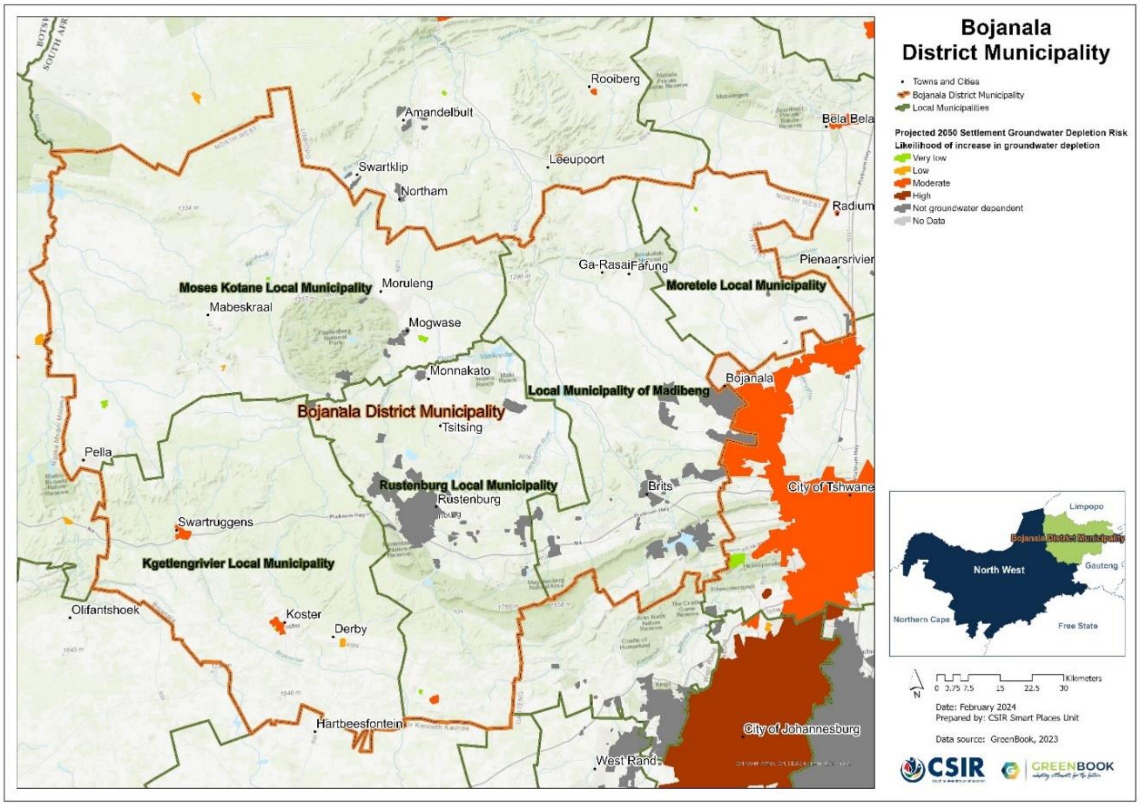

Figure 25: Groundwater depletion risk at settlement level across Bojanala Platinum District Municipality

Table 3 provides an overview of current water supply vulnerability (i.e., demand versus supply) for the Local Municipalities in the Bojanala Platinum District based on the data compiled for the Department of Water and Sanitation's (DWS) All Town's Study (Cole, 2017). A water supply vulnerability score above 1 indicates that demand is more than supply, while a score below 1 indicates that supply is meeting demand.

Table 3: Current water supply and vulnerability across Bojanala Platinum District Municipality

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
Kgetlengrivier	58.51	104.99	0.56
Madibeng	103.18	150.25	0.69
Moretele	86.93	89.21	0.97
Moses Kotane	131.23	173.04	0.76
Rustenburg	132.38	134.19	0.99

Current and future water supply vulnerability estimations are based on: 1) a local water supply perspective incorporating changes to population growth coupled with exposure to climate risk and 2) a regional water supply perspective, based on impacts of regional water supply assuming supply is part of the integrated regional and national bulk water supply network. The water supply vulnerability estimations do not consider the current state of water supply and reticulation infrastructure. The current context and conditions within each of the Local Municipalities need to be considered when interpreting the information provided in this report. See the GreenBook Municipal Risk Profile Tool for more information on surface water, change in precipitation, runoff, and evaporation. Water supply vulnerability per local municipality is discussed below.

Kgetlengrivier

Kgetlengrivier LM water supply vulnerability is currently relatively low in this LM. Water supply vulnerability is however projected to increase into the future, because of the projected decline in mean annual runoff, increase in temperature as well as expected population growth.

Madibeng

Water supply is currently higher than demand in this LM, but because of a projected decline in mean annual rainfall combined with high population growth, water supply vulnerability will increase significantly.

Moretele

Water supply and demand is currently almost in balance and water supply vulnerability is projected to decrease into the future due to a significant decline in population growth.

Moses Kotane

Water supply is currently higher than demand in this LM and water supply vulnerability is expected to decrease further by 2050 due to a decline in population growth.

Rustenburg

Water supply vulnerability is already high and is expected to significantly increase to 1.85 by 2050. Water supply vulnerability is driven by projected extreme population growth pressure, a decrease in average annual rainfall, increased evaporation, and a decrease in mean annual runoff.

1.1.2. Agriculture, forestry, and fisheries

Agriculture and food production is arguably the sector most vulnerable to climate impacts in South Africa. Many settlements in South Africa owe their existence to the primary sector of the country. Agriculture, forestry, and fisheries (AFF) form the bulk of the primary sector and act as catalysts for the economic development of secondary and tertiary sectors. Where these sectors are the primary economic activity in an area, they contribute to the local economy, employment, food security, and livelihoods. They also indirectly benefit from services such as health care, education, and basic infrastructure. In such regions, social and economic stability are linked with the profitability of the agricultural sector.

Climate change, through increased temperature and changing rainfall patterns, can have fundamental impacts on agriculture if the climatic thresholds of the commodities being farmed are breached. However, the nature and extent of these impacts depends on the type of commodity being farmed and the relative geographic location of the farmer with regard to the industries served, and also on the resources available to the farmer. The same climate impact can have different impacts on different commodities and farms. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as has been done in the past.

The methodological approach to understanding the impact of climate and climate change on AFF, consisted of four components. Firstly, the most important areas in terms of Gross Value Added (GVA) and employment for the AFF sector relative to the other sectors of the South African economy were determined. Secondly, an analysis of climate change scenarios was done using historical climate variables, as well as multi-model projections of future climates to help identify specific climate-related risk factors for agriculture within specific regions. Thirdly, crop suitability modelling was done to indicate how the area suitable for crop production under the present climate conditions might shift or expand under the scenarios of future climate change, in addition to using the Temperature Humidity Index (THI) to assess heat stress in livestock. Finally, the climate change analysis was used in conjunction with the crop modelling outputs to assess the potential impacts of climate change over a specific area, or for a specific crop, to give more detail on how predicted climate changes translate into location/crop specific impacts. This was developed at a local municipal level and guided by the outcome of the agricultural industry sector screening and climate scenario analysis.

The AFF sector contributes 1.04 % to the local GVA of the District (CoGTA, 2020). This is significantly less than the agricultural sector's national average contribution of 2.50 % to GVA. BPDM is mainly characterised by commercial farming that ranges from beef cattle farming to maize, sunflower and vegetable farming. Furthermore, some rural parts of BPDM also practice subsistence farming of maize, sunflower and vegetables. Historically, agriculture used to be the main contributor to GVA in BPDM. However, due to trade-offs to other activities such as mining and development, agriculture has turned into a less preferred source of income resulting in loss of high potential agricultural land. Some of the largest cattle herds are to be found in the district, with the area around Rustenburg and Brits being fertile for mixed-crop farming. From a labour intensive growth perspective, the sector remains strategic to the growth of the district. The potential impact of climate change and climate hazards on agriculture is notable considering the contribution this sector makes to support livelihoods of the local residents.

Below, the main agricultural commodities for each local municipality within the district is discussed in terms of what the impact of climate change might be on those commodities under an RCP 8.5 low-mitigation "business as usual" greenhouse gas emissions scenario.

Kgetlengrivier

In the Kgetlengrivier LM, the AFF sector contributes 9 % to the local GVA, which is a contribution of 0.21 % to the national GVA for the AFF sector. Of the total employment, 25.69 % is within the AFF sector. The main agricultural commodities are beef cattle and maize production. The increase in extreme temperatures will increase heat stress for livestock production, reducing growth & reproduction performance in cattle. Heat stress will also negatively impact on maize yield and quality.

Madibeng

In the Madibeng LM, the AFF sector contributes 1.76 % to the local GVA, which is a contribution of 0.72 % to the national GVA for the AFF sector. Of the total employment, 8.65 % is within the AFF sector. The main agricultural commodities are cultivated flower production, beef cattle and tobacco production. Projections are for a warmer will increase production costs associated with temperature regulation for flower production. Hot and moist conditions could cause increased spread of disease and parasites in livestock. It could also lead to reduced growth & reproduction performance in beef cattle due to heat stress. For tobacco, production remains viable as long as heat stress is managed.

Moretele

In Moretele LM, the AFF sector contributes 1.63% to the local GVA, which is a contribution of 0.09 % to the national GVA for the AFF sector. Of the total employment, 3.45 % is within the AFF sector. The main agricultural commodities are beef cattle production and maize cultivation. Climate projections show a generally hotter and wetter climate, becoming drier into the future (at least up to 2050). Hot and moist conditions could cause increased spread of disease and parasites in livestock. It could also lead to reduced growth & reproduction performance in beef cattle due to heat stress. Heat stress will also negatively impact on maize yield and quality.

Moses Kotane

In the Moses Kotane LM, the AFF sector contributes 0.51 % to the local GVA, which is a contribution of 0.08 % to the national GVA for the AFF sector. Of the total employment, 2.29 % is within the AFF sector. The main agricultural commodities are beef cattle production and maize cultivation. Climate projections show a generally hotter and wetter climate, becoming drier into the future (at least up to 2050). Hot and moist conditions could cause increased spread of disease and parasites in livestock. It could also lead to reduced growth & reproduction performance in beef cattle due to heat stress. Heat stress will also negatively impact on maize yield and quality.

Rustenburg

In the Rustenburg LM, the AFF sector contributes 0.47 % to the local GVA, which is a contribution of 0.39 % to the national GVA for the AFF sector. Of the total employment, 2.16 % is within the AFF sector. The main agricultural commodities are beef cattle production and maize cultivation. Climate projections show a generally hotter and wetter climate, becoming drier into the future (at least up to 2050). Hot and moist conditions could cause increased spread of disease and parasites in livestock. It could also lead to reduced growth & reproduction performance in beef cattle due to heat stress. Heat stress and more frequent and intense droughts will also negatively impact on maize yield and quality.

2. Recommendations

The greatest risks faced across the Bojanala Platinum District are drought, heat stress, an increased risk of wildfires and flooding combined with population growth pressure, especially in the Rustenburg, Koster, Hartebeespoort and Brits areas. The Rustenburg Local Municipality accounts for 40.2% of the total population in the Bojanala Platinum District Municipality, which is the most populous region in the Bojanala Platinum District Municipality. The towns that are seeing significant population growth are already experiencing service access pressure, and larger groups of people will become vulnerable and exposed to climate-related hazards.

Environmental vulnerability is relatively high across the entire District, indicating pressure on biodiversity due to rapid urbanisation, expansion of the mining belt and land-use change, thus increasing the vulnerability of the environment to extreme climate events.

The predictions for more frequent droughts pose a risk for water availability, especially in light of future population growth pressure in the LM's of Kgetlengrivier, Rustenburg and Madibeng. Agriculture is the most prominent land use in the BPDM particularly in the Madibeng and Kgetleng River municipal areas. More frequent droughts in combination with increasing temperature will put pressure on livestock and crop production especially for subsistence farming.

There is a heightened wildfire risk due to flammable vegetation and the effects of climate change, such as rising temperatures and frequent heatwaves. Fires on the wildland-urban interface are exacerbated by urban expansion near or within areas of abundant vegetation and by climate change.

An increase in extreme rainfall events is projected over certain parts of the District which could result in flooding. Increase in intensity of rainfall and flooding, especially after droughts, could lead to increased soil erosion, soil loss and degradation, as well as infrastructure damage especially in informal settlements.

Therefore, in response to these climate risks and impacts, the following adaptation goals are recommended:

1. To ensure water security for human consumption and irrigation under a changing climate: Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. Moreover, the projected increases in average temperatures, drought tendencies and population growth, are likely to result

in adverse consequences that make it necessary for the District to take action to ensure water security for consumption and irrigation purposes in the face of climate change. Some of the actions that the District could take include prioritising infrastructure maintenance; investing in efficient water supply infrastructure to meet future demand; promoting water conservation practices by implementing strategies such as public awareness campaigns, leak detection and repairs, water metering and billing; as well as exploring measures to secure alternative water sources such as rainwater (harvesting), groundwater (recharge and extraction) and wastewater (reuse).

2. To protect biodiversity and improve sustainable use of natural resources: As noted earlier, the District's natural environment is under severe pressure due to rapid urbanisation, expansion of the mining belt and land-use change. This therefore makes the District's natural environment and resources, as well as biodiversity, very vulnerable to extreme climate-related events. It is thus necessary to protect and restore these natural environments in order to maintain their key functions. The protection and restoration of natural ecosystems, like high-priority biomes, wetlands, river ecosystems and riparian areas, are integral to maintaining biodiversity, supporting water resource management, and providing natural buffers against climate-related hazards like wildfires and floods. Some of the actions that the District could take to realise this goal include establishing or expanding protected areas, enforcing regulations against harmful practices in such areas, and promoting the sustainable use of natural resources.

3. To increase resilience of the agricultural sector to more extreme events such as drought and storms as well as indirect risks such as pests and diseases: Although the agricultural sector makes a minor contribution to the GVA of the economy in the District, the rural nature of the district makes subsistence and small scale farming critically important for supporting livelihoods. And because agriculture is arguably one of the most vulnerable sectors to the impacts of climate change, at least in South Africa, it is essential to increase its resilience to these anticipated changes, and their impacts. This can be done by providing farmers with access to (i) resilient crop varieties and efficient irrigation systems; (ii) training in sustainable farming techniques; (iii) financial risk management tools; and (iv) market opportunities, i.e., to help the agricultural sector withstand shocks and stresses such as climate change impacts, market fluctuations, and pests.

4. To increase the adaptive capacity of human settlements to climate change and extreme events: To reduce the vulnerability of human settlements to climate-related hazards and extreme events, it is essential to increase their capacity to adapt to such impacts and events. The District could increase the adaptive capacity of settlements by adopting design standards and practices that take into account future climate change impacts, to ensure that Bojanala Platinum urban/settlement fabric is resilient to the anticipated

climate conditions and extreme events (e.g., climate proofing infrastructure and buildings).

These goals should be pursued with the understanding that the District's climate risks are likely to increase due to climate change. Hence, any actions taken need to remain adaptable to the evolving risks over time. Furthermore, while these recommended goals are not exhaustive, they can be enhanced by strategies tailored to the specific needs of BPDM. The key to success lies in integrating these goals and the principles behind them into all aspects of municipal decision-making and operations, as well as in actively engaging communities in these initiatives.

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