# Fezile Dabi District Municipality

## Climate Risk Profile Report based on the GreenBook

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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 |
| FDDM | Fezile Dabi 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 |

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| WUI | Wildland-Urban Interface |

## Glossary of Terms

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| 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). |

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| 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). |

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| 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 Fezile Dabi District Municipality (FDDM), 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.

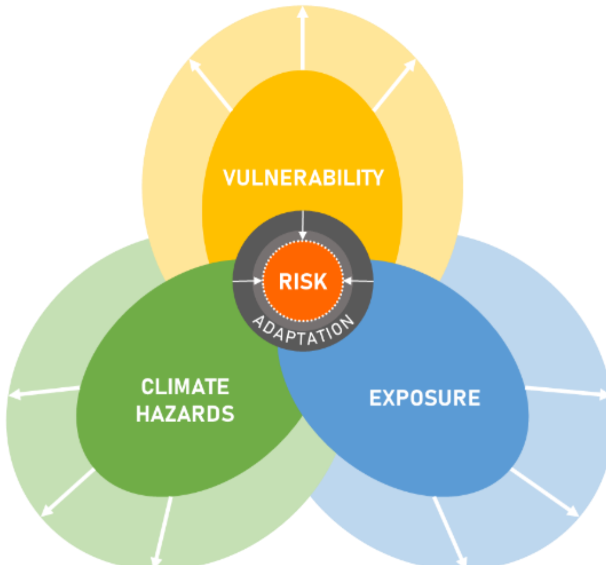


*Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)*

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

Fezile Dabi District Municipality formerly known as the Northern Free State District Municipality, is one of five (5) districts in the Free State Province of South Africa. Fezile Dabi District Municipality is a Category C municipality, established in the year 2000. The municipality is located in the north of the Free State Province and is 20 829.1 km². The municipality is the smallest district in the province, making up 16% of its geographical area. The main attraction is the Vredefort Dome, being the third largest meteorite site in the world.

Fezile Dabi District Municipality is surrounded by Sedibeng in Gauteng to the north; Gert Sibande in Mpumalanga to the north-east; Thabo Mofutsanyane to the south-east; Leweleputswa to the south-west; and Dr Kenneth Kaunda in the North West to the northwest. It consists of four local municipalities namely Moqhaka, Metsimaholo, Ngwathe and Mafube.

Some local contextual statistics to consider:

- The district has a total population of 509 912 (Stats SA, 2022), which is the fourth highest population size after Thabo Mofutsanyane, Mangaung and Lejweleputswa DMs in the Free State province.
- The district hosts 145 539 households, with an average household size of 3,5.
- Young children (0-14 years) make up 25,5% of the total population. The working-age population (15-64 years) accounts for 66,4%, while the elderly (65+ years) constitute 8,1%. The district's dependency ratio is reported as 50,6%.
- Education indicators reveal that 5,0% of individuals aged 20 and above have no formal schooling, while 9,5% have attained higher education qualifications.
- Formal dwellings dominate the housing landscape, representing 89,4% of the housing stock.
- Sanitation and waste management services are accessible, with 88,9% of formal dwellings equipped with flushing toilets connected to sewerage, and 83,3% receiving weekly refuse disposal services. Moreover, 60,6% of households enjoy access to piped water within their dwellings, while 94,3% have electricity for lighting.

In 2019, the manufacturing sector was the largest within Fezile Dabi District Municipality accounting for R14 billion or 27.0% of the total GVA in the district’s economy. The sector that contributed the second most to the GVA of the Fezile Dabi District Municipality was the mining sector at 18.2%, followed by the community services sector with 13.1%. The sector that contributed the least to the economy was the construction sector with a contribution of R1.14 billion or 2.2%

of the total GVA. The community sector, which includes the government services, is generally a large contributor towards GVA in smaller and more rural local municipalities.

The natural areas in Fezile Dabi District Municipality have been substantially changed by human activities, notably formal agriculture (crop and livestock production) and urbanisation, resulting in major habitat losses throughout the area. However, patches of relatively pristine natural areas remain. Natural grasslands are mostly used for grazing and are by far the most prominent natural habitat in Fezile Dabi. Fragmentation of natural grasslands is becoming a concern. Grassland vegetation has a very high biodiversity value, and the remaining pockets should be conserved as far as possible since very little of the vegetation type is formally conserved in conservation areas. Woodland savanna is most prominent in ravines. The Koppies and ridges of the Vredefort Dome are characterised by steep and rugged topography and are impressive topographical features in the study area which are not suitable for development or for cultivation of agricultural crops. As far as surface hydrology is concerned, several important perennial rivers run through the area such as the Renoster River and the Vaal River.

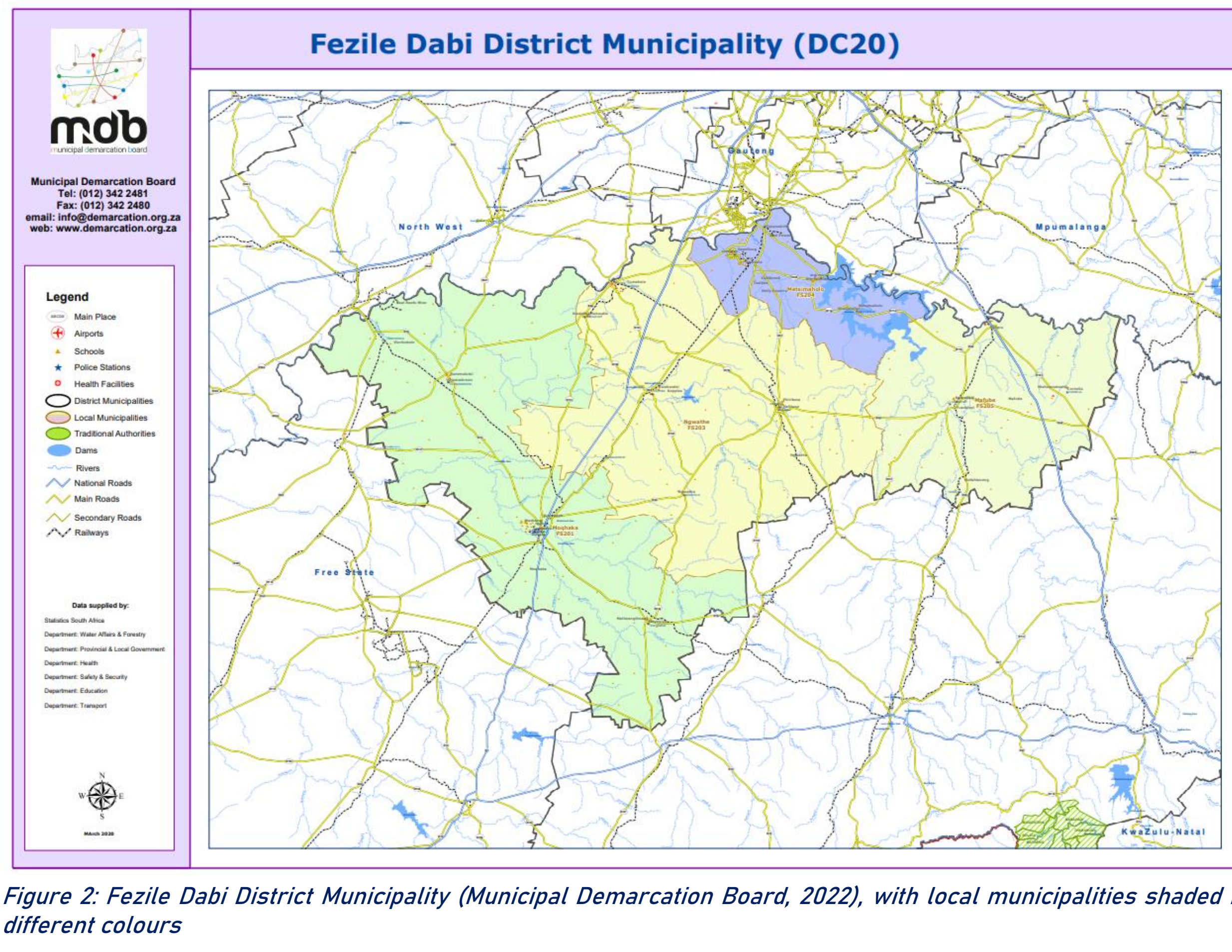


*Figure 2: Fezile Dabi District Municipality (Municipal Demarcation Board, 2022), with local municipalities shaded in different colours*

# 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, and the 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 Fezile Dabi 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 Fezile Dabi 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 Fezile Dabi 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 Fezile Dabi 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 Fezile Dabi District Municipality for 1996 to 2011*

| LOCAL MUNICIPALITY | SEVI 1996 | SEV 2011 | Trend | EcVI 1996 | EcVI 2011 | Trend | PVI | Trend | EnVI | Trend |
|---|---|---|---|---|---|---|---|---|---|---|
| Moqhaka | 5.5 | 4.2 | ↘ | 5.8 | 7.2 | ↗ | 4.7 | N/A | 3.5 | N/A |
| Metsimaholo | 3.3 | 2.7 | ↘ | 4.4 | 7.3 | ↗ | 5.6 | N/A | 4.0 | N/A |
| Ngwathe | 6.0 | 5.0 | ↘ | 6.0 | 7.8 | ↗ | 5.7 | N/A | 3.4 | N/A |
| Mafube | 6.4 | 5.6 | ↘ | 4.8 | 5.8 | ↗ | 6.7 | N/A | 4.9 | N/A |

Socio-economic vulnerability has decreased (improved) across all LMs between 1996 and 2011. The Metsimahlo LM has the lowest socio-economic vulnerability in the province and is ranked 1st out of 19 municipalities. All LMs experienced an increase (decline) in economic vulnerability between 1996 and 2011. Metsimaholo LM had the biggest decline in economic vulnerability and is ranked 14th out of the 19 municipalities in the province. The Ngwathe LM has the highest Economic Vulnerability in the District and scored 16th out of 19 municipalities in the province. Mafube LM has the highest physical vulnerability score in the district and is also ranked 19th out of 19 municipalities in the Free State which indicates areas of remoteness and/or areas with structural vulnerabilities within the LM. Mafube LM has the highest environmental vulnerability in the district and province (19th out of 19) which indicates some conflict in preserving the natural environment and accommodating growth pressures such as population growth, urbanisation and economic development.

### 2.1.2. Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlements within the Fezile Dabi 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.

### Moqhaka Local Municipality

The major settlements in this municipality are Steynsrus, Kroonstad, Rammulotsi and Vierfontein. The settlement facing the greatest growth pressure is Rammulotsi, which also has low access to services, poor regional connectivity and high environmental pressure. Steynsrus has the highest economic vulnerability combined with poor socio-economic vulnerabilities, this is compounded by poor access to services, poor regional connectivity and high environmental pressure. Vierfontein has poor regional connectivity. Kroonstad has the second highest growth pressure in the LM.

### Metsimaholo Local Municipality

The major built-up areas in this municipality are Oranjeville, Holly Country, Kragbron, Coalbrook, Deneysville, Middelbult, Uitkoms, Sasolburg, Bertha Shaft Village, Vaal Park, Rietfontein FS, Viljoensdrift 1, Viljoensdrift 2 and Richmond Valley. Sasolburg is facing the greatest growth pressure in the municipality and has high environmental pressure. Deneysville has the highest socio-economic vulnerability as well as very low access to services. Oranjeville has high socio-economic vulnerability combined with poor regional connectivity. Vaalpark has high environmental pressures.

### Ngwathe Local Municipality

The major settlements in this municipality are Edenville, Heilbron, Koppies, Vredefort, Vaal de Grace Golf Estate and Parys. Parys and Vaal de Grace Golf Estate has the highest growth pressure. Vaal de Grace Golf Estate also has the highest environmental pressure in the LM. Heilbron has the highest economic vulnerability, combined with low access to services, poor regional connectivity and high socio-economic vulnerabilities. Koppies has the third highest socio-economic vulnerability in the LM. Vredefort has high socio-economic vulnerability along with low access to services.

### Mafube Local Municipality

The major settlements in this municipality are Mafahlaneng, Frankfort FS, Cornelia, Qalabotjha. Qualabotjha has the greatest settlement growth pressure as well as high economic pressure. Mafahlaneng has the highest socio-economic vulnerabilities along with high environmental pressure, economic vulnerability and high growth pressure. Frankfort FS has poor regional connectivity and low access to services. Cornelia has high environmental pressures.

## 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 enable 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 Fezile Dabi District Municipality*

| Population per municipality | 2011 | Medium Growth Scenario | |
|---|---|---|---|
| | | 2030 | 2050 |
| Moqhaka | 160 528 | 129 767 | 103 927 |
| Metsimaholo | 149 084 | 192 547 | 261 188 |
| Ngwathe | 120 518 | 106 692 | 96 421 |
| Mafube | 57 876 | 54 310 | 52 488 |
| Fezile Dabi DM Total | 488 006 | 483 316 | 514 024 |

The district's population is projected to increase by 5% between 2011 and 2050, under a medium growth scenario. Most of this growth will take place within the Metsimaholo LM. In Figure 4 the growth pressures that the settlements across the district are likely to experience is shown. The settlements that are likely to experience extreme growth pressures up to 2050, include Vaalpark, with high growth pressure expected for Kragbron, Coalbrook,Deneysville, Sasolberg and Bertha Shaft Village in the Metsimaholo LM. The settlements in the Moqhaka, Ngwathe and Mafube LM will experience decreasing growth pressure.

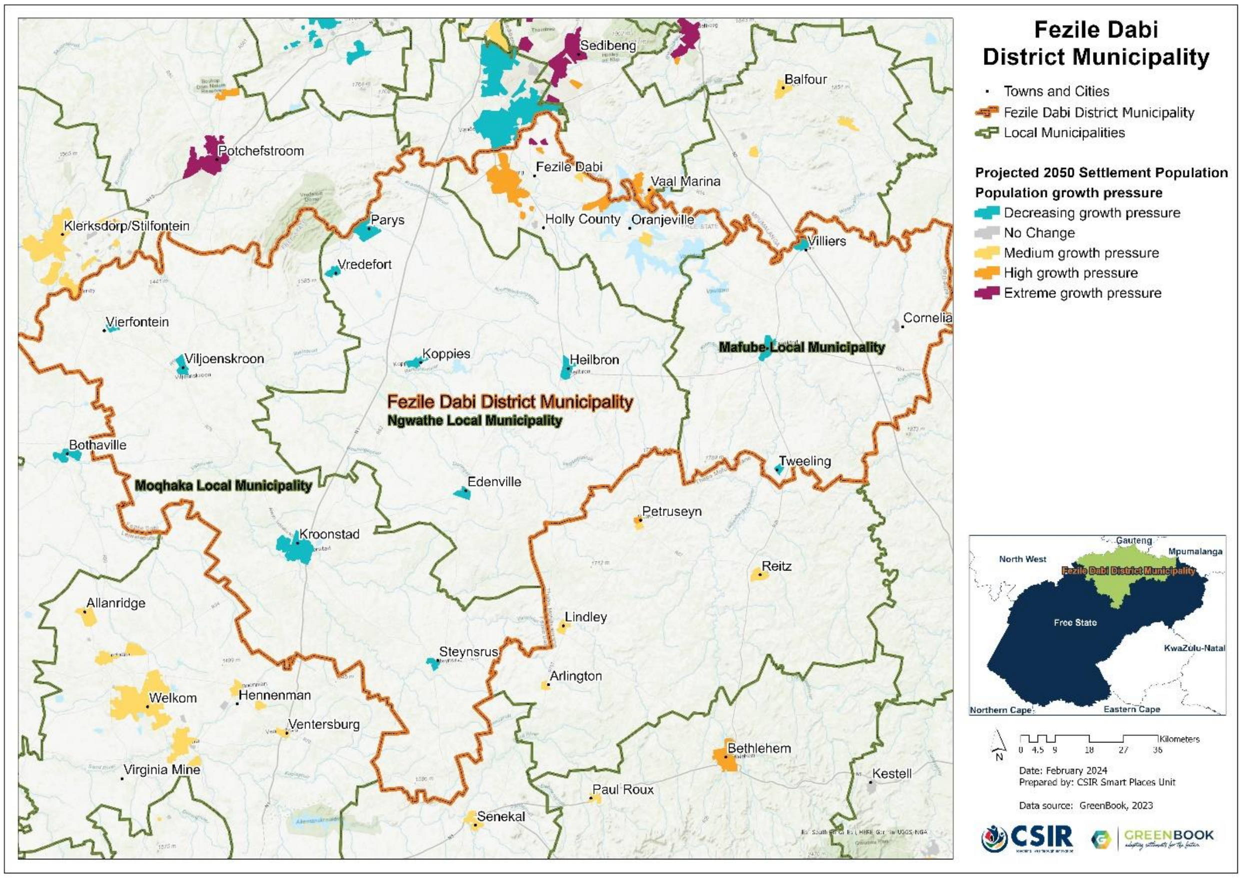


*Figure 3: Settlement-level population growth pressure across Fezile Dabi District Municipality*

## 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 several 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.

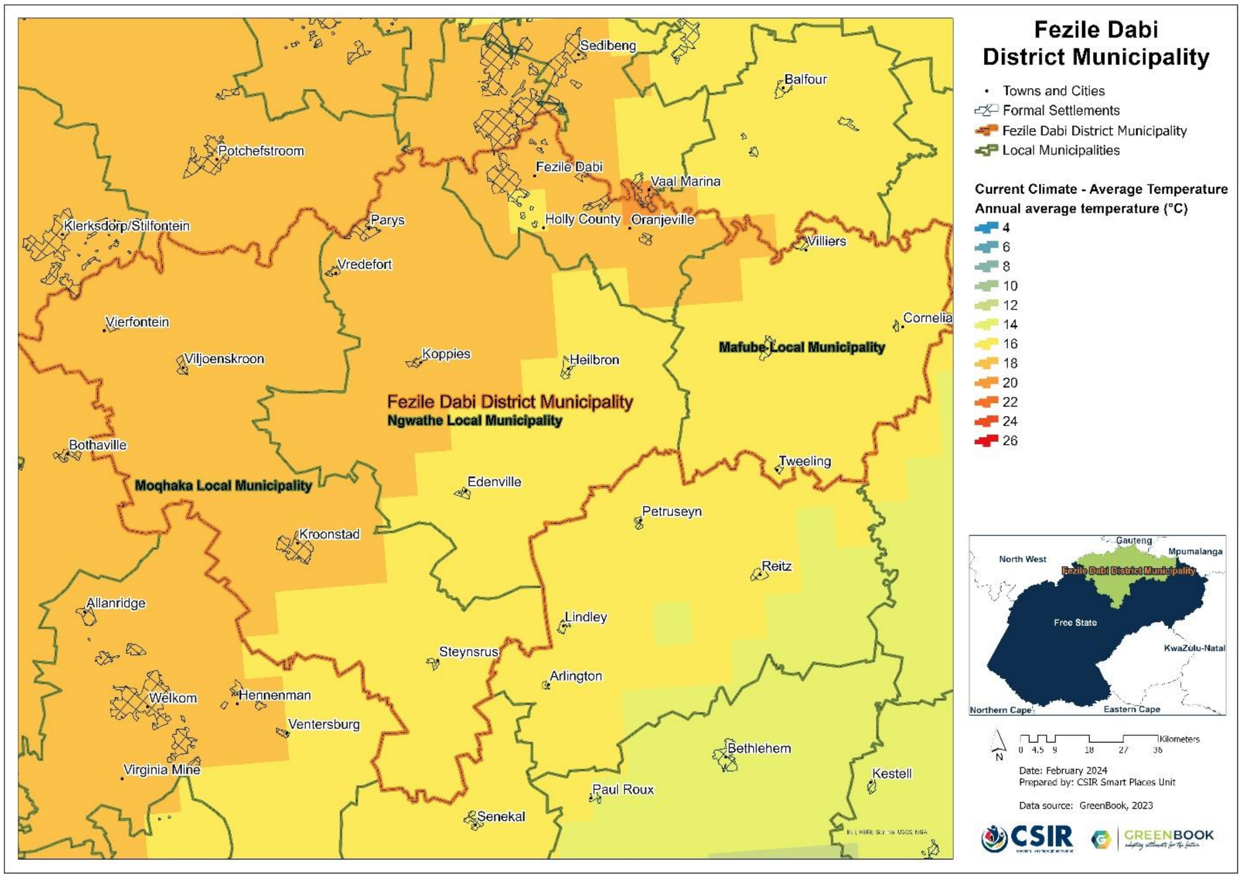


*Figure 4: Average annual temperature (°C) for the baseline period 1961-1990 for Fezile Dabi District Municipality*

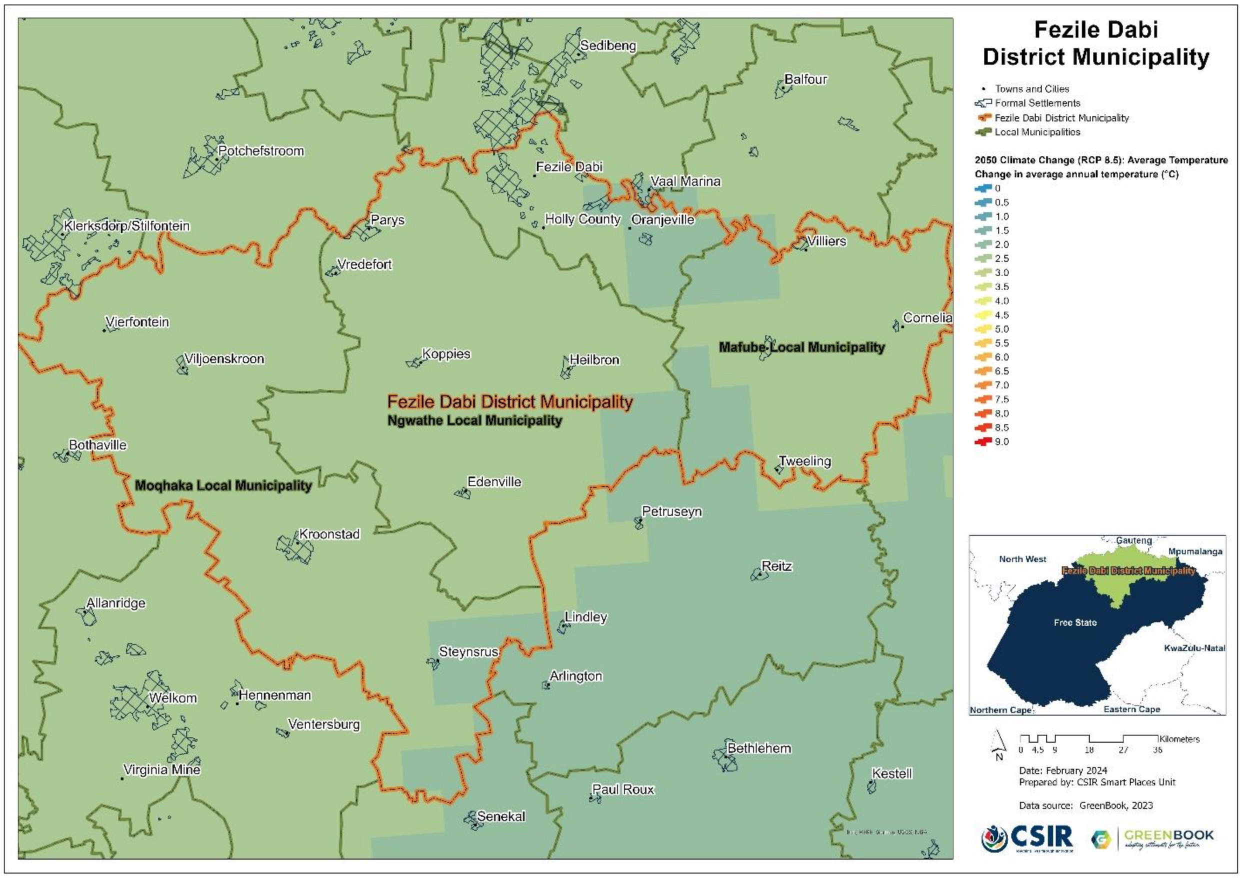


*Figure 5: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for Fezile Dabi District Municipality, assuming an RCP 8.5 emissions pathway*

The FDDM experiences average annual temperatures ranging between 16°C and 20 °C. Projected change in average temperature for the district is expected to range between 2.45°C to 3.36°C.

### 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.

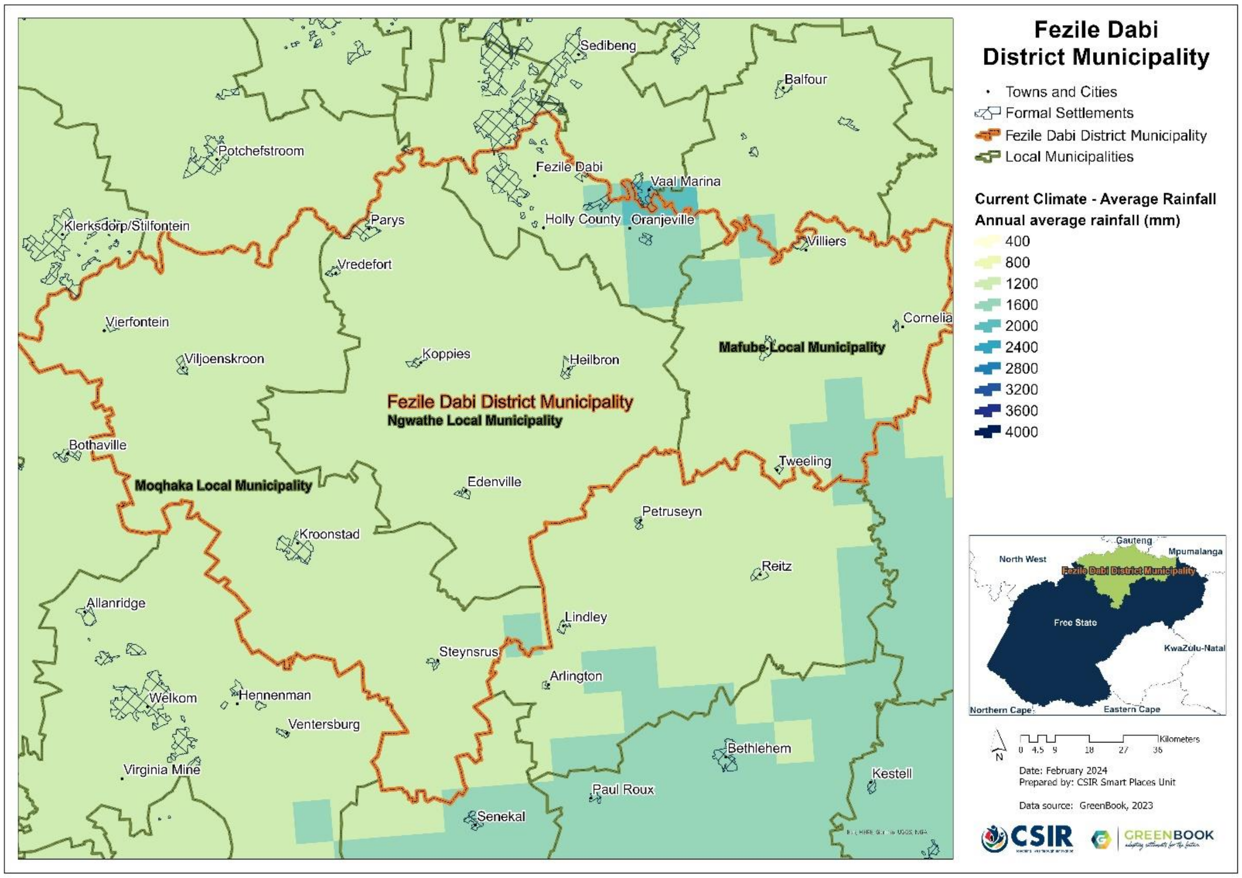


*Figure 6: Average annual rainfall (mm) for the baseline period 1961-1990 for Fezile Dabi District Municipality*

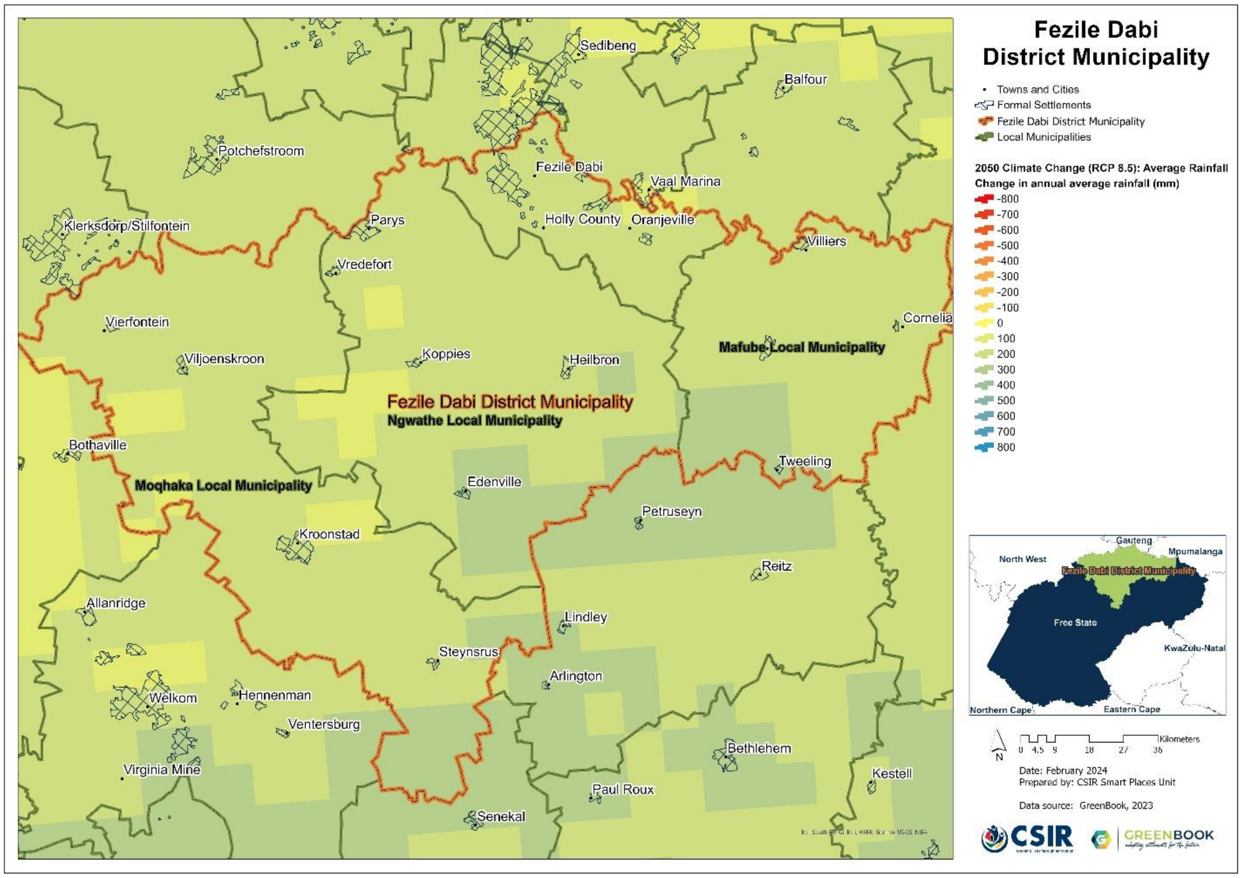


*Figure 7: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for Fezile Dabi District Municipality, assuming an RCP8.5 emission pathway*

As displayed in Figure 6 the FDDM currently receives average annual rainfall of between 1200 mm and 1600 mm. The projected future change in average annual rainfall is variable across the district (Figure 7). In Moqhaka LM average annual rainfall is expected to range between 32.34 mm to 227.32 mm, while in Ngwathe LM average annual rainfall is expected to range between 79.11 mm to 218.93 mm. In Motsimaholo LM average annual rainfall is expected to range between 52.52 mm to 172.99 mm, while average annual rainfall is expected to range between 79.11 mm to 218.93 mm in the Mafube LM. The projected range of change in rainfall across the LMs of the district suggests that there is significant uncertainty regarding the magnitude of the change in annual rainfall. The projected changes represent anything from a relatively modest increase to a substantial increase in rainfall. A change in annual rainfall within this wide range could have significant implications for water availability, agriculture, ecosystems, and various socio-economic activities.

## 2.3. Climate Hazards

This section showcases information with regards to Fezile Dabi 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).

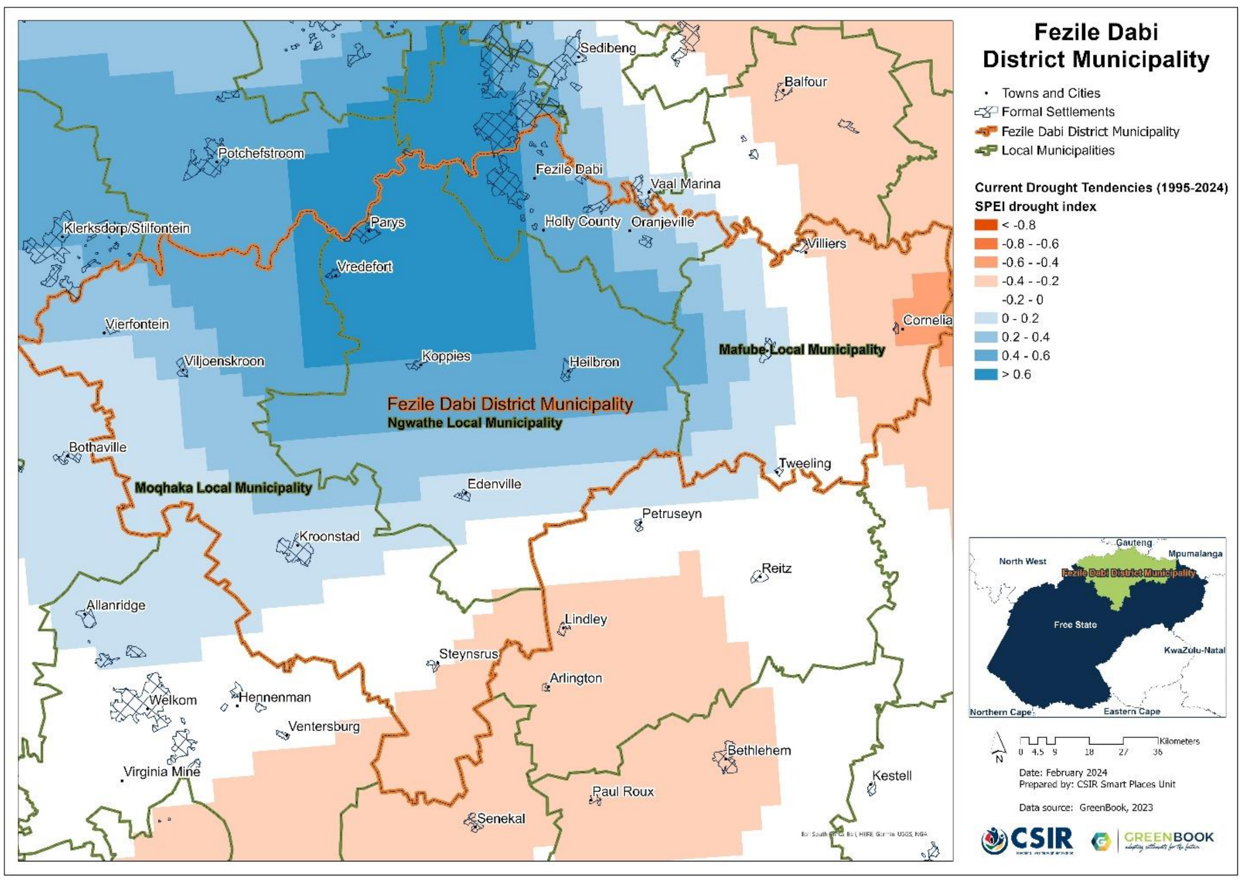


*Figure 8: Current drought tendencies from the baseline period (1986-2005) to the current period (1995-2024) across Fezile Dabi District Municipality*

Figure 8 depicts the current 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.

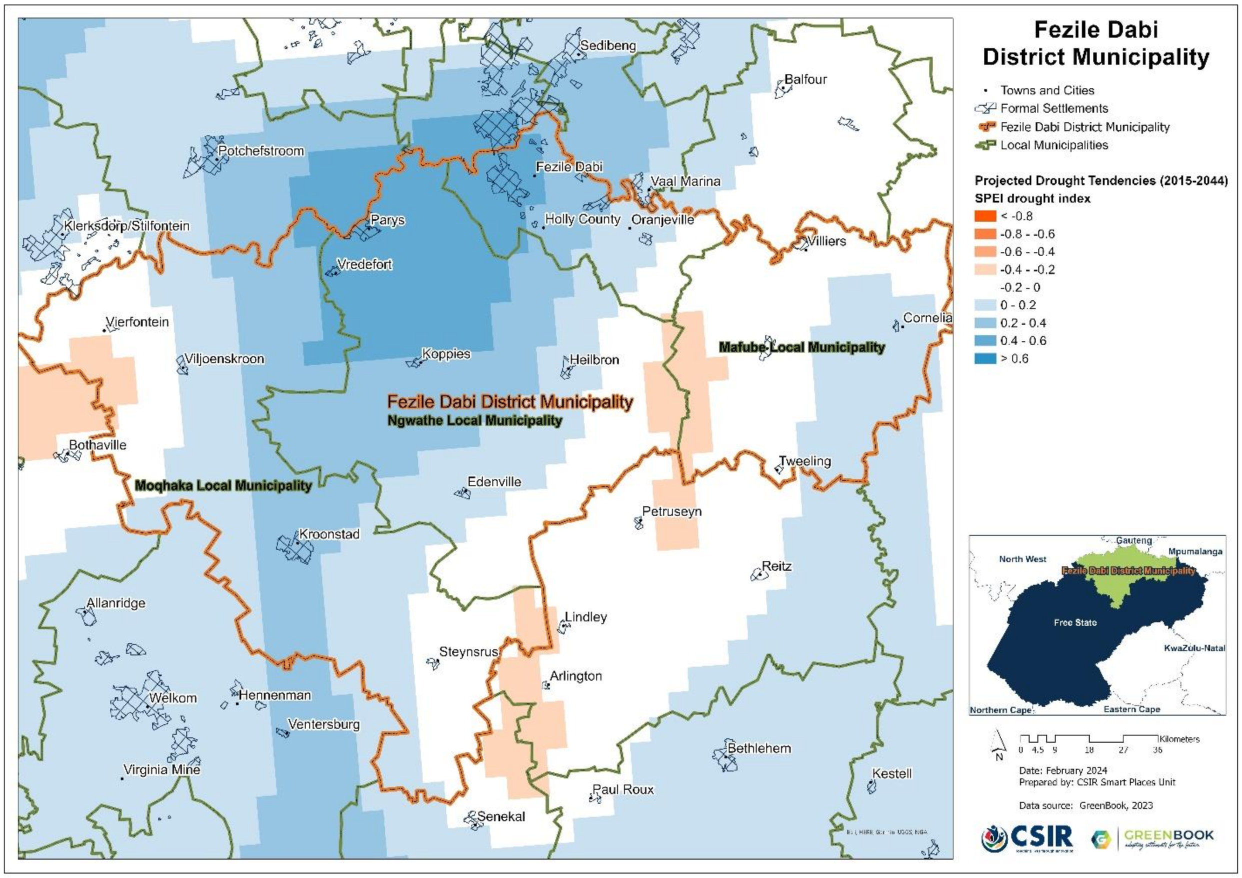


*Figure 9: Projected changes in drought tendencies from the baseline period (1986-2005) to the future period 2015-2044 for Fezile Dabi District Municipality*

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.

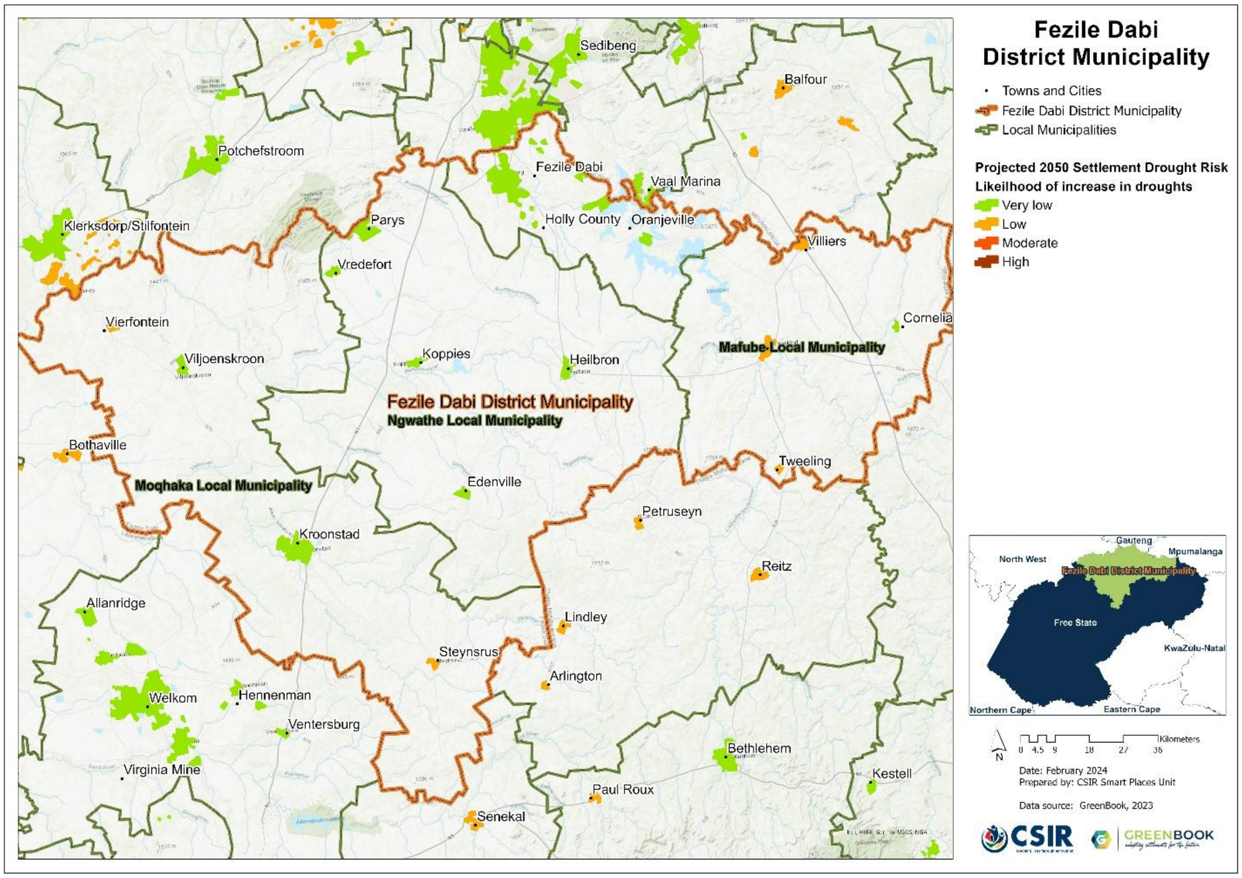


*Figure 10: Settlement-level drought risk for Fezile Dabi District Municipality*

As displayed in Figure 8 the current drought tendencies for FDDM ranges between 0 to >0.6 across large parts of the district with certain pockets having scores of -0.4 to -0.2. A positive SPI value suggests that there is more precipitation than usual for the given period. The upper most part of the Ngwathe and Metsimaholo LM's containing the settlements of Parys, Vredefort and Fezile Dabi has a score of >0.6 this signifies that the surplus of precipitation is notably above average, indicating a relatively large deviation from typical precipitation levels. This surplus can have various impacts on water resources, agriculture, and ecosystems. The central parts of the LM have scores between 0-0.2 and 0.2 to 0.4 indicating a slight excess of precipitation compared to what is typically expected for the period being evaluated. SPI scores ranging between -0.2 to 0 and -0.4 to -0.2 suggests a mild to moderate deficit in precipitation for this period. Future projections show slight shifts in SPI values with the district still expected to have surplus precipitation over most parts. Mafube and Moqhaka LM is expected to have an increase in the areas with a mild to moderate deficit in precipitation. Settlement level drought risk is very low for most of the settlements in the district, with low drought risk for Vierfontein, Steynsrus, Tweeling and Viliers.

### 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.

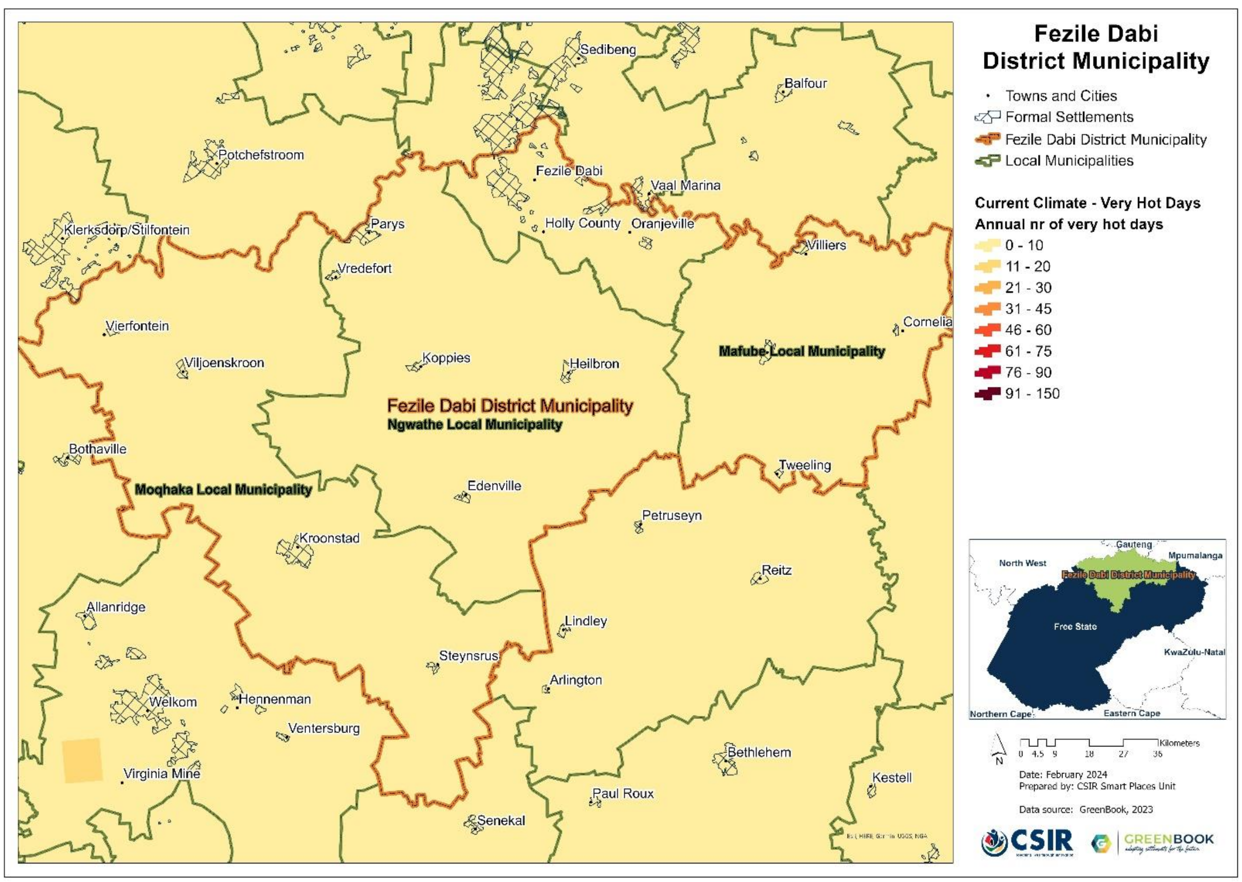


*Figure 11: Annual number of very hot days under baseline climatic conditions across Fezile Dabi District Municipality with daily temperature maxima exceeding 35°C*

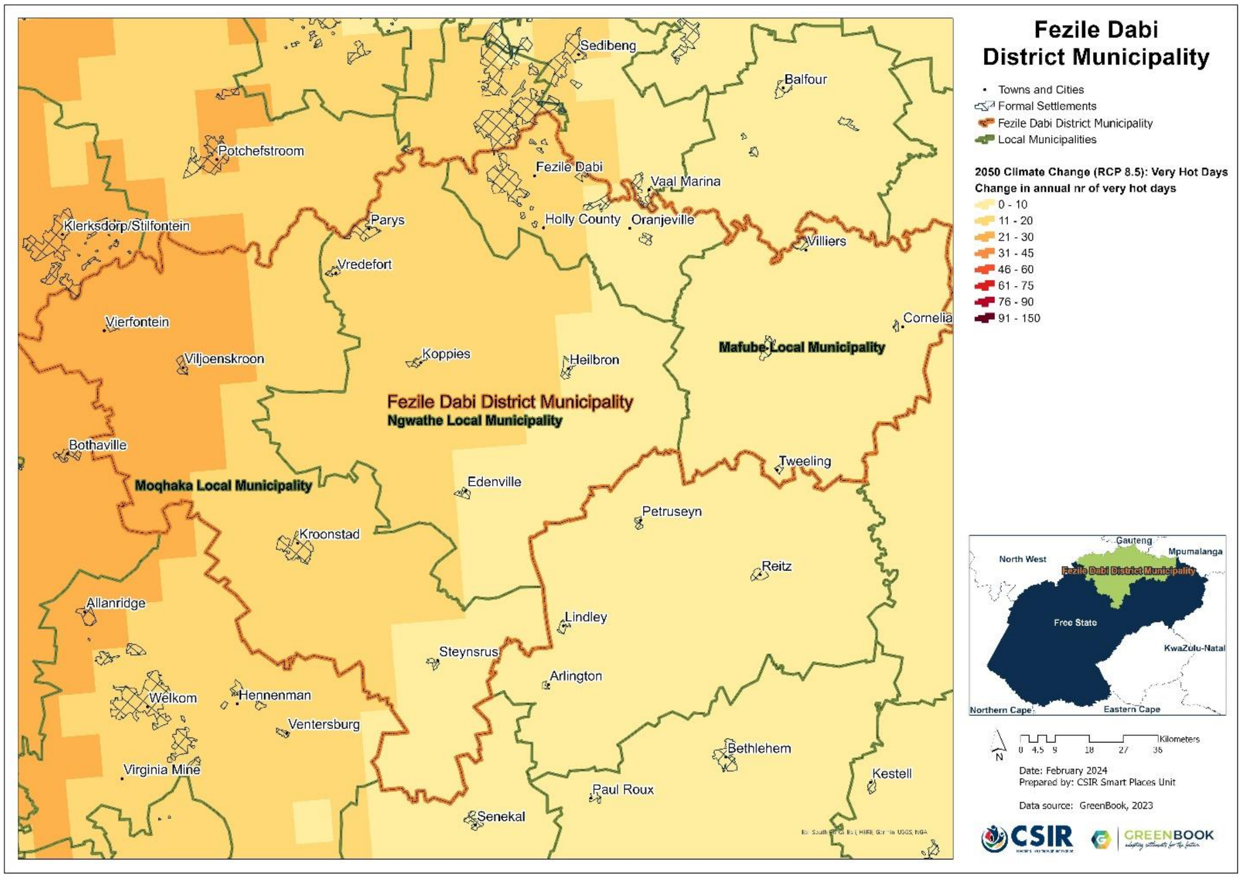


*Figure 12: Projected change in annual number of very hot days across Fezile Dabi District Municipality with daily temperature maxima exceeding 35°C , assuming and RCP 8.5 emissions pathway*

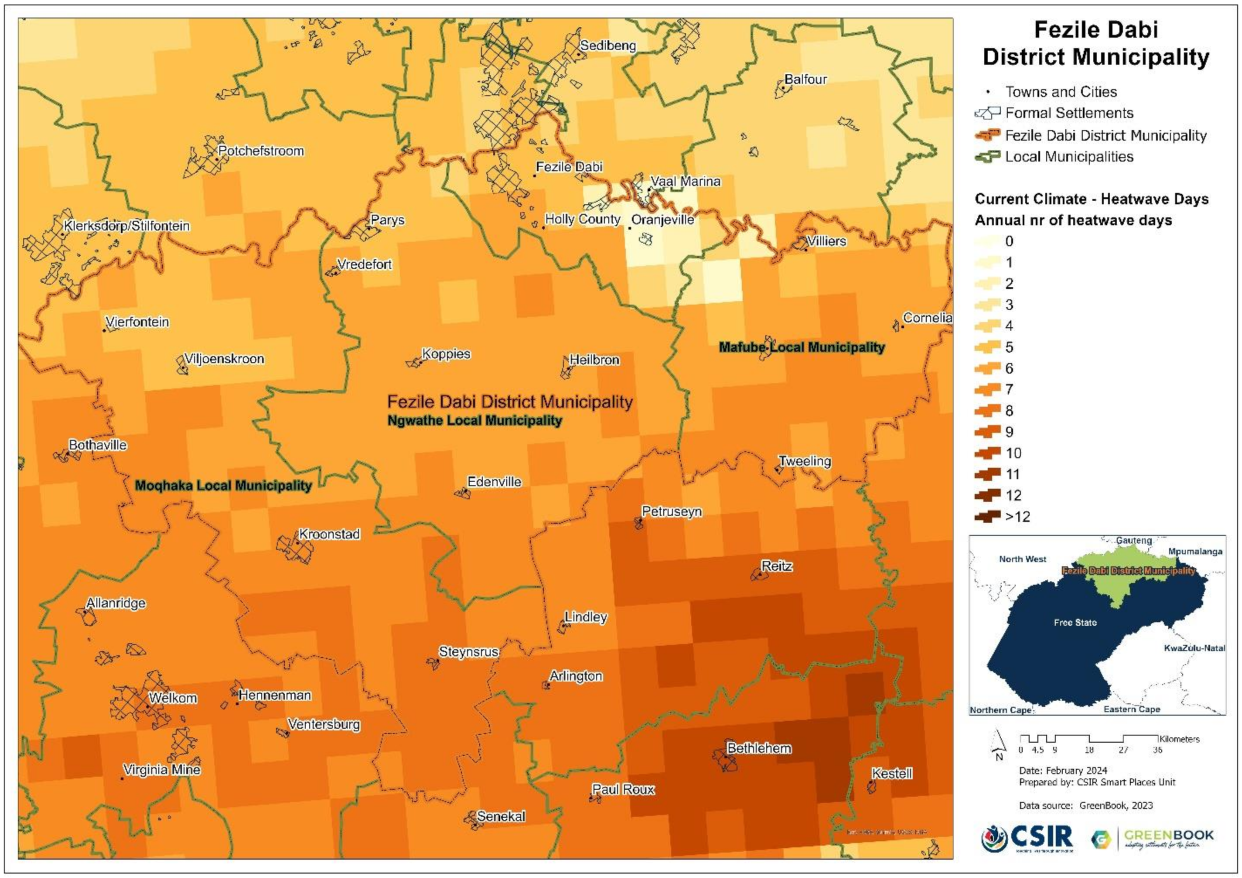


*Figure 13: Number of heatwave days under baseline climatic conditions across Fezile Dabi District Municipality*

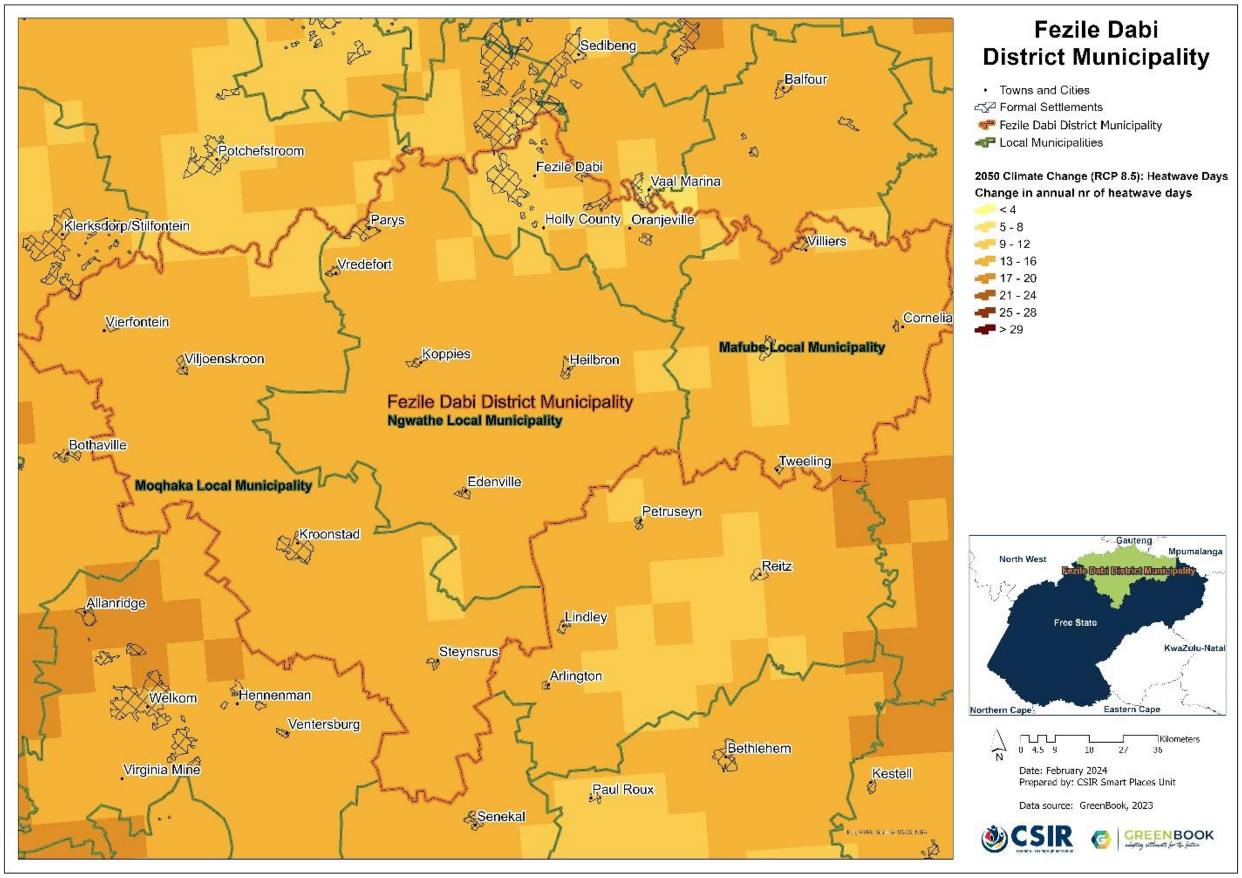


*Figure 14: Projected change in annual number of heatwave days across Fezile Dabi District Municipality, assuming an (RCP 8.5) emissions pathway*

As displayed in Figure 11 the number of very hot days under current conditions ranges between 0 to 10 days across the district. The projected change in the annual number of very hot days is expected to increase to between 3 to 26 days for Nqwathe LM. Whilst for Metshimaholo LM the number of very hot days per annum will increase to between 0-19 days per annum. Mafube LM is expected to have between 0 to 11 very hot days per year. The Moqhaka LM is expected to have the highest increase in number of very hot days in the district with very hot days expected to range to between 7 to 34 days. The number of heatwave days under current climatic conditions ranges between 0-7 days per year. Future projections show an increase in heatwave days for the district ranging between 9 and 13 days per year.

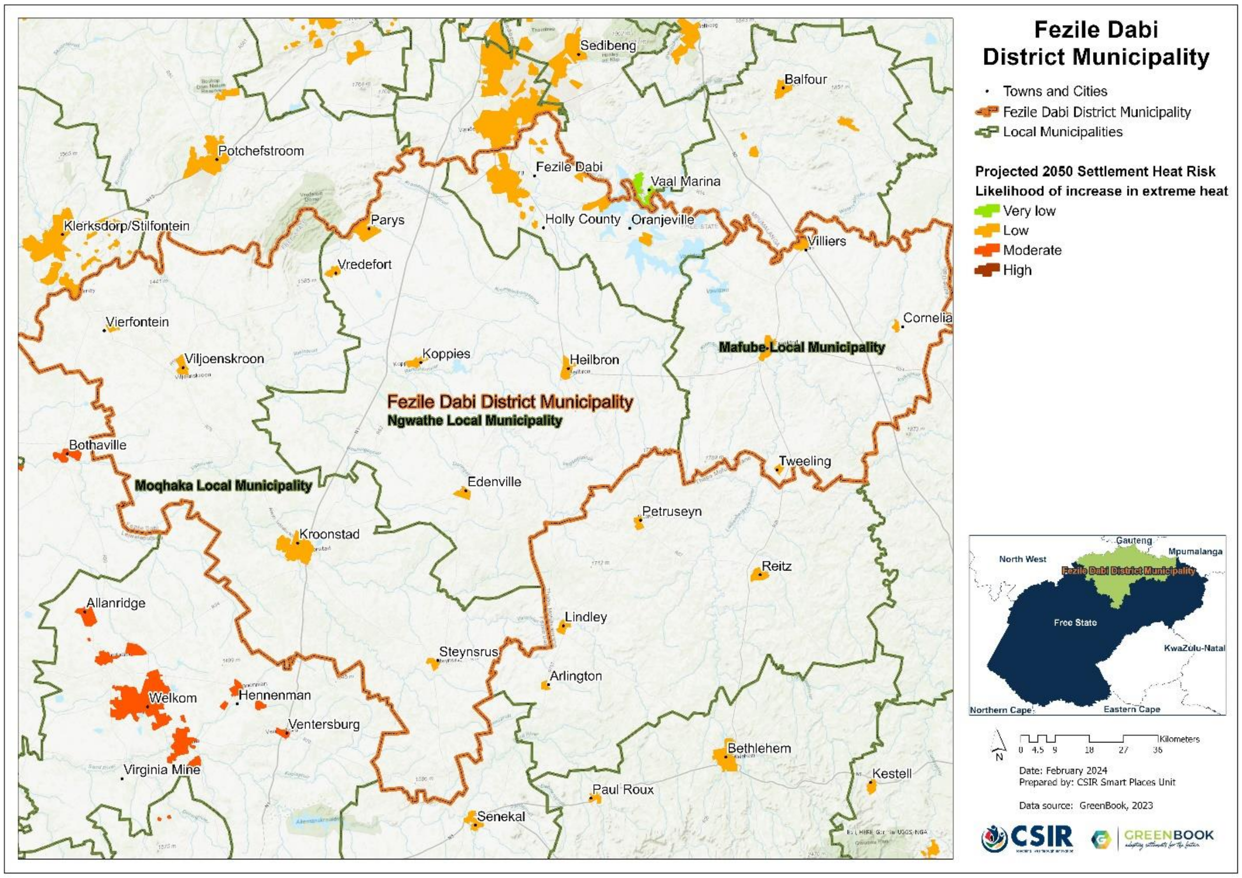


*Figure 15: Settlement-level heat risk across Fezile Dabi District Municipality*

Figure 15 depicts the settlements that are at risk of increases in heat stress. Heat risk likelihood is low across the settlements in the district.

### 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.

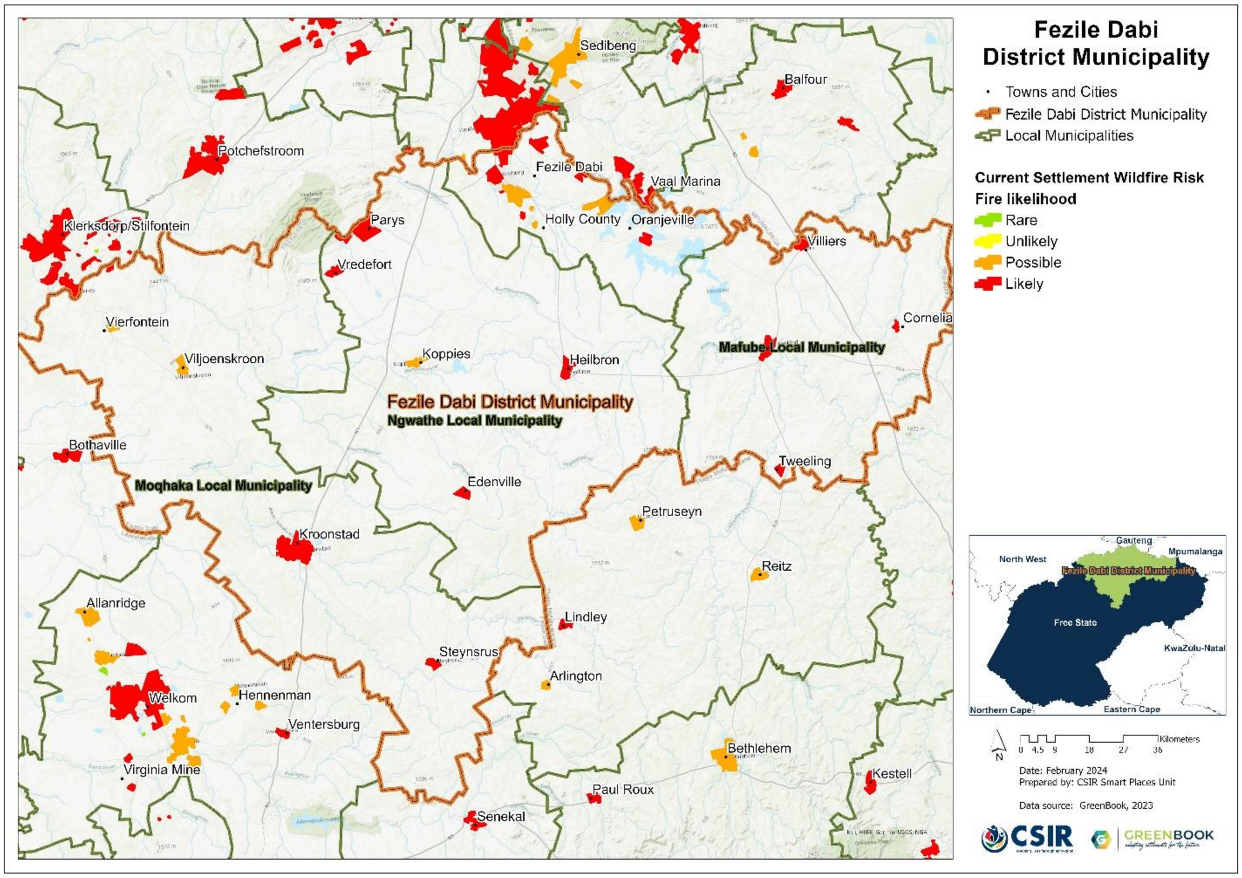


*Figure 16 The likelihood of wildfires under current climatic conditions across settlements in Fezile Dabi District Municipality*

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.

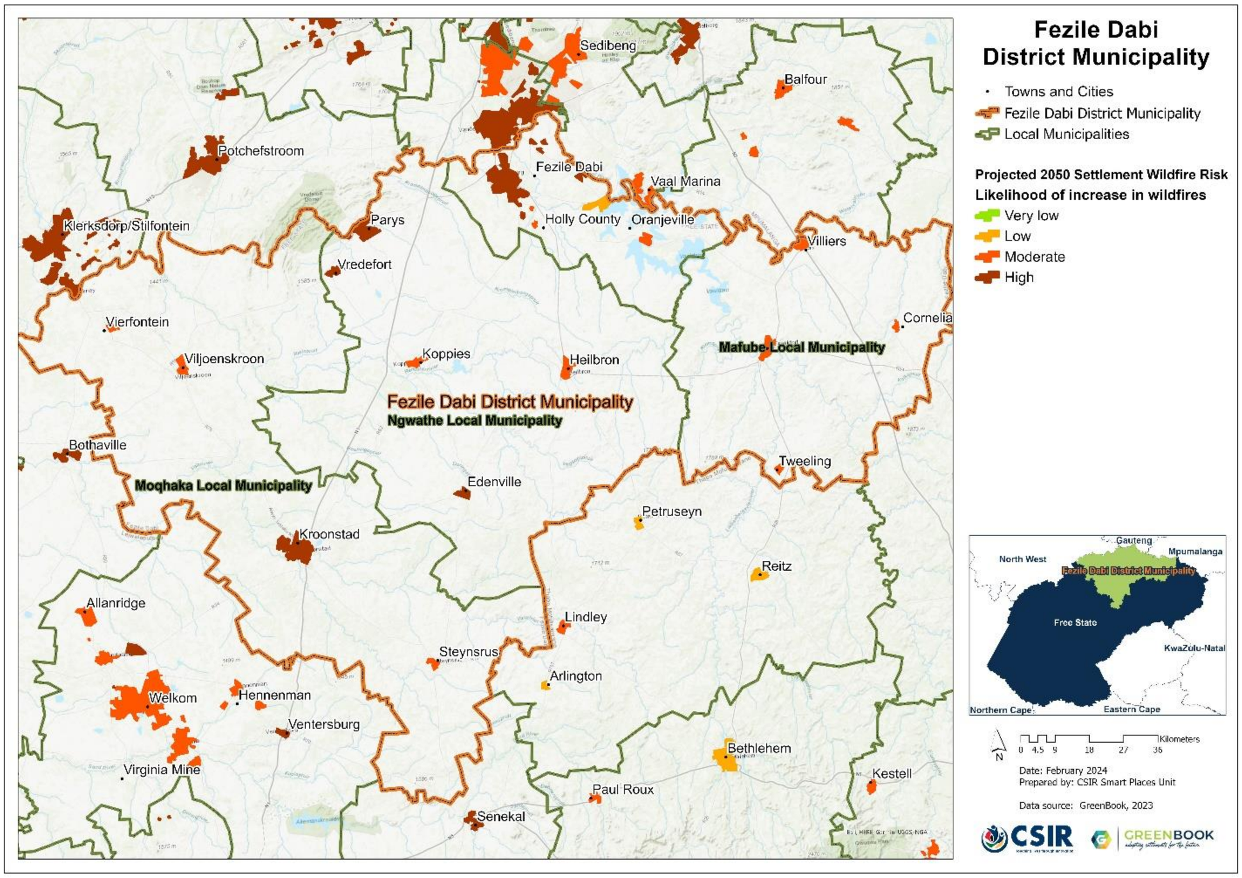


*Figure 17: The likelihood of wildfires under projected future climatic conditions across settlements in Fezile Dabi District Municipality*

The likelihood of wildfires in the settlements of FDDM under current climatic conditions ranges between possible to likely. It is projected that of these settlements Kroonstad, Edenville, Vredefort and Parys will have a high likelihood of increase in wildfires in future. While Vierfontein, Viljoenskroon, Steynsrus, Heilbron, Koppies, Cornelia and Villiers will have a moderate likelihood of increase in wildfires.

### 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.

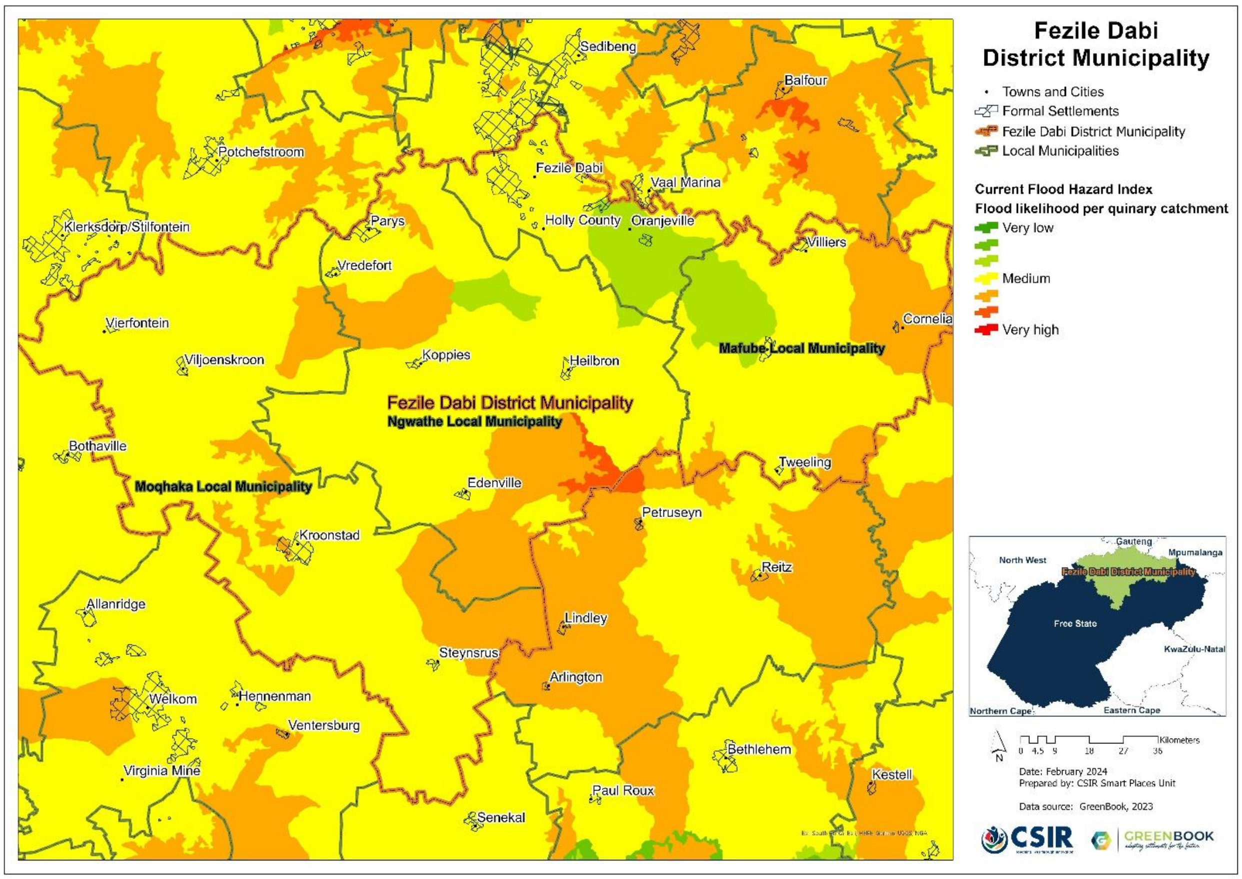


*Figure 18: The current flood hazard index across Fezile Dabi District Municipality under current (baseline) climatic conditions*

Figure 18 depicts the flood hazard index of the individual quinary catchments present or intersecting within 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. The current flood hazard potential for the district is predominantly medium with a high to very high flood hazard potential in the upper and lower parts of the Ngwathe LM. Low flood hazard potential in parts of Metsimaholo and Mafube LM.

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 rainfall. The predicted change in the number of extreme rainfall days ranges between 0-5 days across the district. This indicates a potential shift towards more intense precipitation events in comparison to the current conditions. The projected change in number of extreme rainfall days for Moqhaka LM ranges between -0.64-4.38 days. The range indicates significant uncertainty regarding the projected change in the number of extreme rainfall days. Negative values in the range (-0.64) imply a possible reduction in the frequency of extreme rainfall events, while positive values (4.38) suggest a potential increase. The projected number of extreme rainfall days is highly variable across the Ngwathe Metsimaholo LM and ranges between 0 days to 4 days which suggests a potential increase in the frequency of extreme rainfall days compared to current conditions. In Mafube LM the projected change in extreme rainfall days ranges between 0.48 to 5 day which suggests a significant increase in the frequency of extreme rainfall events.

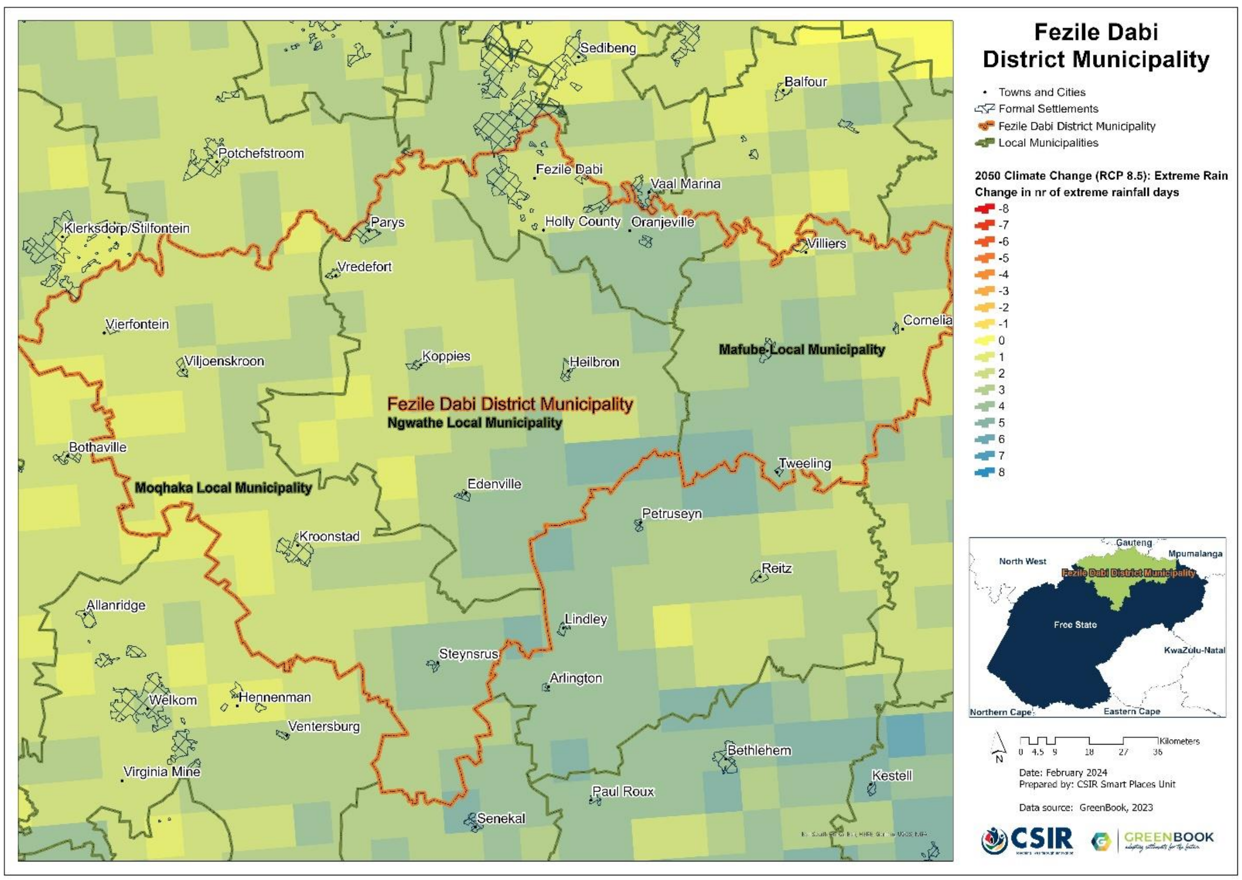


*Figure 19: Projected changes into the future in extreme rainfall days across Fezile Dabi District Municipality*

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.

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. Settlements of Kroonstad, Steynsrus, Hellbron, and Cornelia are projected to have a high likelihood of increased flooding, with a low likelihood of flooding for settlements of Viljoenskroon, Vredefort, Parys and Koppies and moderate likelihood for Edenville and Tweeling.

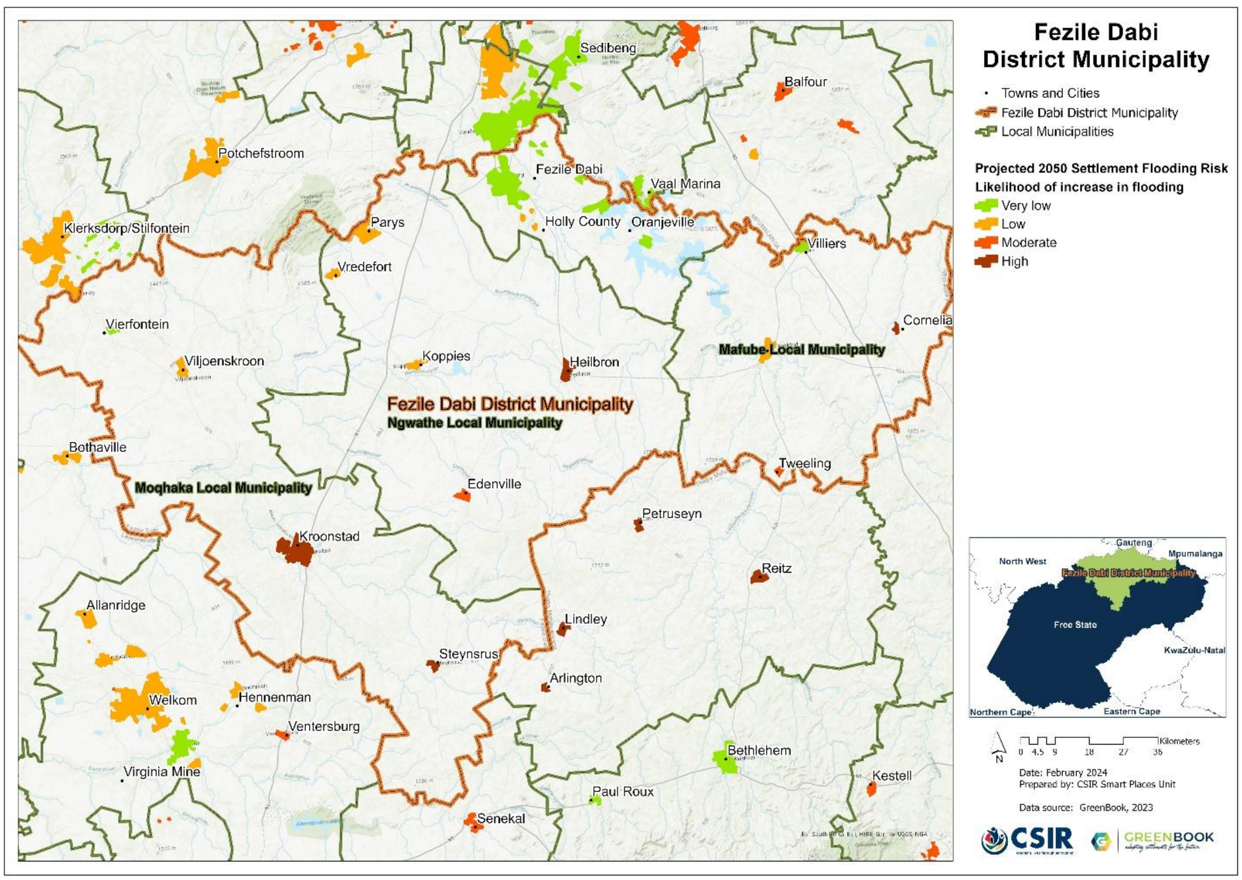


*Figure 20: Flood risk into a climate change future at settlement level across Fezile Dabi District Municipality.*

## 2.4. 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 Fezile Dabi District Municipality.

### 2.4.1. 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 indicates the catchment(s) related to the district. The quaternary catchments serving the district include the Vaal Primary Catchment.

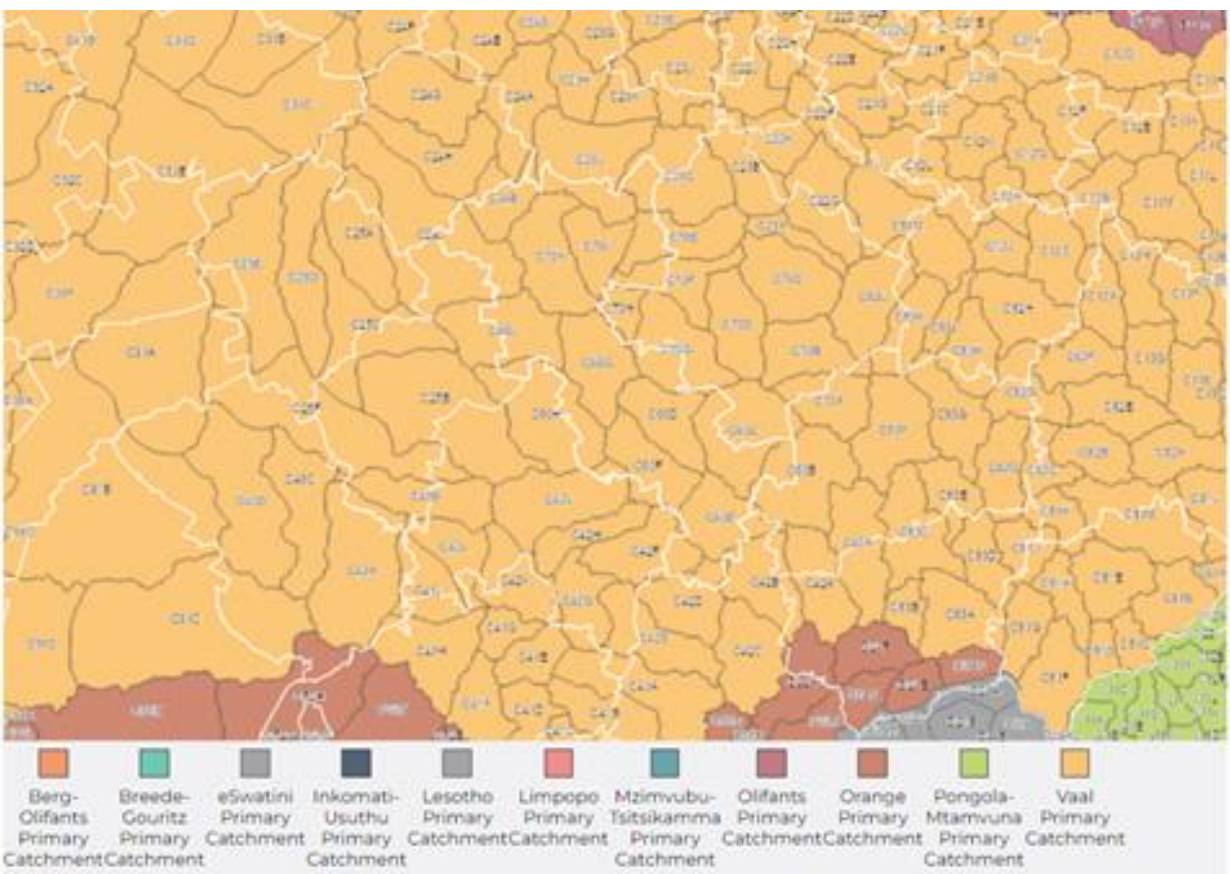


*Figure 21: Quaternary catchments found in Fezile Dabi District Municipality*

Figure 22 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 Fezile Dabi District, most towns are surface water dependent, except for Kroonstad and Steynsrus in Moqhaka LM and Cornelia in Mafube LM using a combination of surface and groundwater sources and Edenville in Ngwathe LM making use of groundwater sources.

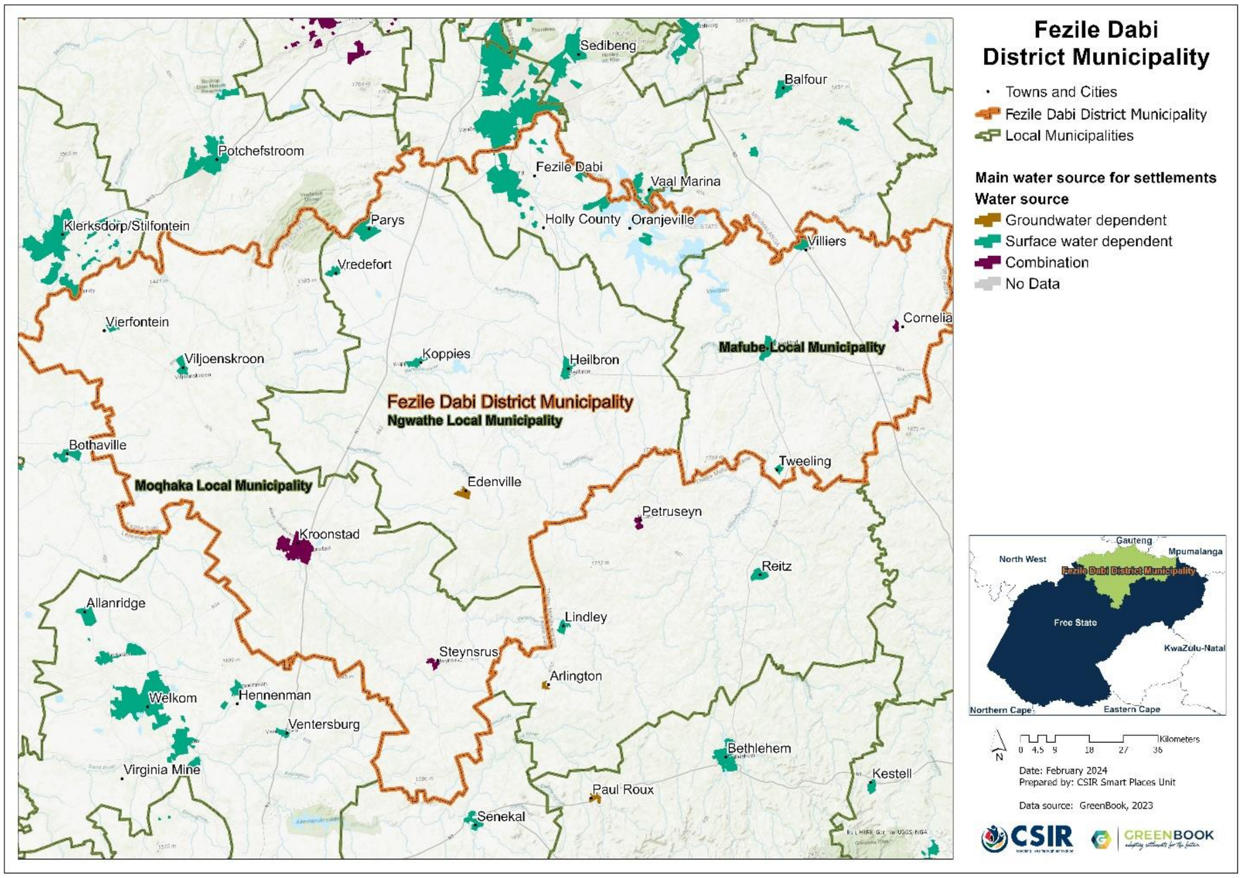


*Figure 22: Main water source for settlements in the Fezile Dabi District Municipality*

Figure 23 indicates the occurrence and distribution of groundwater resources across the District Municipality, showing distinctive recharge potential zones, while Figure 24 indicates the projected change in groundwater potential. Figure 25 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 high for most parts of the district, with moderate recharge potential in the areas surrounding Vierfontein and Viljoenskroon in Moqhaka LM. The projected change in groundwater recharge potential for most of the FDDM indicates a significant increase in recharge potential across the district, except for the area surrounding Vierfontien and

Viljoenskroon settlements in Moqhaka LM which will vary between no change to slight decrease in recharge with pockets of increased groundwater recharge.

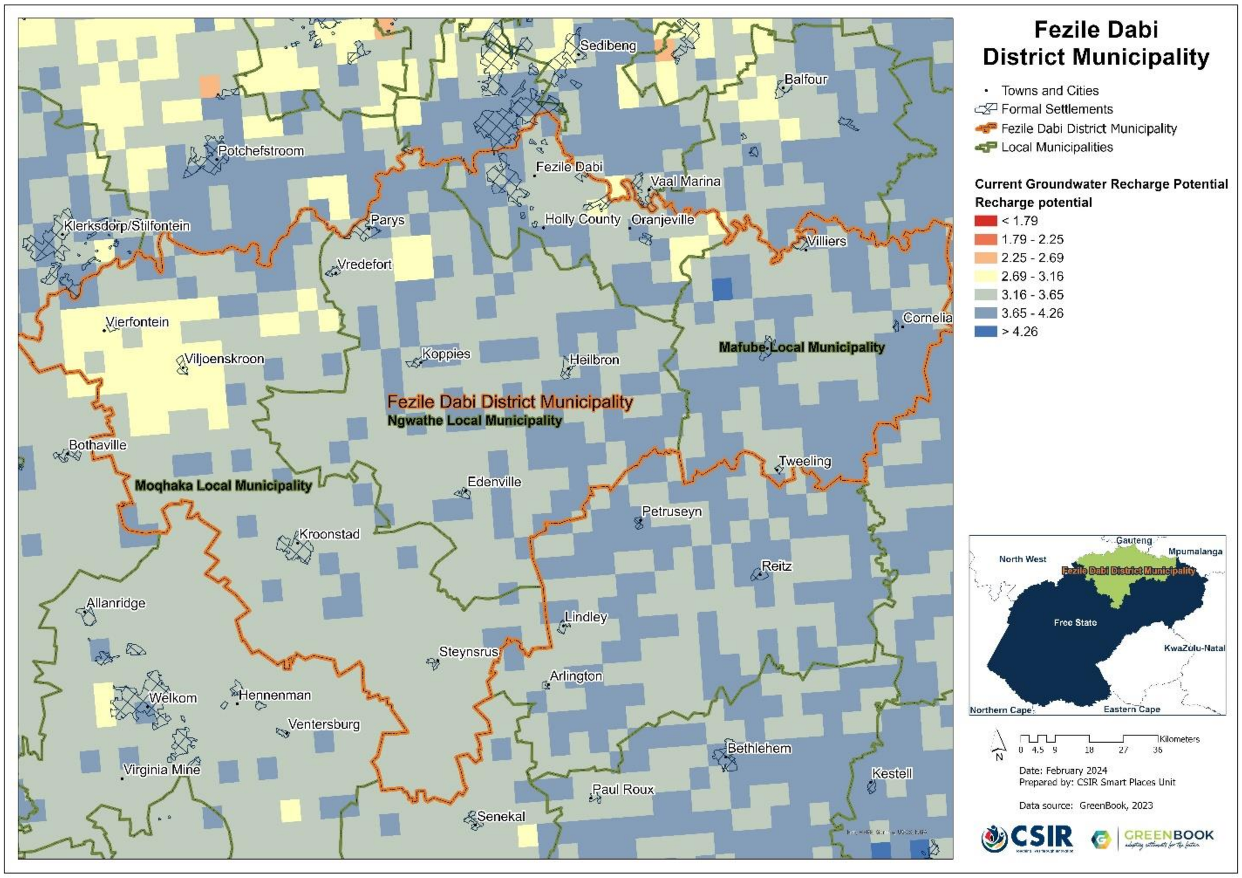


*Figure 23: Groundwater recharge potential across Fezile Dabi District Municipality under current (baseline) climatic conditions*

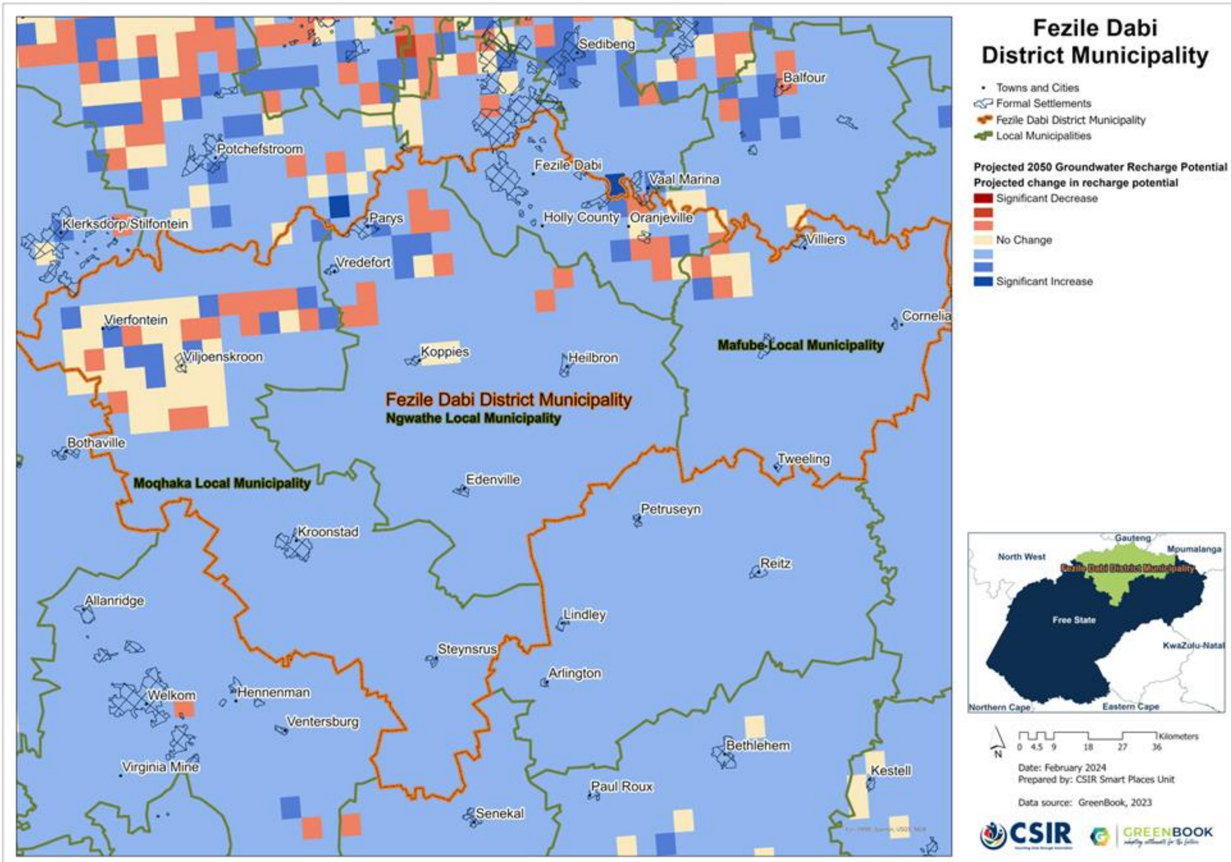


*Figure 24: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across Fezile Dabi District Municipality*

The settlements which are groundwater dependent in the Fezile Dabi District have a very low groundwater depletion risk (See Figure 25).

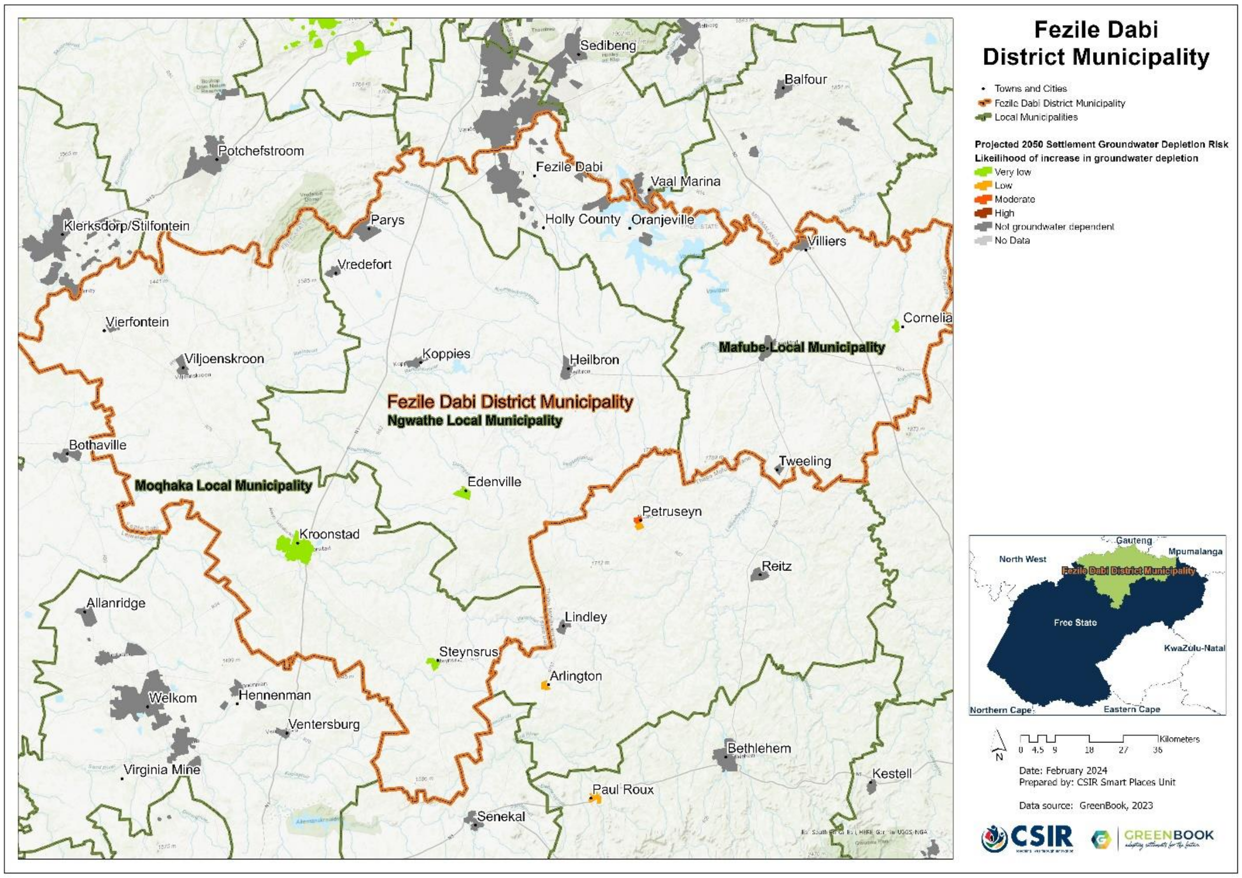


*Figure 25: Groundwater depletion risk at settlement level across Fezile Dabi District Municipality*

Table 3 provides an overview of current water supply vulnerability (i.e., demand versus supply) for the local municipalities in the Fezile Dabi 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 Fezile Dabi District Municipality*

| Local Municipality | Water Demand per Capita (l/p/d) | Water Supply per Capita (l/p/d) | Current Water Supply Vulnerability |
|---|---|---|---|
| Moqhaka | 306.06 | 207.36 | 1.48 |
| Metsimaholo | 496.18 | 496.18 | 1 |
| Ngwathe | 213.39 | 434.88 | 0.49 |
| Mafube | 157.45 | 0 | 0 |

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.

#### Moqhaka

Moqhaka LM's water demand is currently higher than supply giving it a high-water supply vulnerability. Water supply vulnerability is however projected to decrease significantly into the future, this is due to a projected increase in rainfall, and decreased population growth.

#### Metsimaholo

Metsimaholo LM's water supply currently meets demand. Water supply vulnerability is projected to increase significantly in the future for most future scenarios, this is due to increase in mean annual evaporation and projected population growth of 46%.

#### Ngwathe

Ngwathe LM's water supply currently matches its demand. In future the water supply vulnerability is projected to increase for most scenarios and can be attributed to increased evapotranspiration and increased population growth.

#### Mafube

Mafube LM has a water supply need of 157.45 litres per day which cannot be met by the LM. As a Water Supply Authority Mafube LM has a blue drop score of 4.25% and a Blue Drop Risk Rating score of 98.9% placing it in the critical risk category (Blue Drop Report, 2023). The minimum blue drop target for Water Supply Systems is 31% which is an indication of the dire state of management and drinking water quality in the LM.

### 2.4.2. 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 12% to the local GVA of the district (IDP, 2020). This is significantly higher than the agricultural sector's national average contribution of 2.5 % to GVA. Fezile Dabi District Municipality has a strong agriculture base and is known as the grain/maize basket of South Africa. The district has 327 592 ha of high potential agricultural land (15,4% of all agricultural land in the province) and 59% of agricultural land has low potential. The Villiers area is predominantly agriculture-orientated, where products such as maize, sunflower, wheat, grain, sorghum, meat and dairy are produced. In the Greater Tweeling area agricultural activities include sheep and cattle farming, maize, and sunflower seed production.

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.

### Moqhaka

In the Moqhaka LM, the AFF sector contributes 5% to the local GVA, which is a contribution of 0.6% to the national GVA for the AFF sector. Of the total employment, 19.89% is within the AFF sector. The main agricultural commodities are maize for grain, wheat and beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events. Increase in temperature with increase in rainfall will lead to a potential increase in maize and wheat production in the near future.  Heat stress can however negatively impact maize production towards 2050. Yield and crop suitability of wheat will also decline over time as temperatures start to exceed critical crop thresholds. Hot and moist conditions can cause increase spread of disease and parasites. Heat stress can also lead to reduced growth and reproduction performance for beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events.

### Metsimaholo

In the Metsimaholo LM, the AFF sector contributes 0.86% to the local GVA, which is a contribution of 0.17% to the national GVA for the AFF sector. Of the total employment, 4.57% is within the AFF sector. The main agricultural commodities are beef cattle and maize for grain. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events. Hot and moist conditions can cause increased spread of disease and parasites. Heat stress can also lead to reduced growth and reproduction performance for beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events. The increase in temperature combined with increase in rainfall will lead to a potential increase in maize production in the near future. Heat stress can however negatively impact on maize production towards 2050.

### Ngwathe

In the Ngwathe LM, the AFF sector contributes 7.05% to the local GVA, which is a contribution of 0.44% to the national GVA for the AFF sector. Of the total employment, 20.89% is within the AFF sector. The main agricultural commodities are maize for grain, chickens and beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events. The increase in temperature combined with increase in rainfall will lead to a potential increase in maize production in the near future. Heat stress can however negatively impact maize production towards 2050. Increase in temperature will lead to increased production costs (and increased investment will be required in ventilation and cooling) to maintain optimal seasonal temperatures and reduce the risk of heat stress for chickens. Heat stress on birds will reduce body weight gain, reproduction efficiency and egg quality. Hot and moist conditions can cause increase spread of disease and parasites. Heat stress can also lead to reduced growth and reproduction performance for beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events.

### Mafube

In the Mafube LM, the AFF sector contributes 7.19% to the local GVA, which is a contribution of 0.19% to the national GVA for the AFF sector. Of the total employment, 20.38% is within the AFF sector. The main agricultural activities are centred around maize for grain and beef cattle. Climate projections show a generally hotter and wetter climate, with more extreme rainfall events. The increase in temperature combined with increase in rainfall will lead to a potential increase in maize production in the near future. Heat stress can however negatively impact on maize production towards 2050. Hot and moist conditions can cause increase spread of disease and parasites.  Heat stress can also lead to reduced growth and reproduction performance for beef cattle.

## 3. Recommendations

The greatest climate risks faced across the Fezile Dabi District are increased temperatures, a considerable degree of uncertainty and variability regarding future precipitation patterns as well as significant increases in extreme rainfall. Changes in annual rainfall could have significant consequences for water availability, agriculture, ecosystems, and various socio-economic activities. Whereas an increase in extreme rainfall events can have significant implications for water management, infrastructure resilience, and disaster preparedness. The settlements of Kroonstad, Steynsrus, Hellbron, and Cornelia are projected to have a high likelihood of increased flooding in future. Extreme rainfall may also lead to additional challenges such as erosion, and strain on drainage systems. The projected wildfire risk for 2050 is high for certain settlements in the district. This underscores the importance of adaptive planning and resilience-building measures to mitigate potential risks and capitalize on opportunities associated with changing precipitation patterns.  Fezile Dabi District Municipality is currently experiencing issues of water scarcity and quality which will only be exacerbated with future climate change impacts.

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: Initiatives that will increase the resilience include invest in infrastructure such as reservoirs and water storage tanks to capture and store water during wet periods for use during dry periods. Promote rainwater harvesting systems for individual households and communities to improve local water resilience. Encourage the adoption of water-efficient technologies such as drip irrigation and low-flow fixtures in agriculture and households. Invest in water treatment facilities to improve water quality and safety. Ensure water supply systems are resilient to floods and droughts, including measures such as elevating facilities and protecting them from water contamination. Coordinate water management across sectors, such as agriculture, industry, and municipalities, to optimise water use and allocation. Establish monitoring systems for water quality and quantity to track changes and identify potential risks. Encourage collaboration among local governments, water utilities, and community groups to address water challenges collectively.

2. To reduce the quantity of stormwater runoff from developed areas and to slow its flow, thereby improving the quality of water and the health of downstream water sources by identifying suitable areas for managing water runoff: Drainage systems in the district should be retrofitted/adapted to handle larger volumes of water and prevent flooding. Construct or enhance stormwater retention and detention systems, such as retention

basins, rain gardens, and permeable pavements. Maintain and clear drainage channels and rivers regularly to ensure unobstructed water flow. Enhance stormwater management infrastructure to prevent flooding and water pollution.

3. To ensure that space is set aside for recreation, ecological support and stormwater management, and to guide decision making across all sectors: Green infrastructure should be planned for, such as parks and wetlands, to absorb excess water and reduce urban flooding. Restore wetlands and riparian buffers to absorb and manage floodwaters. Reforest areas to stabilize soil, improve water infiltration, and reduce runoff. Promote conservation agriculture practices to retain water in soils and minimize erosion. Protect existing natural areas such as forests, wetlands, and riparian zones, which provide habitat for wildlife and help manage stormwater. Restore degraded ecosystems to improve their capacity for stormwater management and ecological support. Design spaces that serve multiple purposes, such as parks with walking trails, native plant gardens, and stormwater management features.

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. Considering the uncertainty and variability in precipitation patterns predicted for Fezile Dabi District it would be important to develop efficient water storage and conservation systems to manage variability in precipitation and extreme rainfall. To implement water reuse and recycling programs to maximize water resources. Engage local communities in flood risk planning and adaptation efforts to tailor strategies to specific needs. Provide training on emergency response and flood and fire preparedness and safety measures for community members, including how to secure property and navigate floods and fires safely. Promote awareness campaigns on flood and fire risks and preparedness actions. Develop and deploy early warning systems to alert communities to imminent flood risks and wildfires. Establish evacuation plans and designate safe shelters for populations affected by flood or wildfires.

5. To increase resilience of the agricultural sector to more extreme events such as heat waves and storms as well as indirect risks such as pests and diseases: To increase resilience of the agricultural sector a combination of proactive planning, adaptation strategies and technological innovation is required. Crop and livestock diversification should be encouraged to reduce dependence on a single variety or breed, which can be more susceptible to extreme events and diseases. Promote the use of polycultures and intercropping, which can enhance resilience and improve soil health. Promote the use of drought-tolerant, heat-resistant, and pest-resistant crop varieties. Incorporate trees and shrubs into agricultural landscapes to provide shade, reduce heat stress, and protect soil and water resources. Use silvopasture systems that integrate trees with livestock grazing to improve ecosystem services and reduce vulnerability. Provide farmers with

access to real-time weather data and forecasts to help them plan agricultural activities and respond to extreme events. Promote integrated pest management to control pests and disease while minimising the use of chemical pesticides. Encourage collaboration among farmers, researchers and policymakers to share best practices and innovative solutions.

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 FDDM. 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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