GREENBOOK
adapting settlements for the future

Mthatha CBD and surrounds PHSHDA
Climate Risk Profile Report

SEPTEMBER 2023

Report compiled by the CSIR
Funded by the GIZ
DFFE, DHS and the HDA as collaborative partners

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Title: Mthatha CBD and surrounds PHSHDA: Climate Risk Profile Report
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Date: September 2023
Citation: CSIR, 2023. Mthatha CBD and surrounds PHSHDA: Climate Risk Profile Report. GIZ, DFFE, DHS, the HDA & King Sabata Dalindyebo Local Municipality.
Version: Draft 1

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List of Acronyms and Abbreviations

°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
CRVA	Climate Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DHS	Department of Human Settlements
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
GDP	Gross Domestic Product
GRiMMS	Groundwater Drought Risk Mapping and Management System
GVA	Gross Value Added
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometre
l/p/d	Litres Per Person Per Day
LM	Local Municipality
LRT	Let’s Respond Toolkit
mm	Millimetre
NDMC	National Disaster Management Centre
PHSHDA	Priority Human Settlement and Housing Development Area
PHS	Priority Human Settlement
PHDA	Priority Housing Development Area

PVI	Physical Vulnerability Index
RCP	Representative Concentration Pathways (mitigation scenarios)
SCIMAP	Sensitive Catchment Integrated Modelling and Prediction
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, 2023).
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 proposed Adaptation Actions Plan (still to be developed), was developed specifically for Mthatha CBD and surroundings in the King Sabata Dalindyebo Local Municipality (KSD LM), 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 GreenBook l Adapting settlements for the future).

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

- Build and further the climate change response agenda,
- Inform strategy and planning in the Priority Human Settlement Housing Development Area (PHSHDA),
- Identify and prioritise risks and vulnerabilities,
- Identify and prioritise interventions and responses, as well as
- Guide and enable the mainstreaming of climate change response, particularly adaptation.

The main climate risks for the PHSHDA are flood risk and wildfire risk, which pose high and medium risk, respectively. The floods have a huge impact on people's livelihoods, life, roads and bridges and various infrastructures which will severely be damaged because of the disaster. Although the projected likelihood and intensity of wildfires is expected to increase moderately over Mthatha and Sheshenge, this will have a negative effect on biodiversity, soil structure and the spread of fire-adapted alien invasive plants.

The outline of the report is as follows: firstly the approach followed to compile the report is explained in order to understand the subsequent descriptions of climate risk. Then follows detailed maps and descriptions of vulnerability, the climate, the potential exposure of settlements to specific climate hazards, and the impact of climate change on key resources. Lastly the report recommends adaptation goals to limit the impacts of climate change in the PHSHDA.

1.1. Approach followed

The approach used in the GreenBook, and the Climate Risk Profile report 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 [as well as] 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.

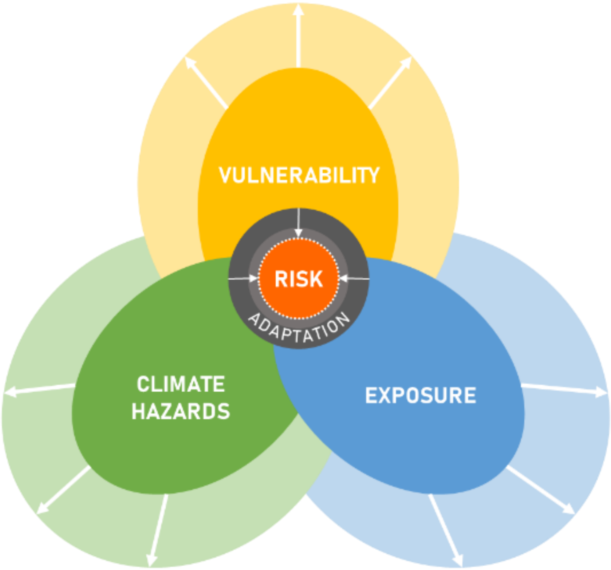


Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

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

All information contained in this report is based on the GreenBook, unless otherwise specified. The information in the GreenBook is provided at local municipal level and settlement level. Information and data were derived using GIS analysis and modelling techniques using secondary data and is not based on local surveys.

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" (Republic of South Africa, 2013, p. 20) – 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 takes it further by setting out reporting requirements on climate change response needs and interventions for every municipality in the country.

The National Climate Change Adaptation Strategy outlines several actions 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 into municipal development plans and relevant sector plans, i.e., mainstreaming. 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.

In response to the national call to advance spatial transformation and consolidation in human settlement development, the National Department of Human Settlements (DHS) has identified a total of 136 Priority Human Settlements and Housing Development Areas (PHSHDAs). The PHSHDAs were declared to ensure that housing delivery is used to restructure and revitalise towns and cities, strengthen the livelihood prospects of households, and overcome apartheid spatial patterns by fostering integrated urban forms (DHS, 2020). PHSHDAs were designated using national criteria which includes an area or settlement's potential to support sustainable environmental management (which plays a critical role in mitigating the negative impacts of climate change), as well as its potential to accommodate the integration of land uses and amenities, i.e., in addition to other criteria.

The DHS has identified two key objectives for PHSHDAs, including (1) targeting and prioritising areas for integrated housing and human settlements development to ensure the delivery of housing for a diverse range of income groups within an integrated mixed-use development, as well as (2) transforming spatial patterns which have historically exacerbated social inequality and economic inefficiency (DHS, 2020). As part of the second objective, this initiative aims to develop post-apartheid cities and city patterns that ensure urban access, as well as achieve a balance between spatial equity, economic competitiveness, and environment sustainability (DHS, 2020). As the impacts of climate change become more severe, the latter outcome (i.e., ensuring and maintaining environmental sustainability) will become increasingly important.

Furthermore, as part of the implementation approach for housing and human settlement development in PHSHDAs, the DHS has identified the provision and maintenance of ecological infrastructure to support development in priority areas as a key avenue for integrating climate considerations and mainstreaming climate responses (DHS, 2022).

1.3. Local Municipal context

The King Sabata Dalindyebo Local Municipality (KSD LM), in the OR Tambo District Municipality, in the Eastern Cape province of South Africa, was formed in the year 2000 just before the government elections, when the Mqanduli and Mthatha Transitional and Rural Councils were merged. The municipal area covers 3027 square kilometres with 37 wards accommodating an estimated population of 520 000 people in 126 000 households in 2020 (O.R. Tambo District Municipality Integrated Development Plan, 2022/27) It is the most populous and densely populated municipality amongst the five municipalities found in the OR Tambo District in the Eastern Cape Province and considered a category B municipality. The municipality is a prominent urban settlement and regional economic hub and has both urban and rural characteristics. The municipality has two major towns namely, Mthatha and Mqanduli, and its rural settlements show a scattered village-type rural settlement (King Sabata Dalindyebo Local Municipality Community Safety Plan, 2019/2022).

KSD LM has experienced an average annual increase of 1.28% population growth (OR Tambo District Municipality 2022/2027 IDP). The percentage of people living in poverty in KSD LM has increased from 72.52% in 2010 to 75.56% in 2020. The labour force was 45.3% in 2020, while the unemployment rate in KSD LM was 41.6% compared to 28.5% in 2010. Between 3-5% of the working population is projected to migrate out of the local municipality between 2020 and 2025 (KSD IDP 2022).

Mthatha, which derives its name from the nearby Mthatha River (named after the Sneezewood trees "umtati", is located in the northeastern corner of the King Sabata Dalindyebo Local Municipality (KSD LM). The PHSHDA of Mthatha CBD and surrounds is home to 121 399 people and is of particular significance to the Municipality. It is a major regional transport hub at the intersection of a national, provincial and several local routes and at the end of a regional rail line. Mthatha is the capital of OR Tambo District Municipality and is a regional economic hub as well as administrative centre in the district. It also boasts an airport and is home to the historical Walter Sisulu University. The N2 national road (N2) runs through Mthatha and connects Mthatha to the towns Qumbu, Mount Frere and Kokstad, while the regional R61 road connects Mthatha with Port St Johns on the coast and Engcobo on the inland. These are critical routes for trade and logistics along the towns and local municipalities in the OR Tambo District Municipality (KSD SDF, 2022). Mthatha is also a gateway to a wide range of tourist offerings and serves as a popular stop-over point on the way to tourist attractions like Coffee Bay and Hole-in-the-Wall in the King Sabata Dalindeyebo Local Municipality and Port St Johns and Mbotyi in neighbouring LMs. It is linked to East London by the Kei Rail.

KSD LM, with Mthatha as its economic centre, makes the biggest contribution to the OR Tambo GDP, contributing approximately R33 billion per annum. The biggest economic sectors within the municipality are community services, finance and trade, each contributing, 35%, 24% and 23% respectively to the Gross Value Added in the local municipality. Accordingly, community services, finance and trade are the biggest areas of employment within the municipality (KSD SDF, 2022). The agricultural sector only contributes 1% of the total GVA and approximately 2% of households are employed in the agricultural sector. The mining sector employs the least number of people.

The KSD LM is largely rural in nature and is considered to have rich natural resources which gives it a comparative advantage in terms of potential for agricultural production. The area is climatically suitable to produce several high value crops such as citrus and subtropical fruits. Agriculture however is one of the sectors with the lowest contribution to the GDP and employment sector. Several vegetation types can be found in the KSD local municipality and includes Savanna, Grassland and Indian Ocean Coastal Belt, with Grassland and Savanna more prevalent in the area around Mthatha. The Mthatha River cuts through most of the KSD LM area into the Indian Ocean at the Mthatha Mouth. The Mthatha River is joined by the Cicira River between the Mthatha Dam and Mthatha town. Several wetlands and dams are found in the KSD LM area offering significant advantages in terms of water storage, retention, flood control and creating habitat for wildlife. Land degradation is a significant problem, especially in the grasslands area where subsistence farming is the main land use. Inappropriate agricultural practices, leading to soil erosion, wetland destruction and species loss is a threat to biodiversity in the district.

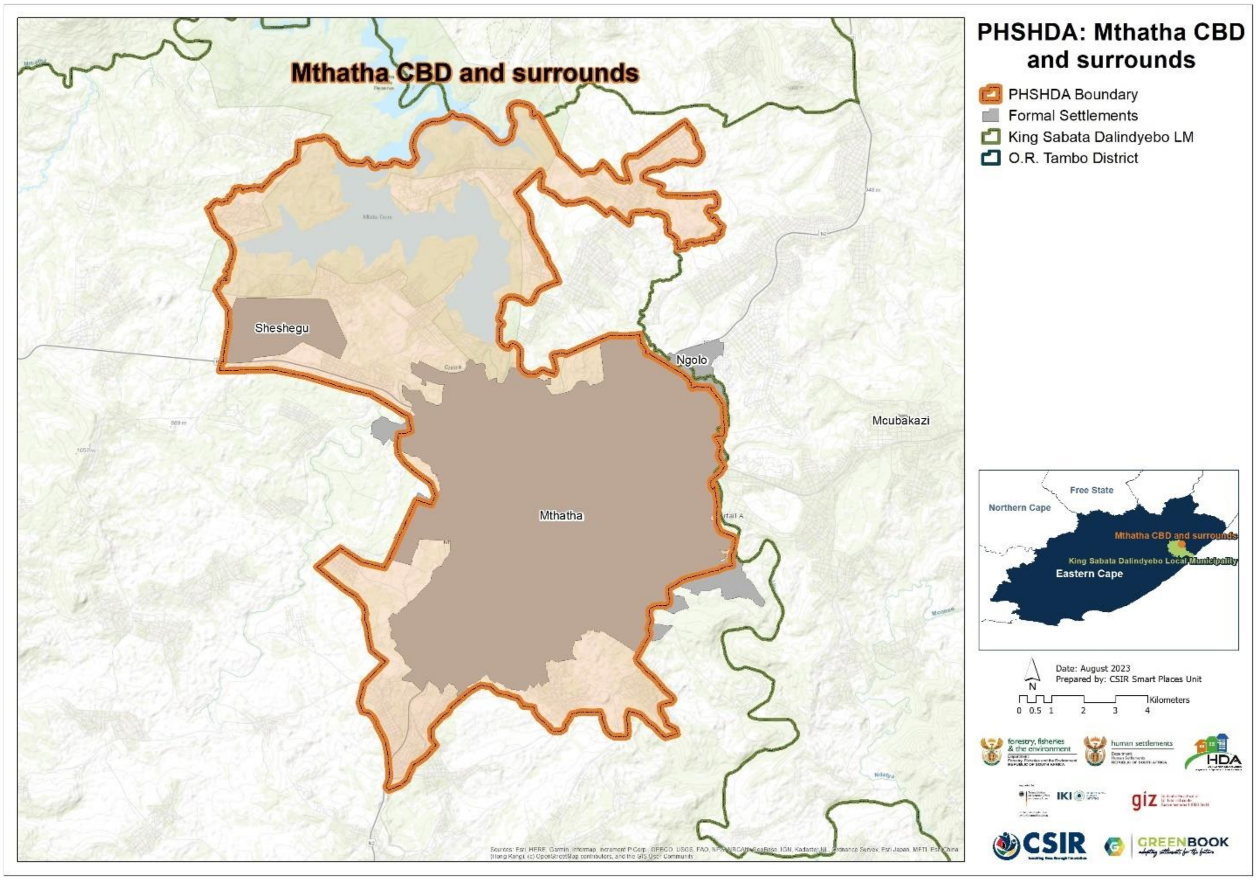


Figure 2: Mthatha CBD and surrounds, 2023

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. Current as well as future exposure to drought, heat, wildfire, and flooding are also set out. Together, this information provides an overview of current and future climate risk for Mthatha CBD and surroundings 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 Mthatha CBD and surrounding 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 drives vulnerability into the future, and therefore population growth and decline of settlements across the local municipality 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 Mthatha CBD and surrounding.

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 that the municipality houses 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, and the inequality present in the municipality. The higher the economic vulnerability the more susceptible the municipality is 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.

King Sabata Dalindyebo LM is provided with 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 is only available for Socio-Economic Vulnerability and Economic Vulnerability.

Table 1: Vulnerability indicators across King Sabata Dalindyebo Local Municipality

MUNICIPALITY	SEVI 1996	SEVI 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
King Sabata Dalindyebo	7.11	6.91	↘	5.37	6.31	↗	7.23	↘	4.33	N/A

As outlined in Table 1 above, DSK LM's socio-economic vulnerability has decreased (improved) between 1996 and 2011 indicating that the number of vulnerable households has decreased, particularly in terms of their lack of access to basic and social services. Thus, implying that essential resources that influence their ability to withstand adverse shocks from the external environment, inclusive of the climate change induced.

Meanwhile, the LM's economic vulnerability has increased (worsened) within the same period, thereby indicating the municipality as highly susceptible to being adversely affected by external shocks. The King Sabata Dalindyebo LM has a very high physical vulnerability score, i.e., the fifth highest in the province, which indicates high structural vulnerabilities in the LM, especially when considering the municipality's buildings and infrastructure.

2.1.2.Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlement in which the PHSHDA is to be found within the King Sebata Dalindyebo Municipal Area, with regards to six composite indicators. This enables the investigation of the relative vulnerabilities of the settlement (PHSHDA) within the LM compared to other settlements.

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 are experiencing growth pressures on top of the other dimensional vulnerabilities.

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.

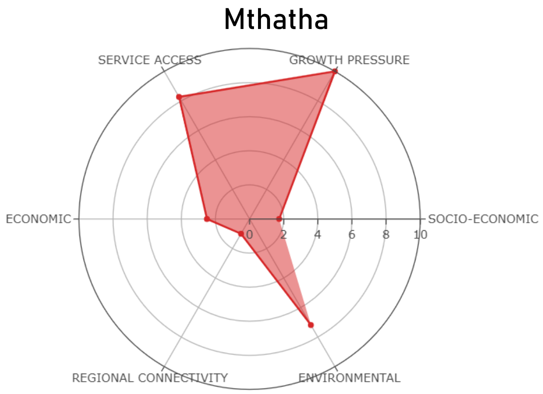
The Growth-Pressure Vulnerability Index shows the relative (1996-2011 growth rates) and anticipated pressure on settlements.

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.

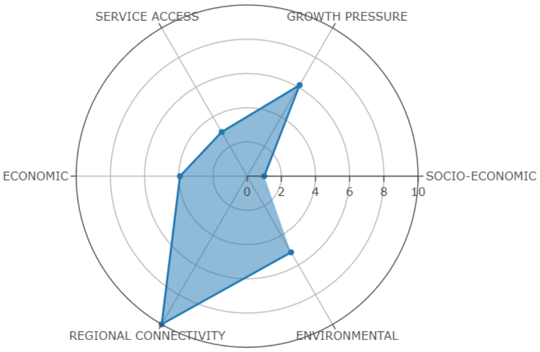
The Service Access Vulnerability Index comprises of 10 variables grouped into four indictors, that show the level of services offered and rendered within a settlement and includes the settlement's (1) access to basic services (electricity, water, sanitation, and refuse removal), (2) settlement's access 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.

The major settlements in the LM of King Sabata Dalindyebo are Mthatha, Coffee Bay, Mqanduli, Sheshengu, with the rest of the settlements (more than 64%) classified as traditional areas. A brief description of the settlement vulnerability in the King Sabata Dalindyebo LM follows below.

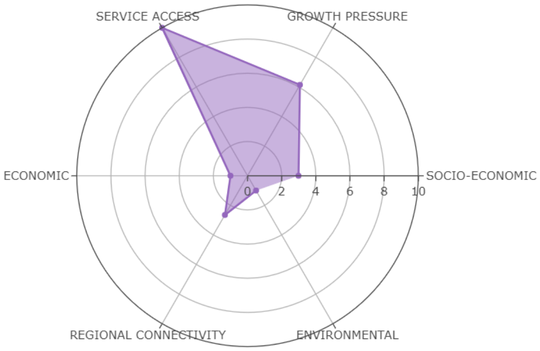
Mthatha faces the highest growth pressure, and also has high service access vulnerability indicating challenges to access basic services such as electricity, water and sanitation as well as access to healthcare and education. Mthatha, however, has low economic and socio-economic vulnerability.



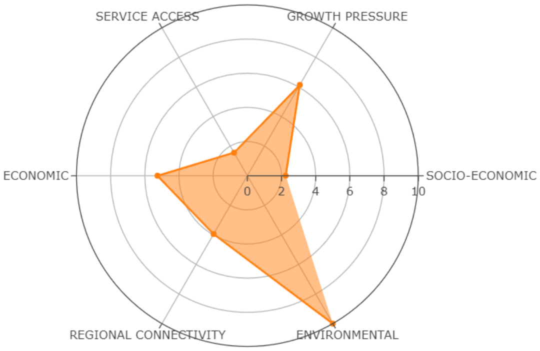
Coffee Bay has the highest regional connectivity vulnerability.


Coffee Bay

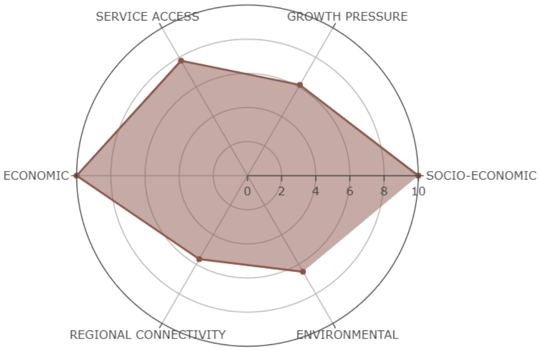
Sheshego has high service access vulnerability indicating challenges to access basic services such as electricity, water and sanitation as well as access to healthcare and education.


Sheshegu

Mqanduli has the highest environmental vulnerability in the Municipality, indicating that there is conflict between preserving the natural environment and pressure associated with population growth.


Mqanduli

Traditional areas have the highest economic vulnerability in the area and are home to the most socio-economically vulnerable populations in the LM.


Traditional authority areas

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 their in- and out-migration assumptions. The medium growth scenario (see 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: Population growth pressure across King Sabata Dalindyebo Local Municipality

Municipal Population Growth	2011	Medium Growth Scenario	
		2030	2050
King Sabata Dalindyebo Local Municipality	449 964	576 344	674 881

King Sabata Dalindyebo LM's population is projected to increase by 49.99% between 2011 and 2050, under a medium growth scenario. Most of the growth will occur between 2011 and 2030. Figure 4 depicts the growth pressures that the settlements across the KSD LM will likely experience. The map is accompanied by a table that provides, in addition to the expected growth pressure (under a medium population growth scenario), the baseline (2011) and projected (2030 and 2050) population figures for each settlement.

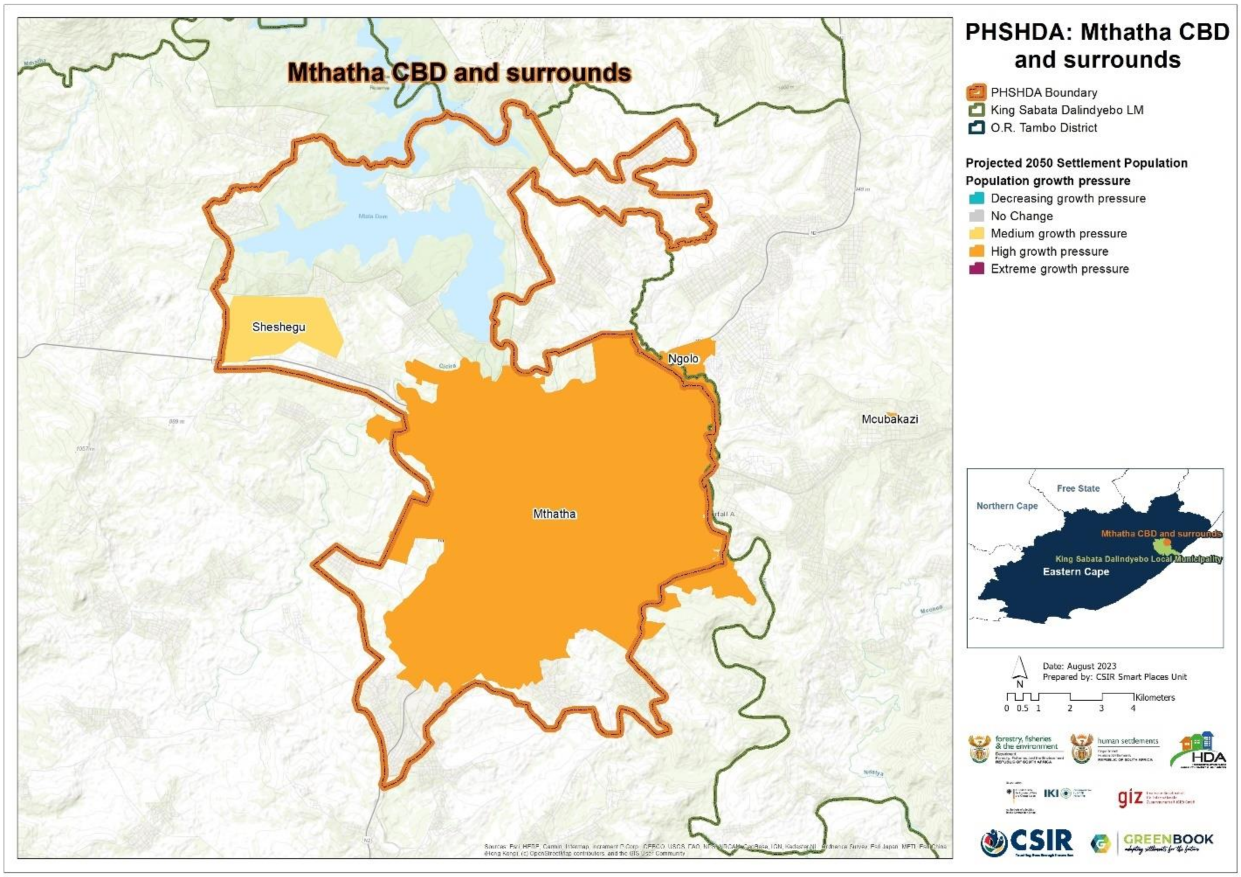


Figure 3: Settlement-level population growth pressure across Mthatha CBD and surrounds.

King Sabata Dalinyebo Local Municipality				
Town	Pressure	2011	2030	2050
Coffee Bay	Medium	1 217	1 534	1 781
Mqanduli	Medium	4 216	4 816	5 283
Kubeke	Medium	598	716	808
Mthatha	High	162 778	232 860	287 001
Sheshegu	Medium	4 144	4 941	5 532

Table 3: Settlement-level population growth pressure across King Sabata Dalinyebo Local Municipality

As displayed in Figure 3 and outlined in Table 3, no settlements are projected to experience extreme growth pressure. However, Mthatha, the LM's most populous settlement is projected to experience high growth pressure – thus alluding to the potential increase in the exposure of people and their assets to future climate conditions and their impacts. Sheshego and the rest of the Municipality's major settlements are expected to experience medium growth pressure.

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 six 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 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.

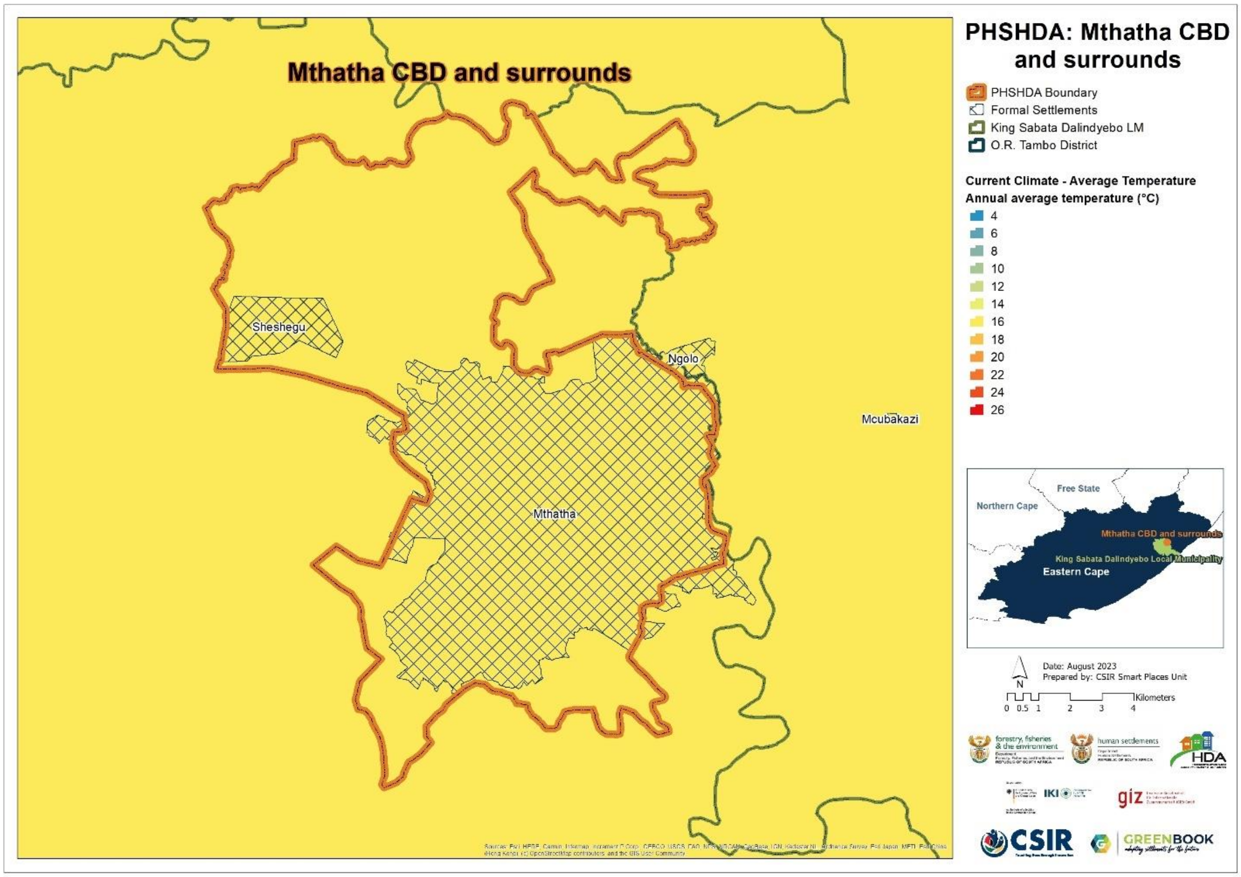


Figure 4: Average annual temperature (°C) for the baseline period 1961 – 1990 for Mthatha CBD and surrounds

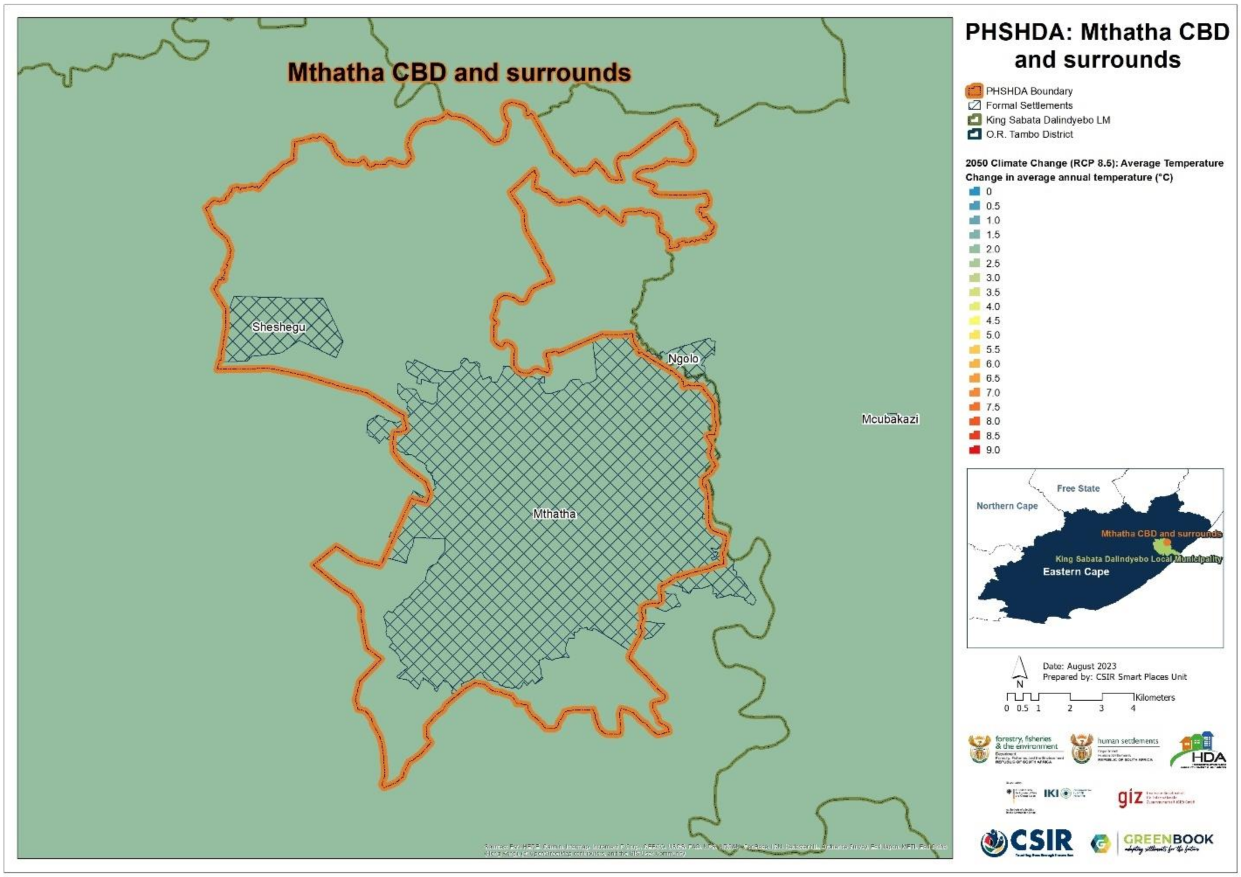


Figure 5: Projected change in average annual temperature (°C) from the baseline period to the period 2021 – 2050 for Mthatha CBD and surrounds, assuming an (RCP 8.5) emissions pathway

The King Sabata Dalindyebo Local Municipality's temperature conditions generally range from a mean minimum of 14.3-19.8 °C in January and 1.8-13.4 °C in July to a mean maximum of 14.3-25.3 °C in January and 19.5-21.4 °C in July. However, the Mthatha and Surrounds PHSDSA experiences average annual temperatures of below 17°C (Figure 4).

Figure 5 indicates the projected change in average annual temperature (i.e., temperature conditions exceeding near-normal per decade) for the period 2021–2050, relative to the baseline period 1961–1990, under the low mitigation "business as usual" emissions scenario (RCP 8.5). Generally, the Eastern Cape is expected to experience higher temperature increases towards the northwest interior, while lower increases are likely along the coast. The temperatures for KSD LM is expected to increase by between 1.9 °C and 2.2 °C respectively in future.

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.

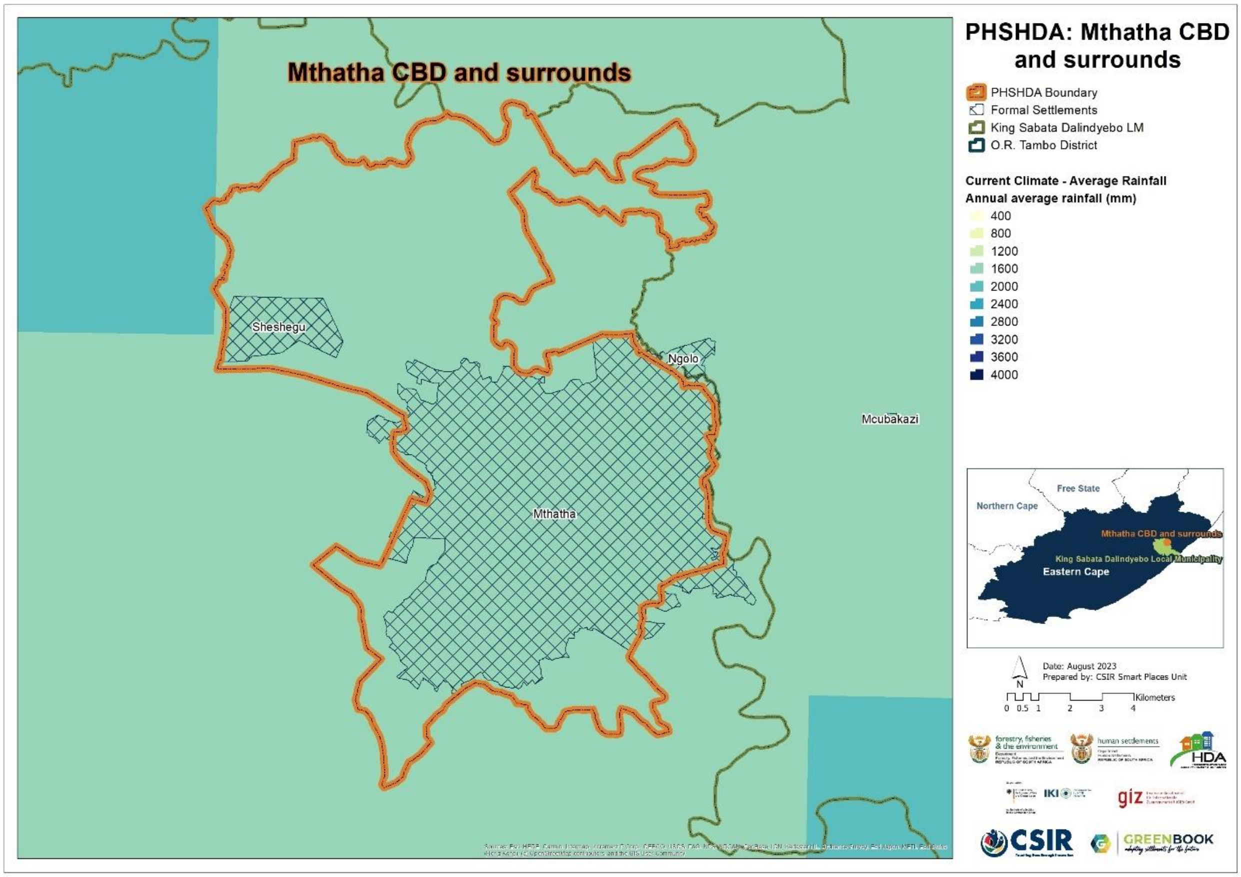


Figure 6: Average annual rainfall (mm) for the baseline period 1961 – 1990 for Mthatha CBD and surrounds.

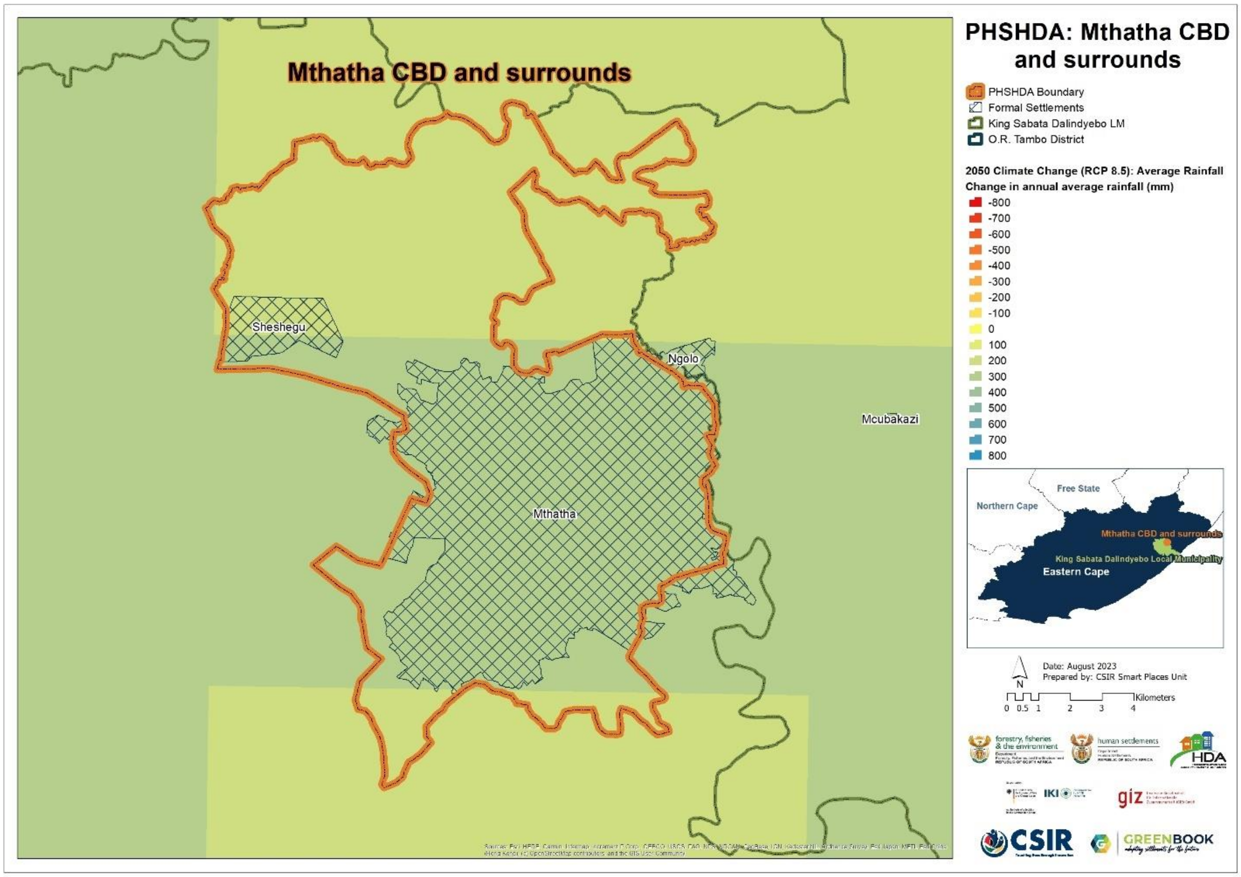


Figure 7: Projected change in average annual rainfall (mm) from the baseline period to the period 2021 – 2050 for Mthatha CBD and surrounds, assuming an (RCP 8.5) emissions pathway

Most of King Sabata Dalindyebo area receives an annual rainfall of above 1200mm. Rainfall decreases steadily inland and is particularly low in major river valleys. An appreciable amount of rain falls in the winter months in the coastal areas, but inland areas receive 80% or more of their precipitation in the 6 months from October to March (81% at Mthatha), evident in Figure 6 above.

Figure 7 shows the projected change in average annual rainfall (i.e., rainfall incidences exceeding near-normal per decade) for the period 2021–2050, relative to the baseline period 1961–1990, under the low mitigation “business as usual” emissions scenario (RCP 8.5). A positive value is indicative of an increase in rainfall occurrences per 10 years (more frequent than baseline) into the future period and a negative value indicative of an increase.

Generally, scenarios of regional climate change in South Africa remain uncertain especially regarding rainfall projections. However, current downscaling models show a wetting trend is expected in the eastward of the Eastern Cape. Figure 7 indicates projections for Mthatha and Surrounds indicating stable or slightly increasing rainfall, with increasing intensity except for Sheshengu settlement. The Sheshengu settlement indicates a variable increasing rainfall, with the northern part of the region showing less increase in rainfall compared to the southern part of it that correlates with the projections for the whole PHSHDA.

2.3. Climate Hazards

This section showcases information with regards to Mthatha CBD and Surrounds' 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).

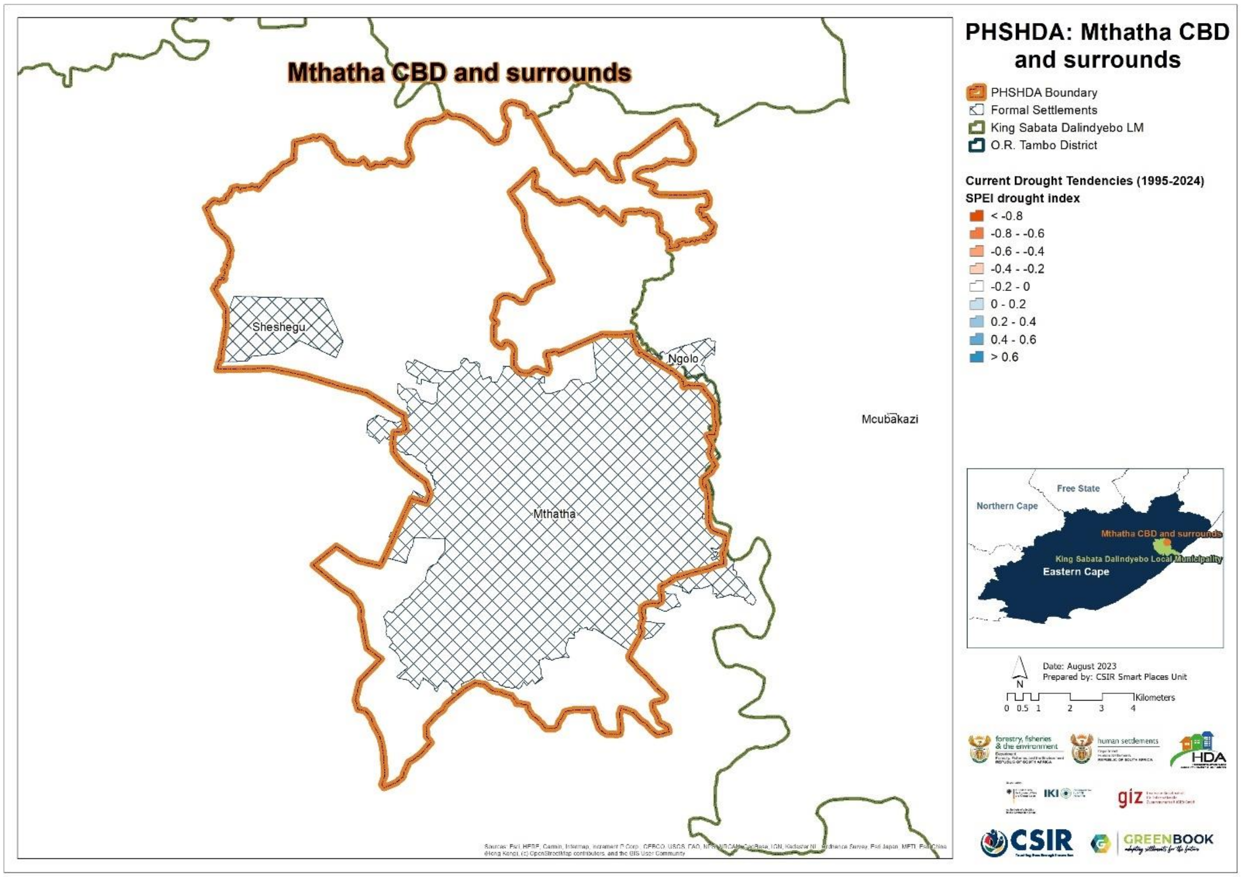


Figure 8: Projected changes in drought tendencies from the baseline period (1986 - 2005) to the current period (1995 - 2024) across Mthatha CBD and surrounds.

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. 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. The SPEI index do not indicate any significant trends in drought tendencies for the current period (1995 - 2024).

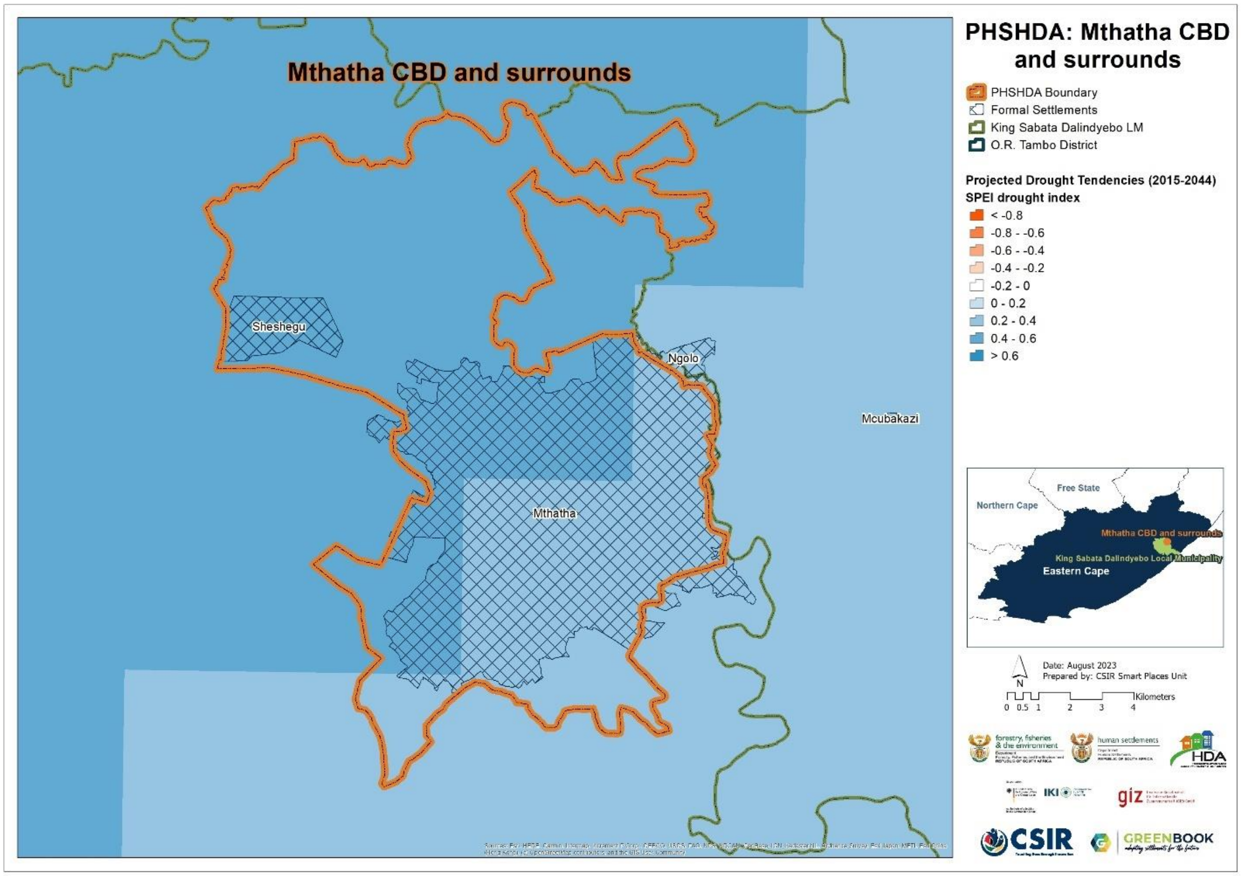


Figure 9: Projected changes in drought tendencies from the baseline period (1986 - 2005) to the future period (2015 - 2044) for Mthatha CBD and surrounds.

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 period and a positive value indicative of a decrease.

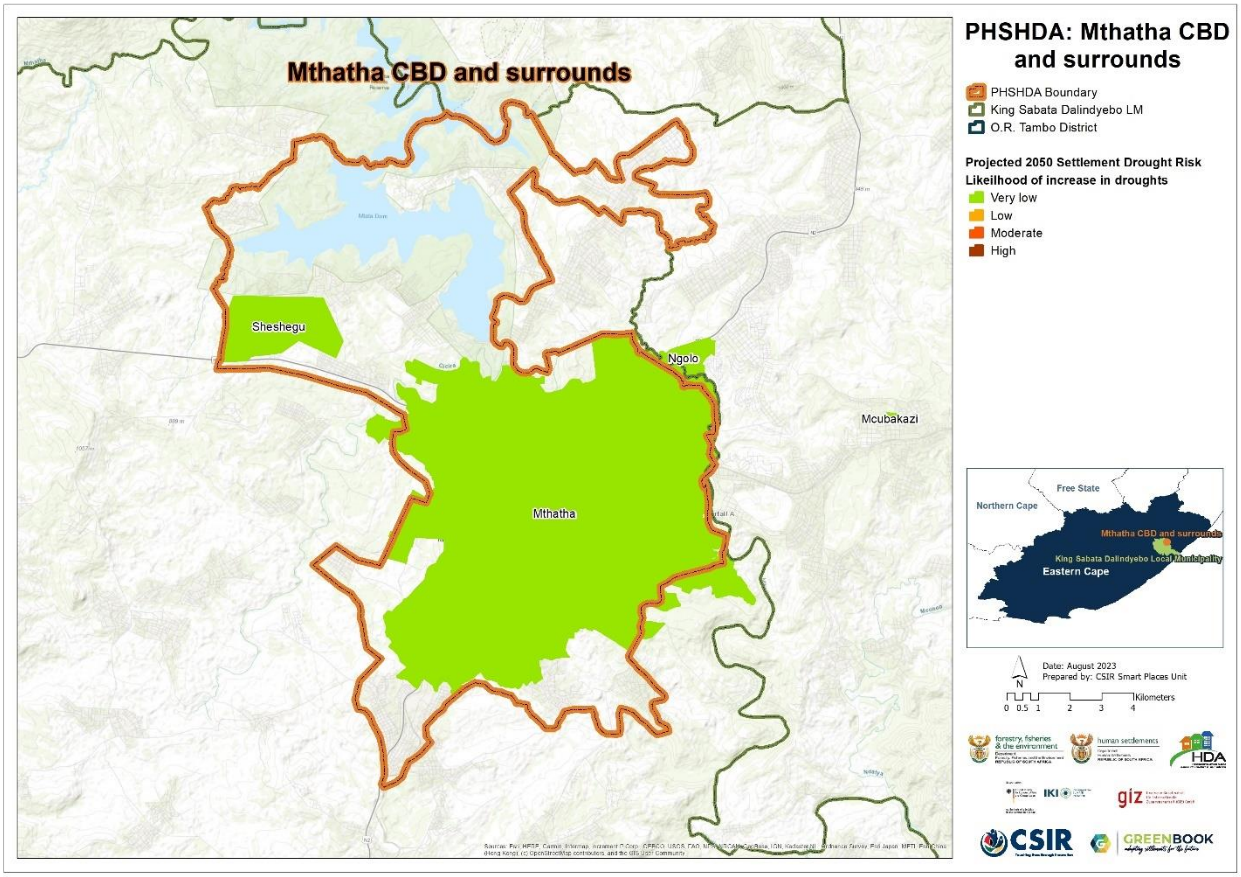


Figure 10: Settlement-level drought risk for Mthatha CBD and surrounds

Figure 10 depicts the settlements that are at risk of increases in drought tendencies. Average drought conditions across the PHSHA have varied over time. The period 1995 - 2024 sees the least widespread drought (see Figure 8), while the period 2015–2044 has generally been wetter than average (see Figure 9). Small and consistent decreases are observed throughout the PHSHDA. This is indicative of the settlements having a very low drought risk.

However, the King Sabata Dalindyebo is known as the third highest drought prone area in the district municipality, after Nyandeni and Mhlontlo. Although the area is known to be susceptible to agricultural droughts, the drought are considered to be normal.

2.3.2. Heat

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 change for period 2021–2050 (Figure 12), assuming a "business as usual" (RCP 8.5) emissions pathway.

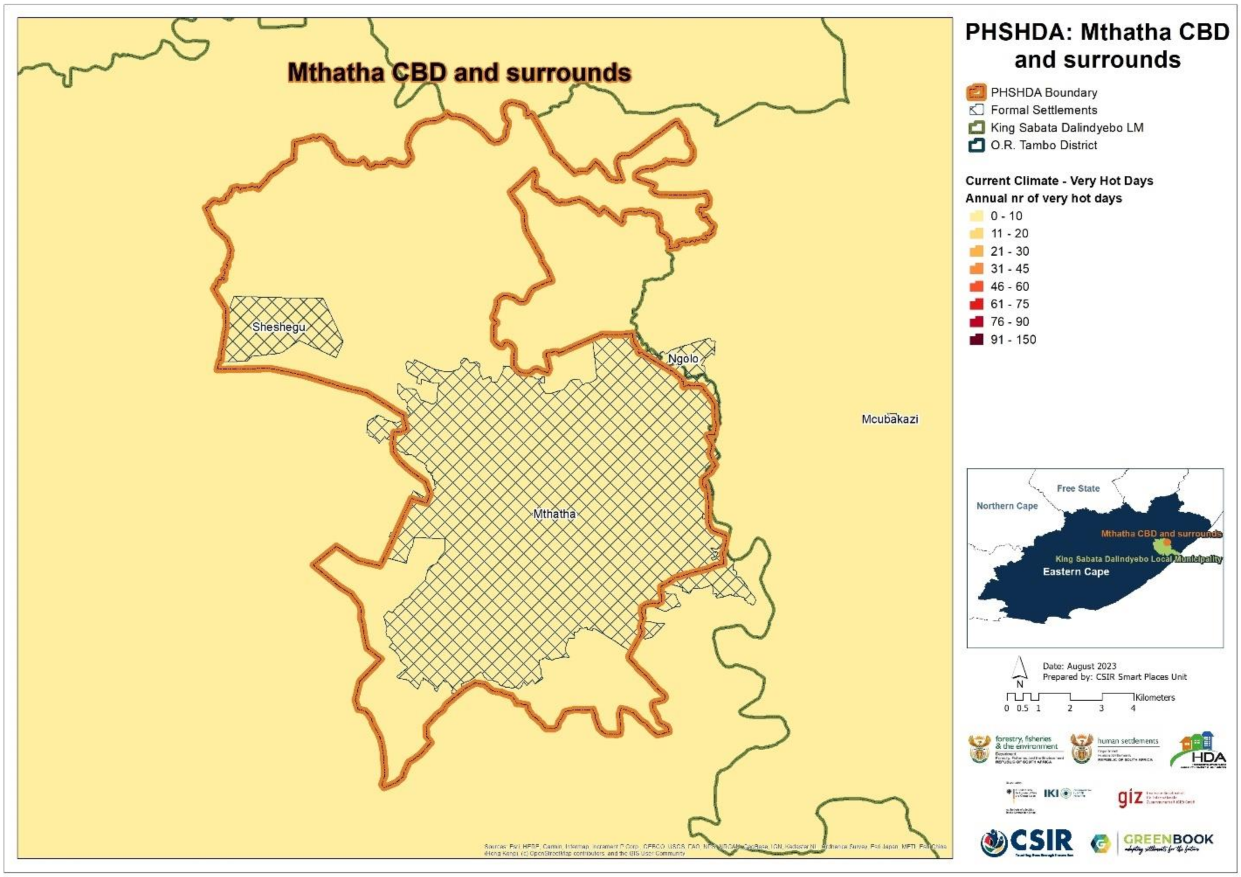


Figure 11: Annual number of very hot days under baseline climatic conditions across Mthatha CBD and surrounds with daily temperature maxima exceeding 35 °C

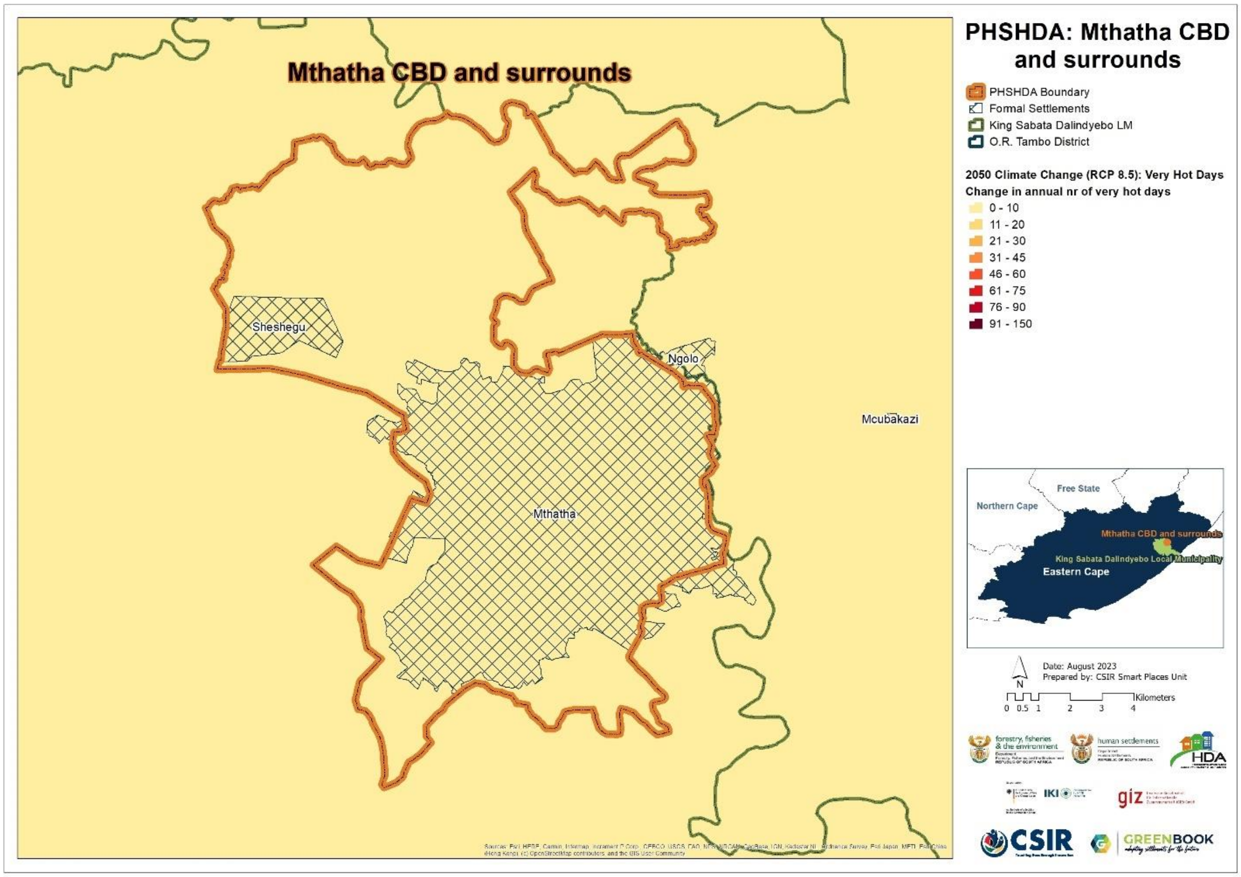


Figure 12: Projected change in annual number of very hot days across Mthatha CBD and surrounds with daily temperature maxima exceeding 35 °C, assuming an (RCP 8.5) emissions pathway

Figure 11 indicates the annual number of very hot days across Mthatha CBD and surrounds with daily maximum temperature of 35 °C. The PHSHDA has few very hot days per year, not totalling more than 10 days (Figure 11). Although it is expected that climate change will generally result in an increase in heat extremes, there seems to be no projected change in the annual number of very hot days across the PHSHDA (see 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, i.e., 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.

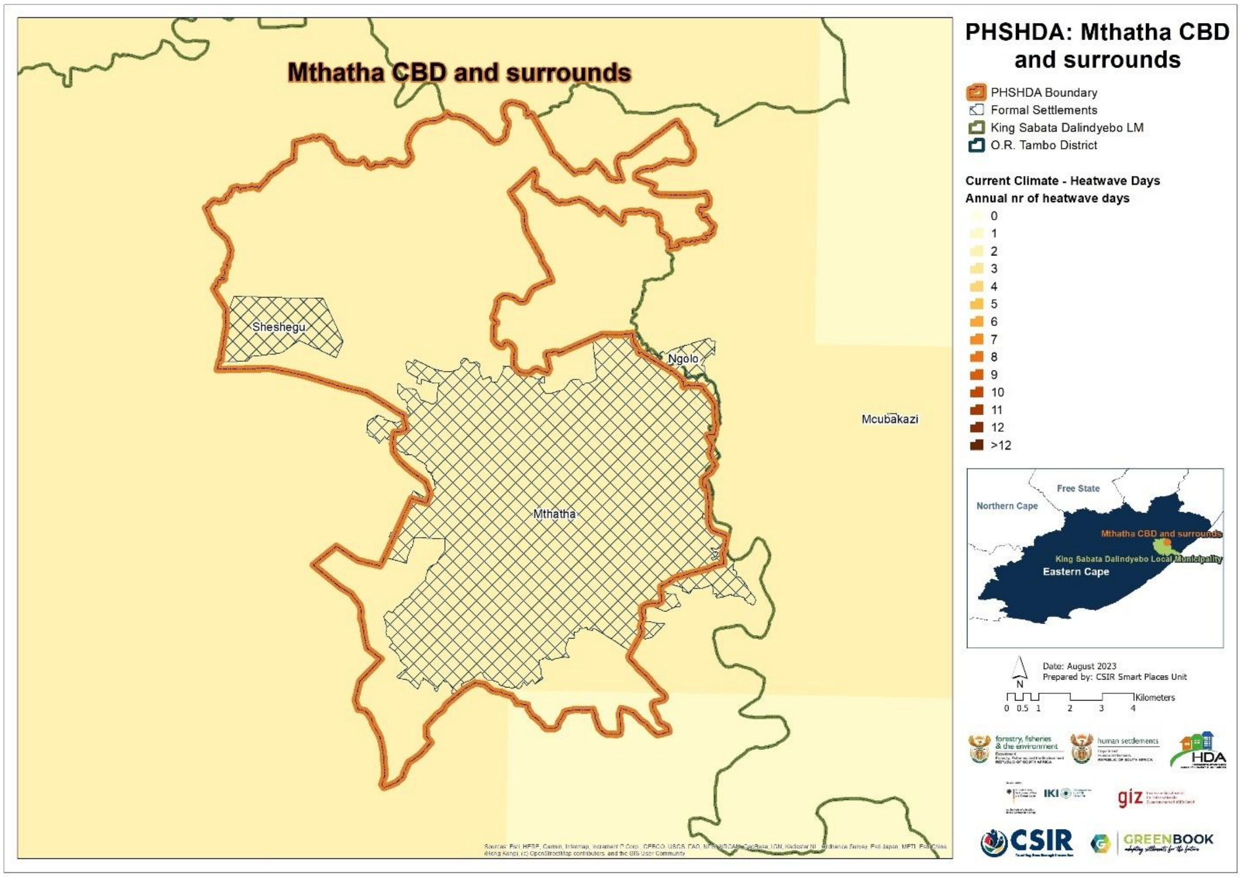


Figure 13: Annual number of heatwave days under baseline climatic conditions across Mthatha CBD and surrounds

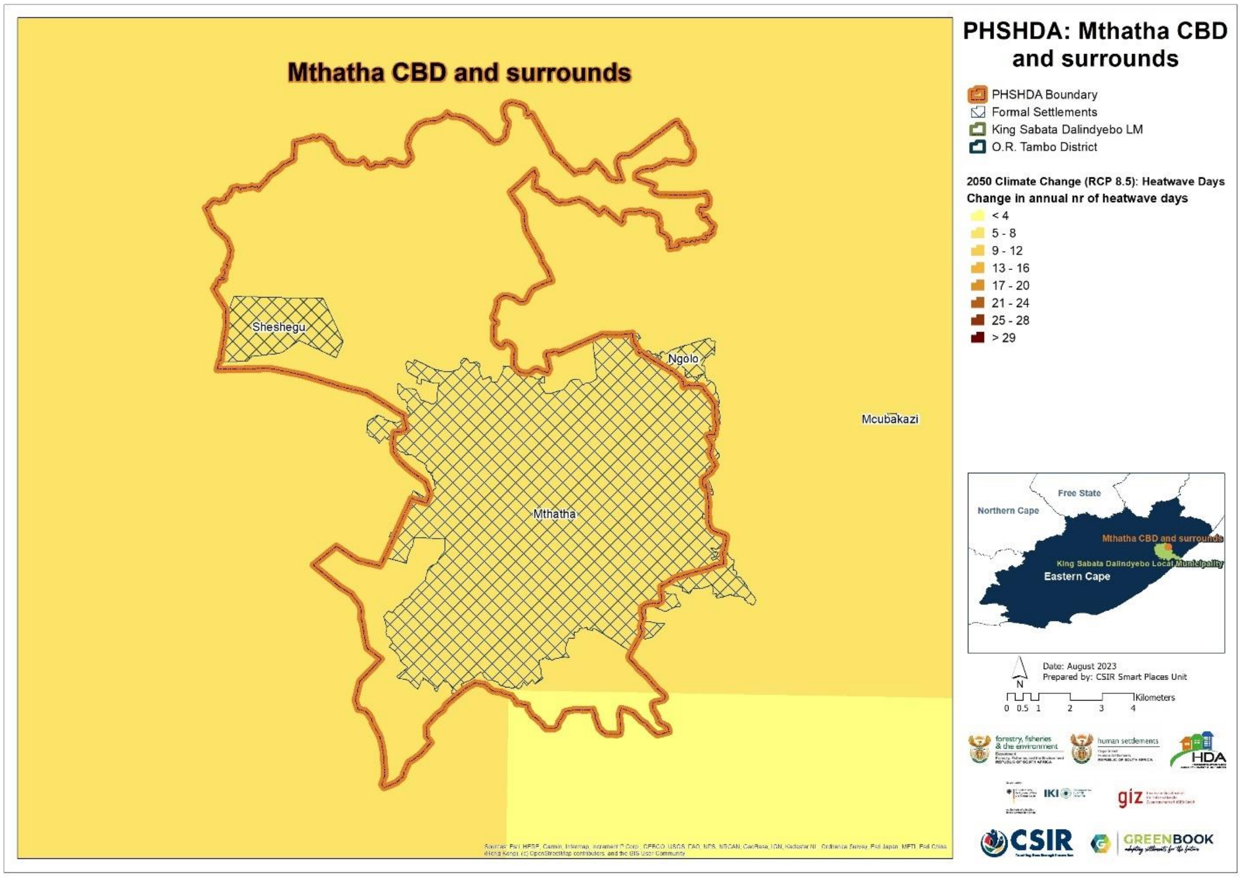


Figure 14: Projected change in annual number of heatwave days across Mthatha CBD and surrounds, assuming an (RCP 8.5) emissions pathway

Figure 13 shows the annual number of heatwave days under baseline climate conditions across Mthatha CBD and surrounds. Mthatha and surrounds experience at most about 4 heatwave days on average annually.

Figure 14 shows the projected change in annual number of heatwave days, under the low mitigation "business as usual" emissions scenario (RCP 8.5). Mthatha CBD and surrounds are projected to experience an increase in heatwave days by 2050.

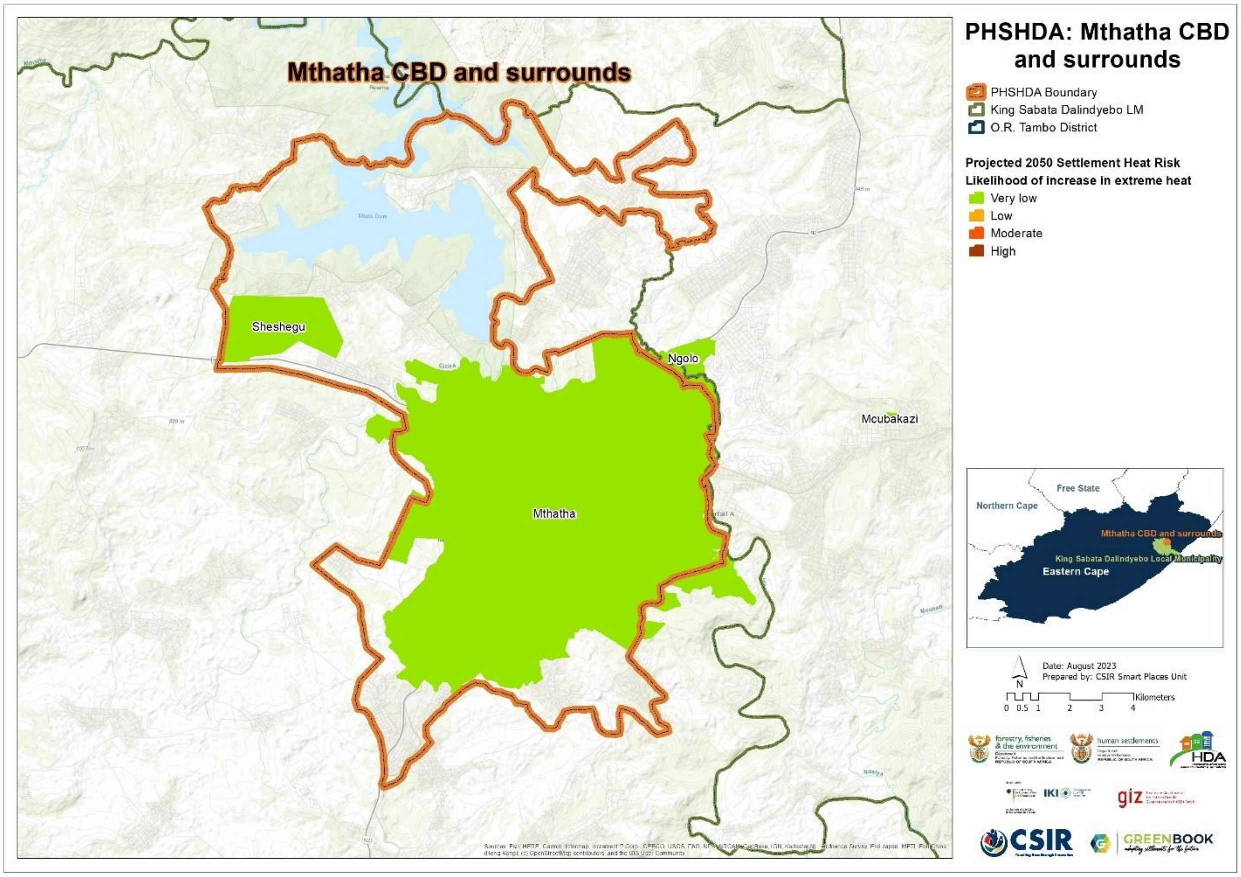


Figure 15: Heat stress risk across Mthatha CBD and surrounds at settlement level in the 2050s

Figure 15 depicts the settlements that are at risk of increases in heat extreme risk. Projections show that Mthatha and Sheshegu have a very low likelihood of increases in heat extremes risk.

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 and where they should not. Much of the natural vegetation requires fires to maintain the ecosystems 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. We used a scale 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.

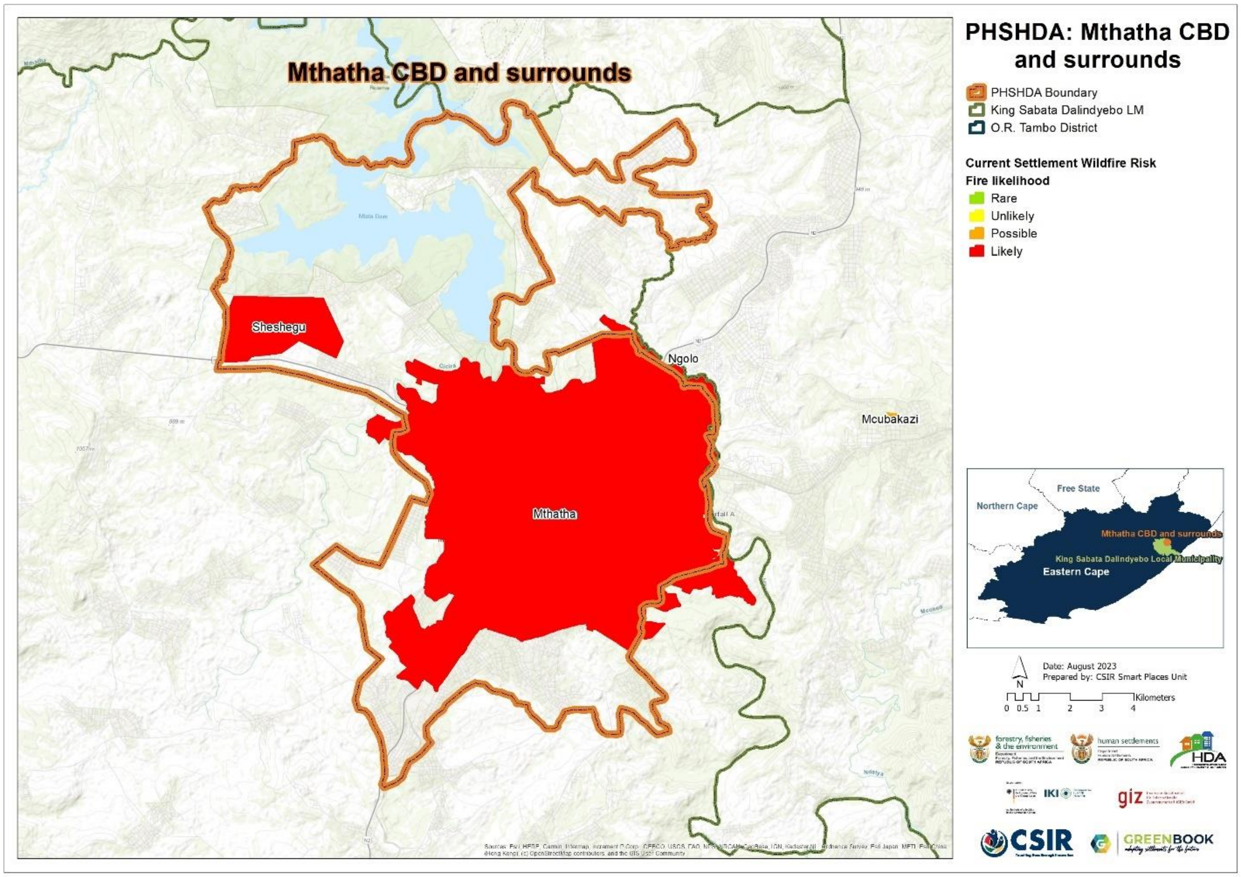


Figure 16: The likelihood of wildfires under current climatic conditions across settlements in Mthatha CBD and surrounds

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 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.

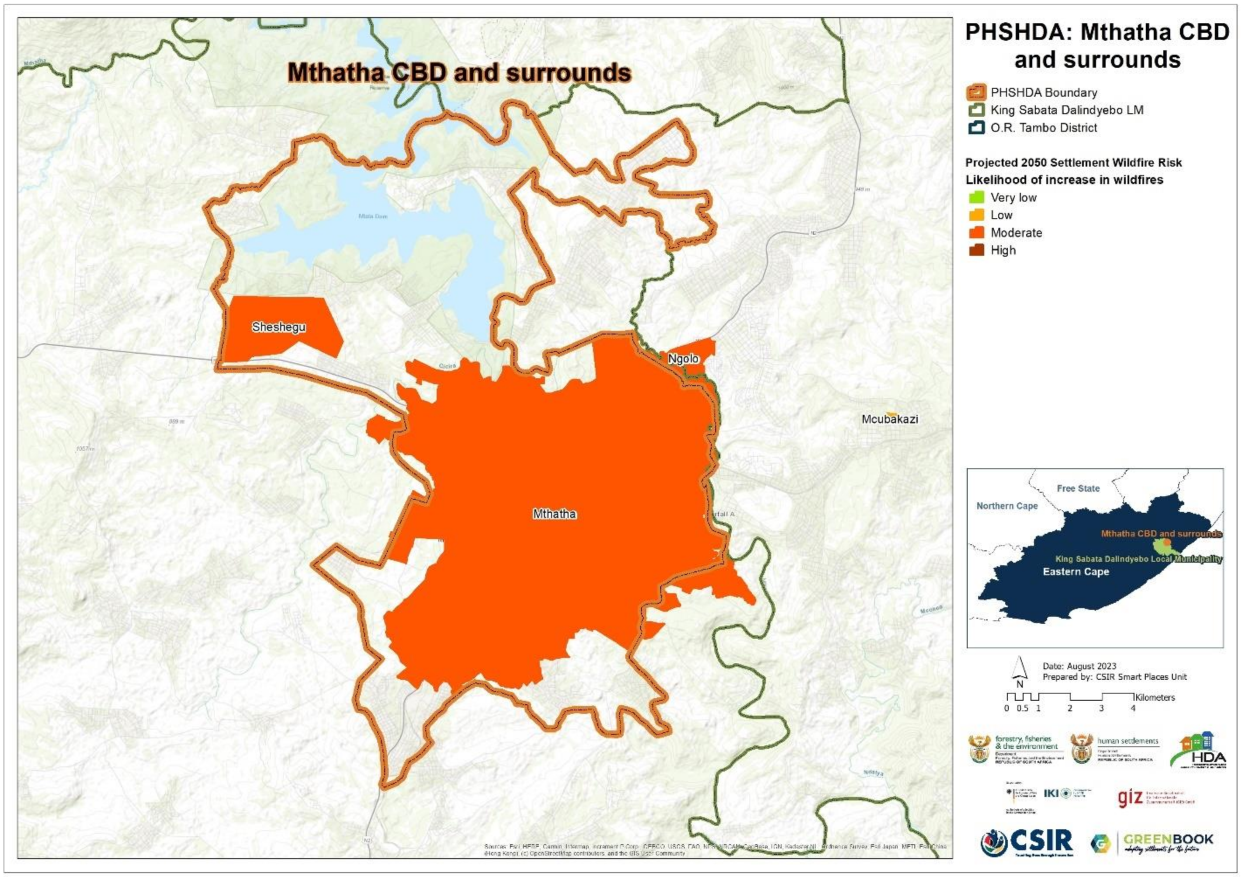


Figure 17: The likelihood of wildfires under projected climatic conditions across settlements in Mthatha CBD and surrounds

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, while Figure 17 depicts the settlements that could be at risk of increases in wildfires by the year 2050. The likelihood of wildfires under the current climate conditions shows likely fire conditions for almost the whole PHSHDA, especially Mthatha and Sheshegu settlements. Although the risk is moderate, this has a negative effect on biodiversity, soil structure and the spread of fire-adapted alien invasive plants.

The projected likelihood and intensity of wildfires is expected to increase moderately over Mthatha and Sheshegu settlements due to rise in temperatures, moderated by rainfall (increasing the moisture content of fuels), higher relative humidity, shorter droughts, and lower wind speeds. High fire risk conditions are projected to almost triple in the west of the province. This will have a negative effect on biodiversity, soil structure and the spread of fire-adapted alien invasive plants.

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 et al. 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 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, estimates of 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 calculated using a risk matrix, that considered the flood hazard index and the change in extreme rainfall days from the baseline period of 1961-1990, to the 2050s.

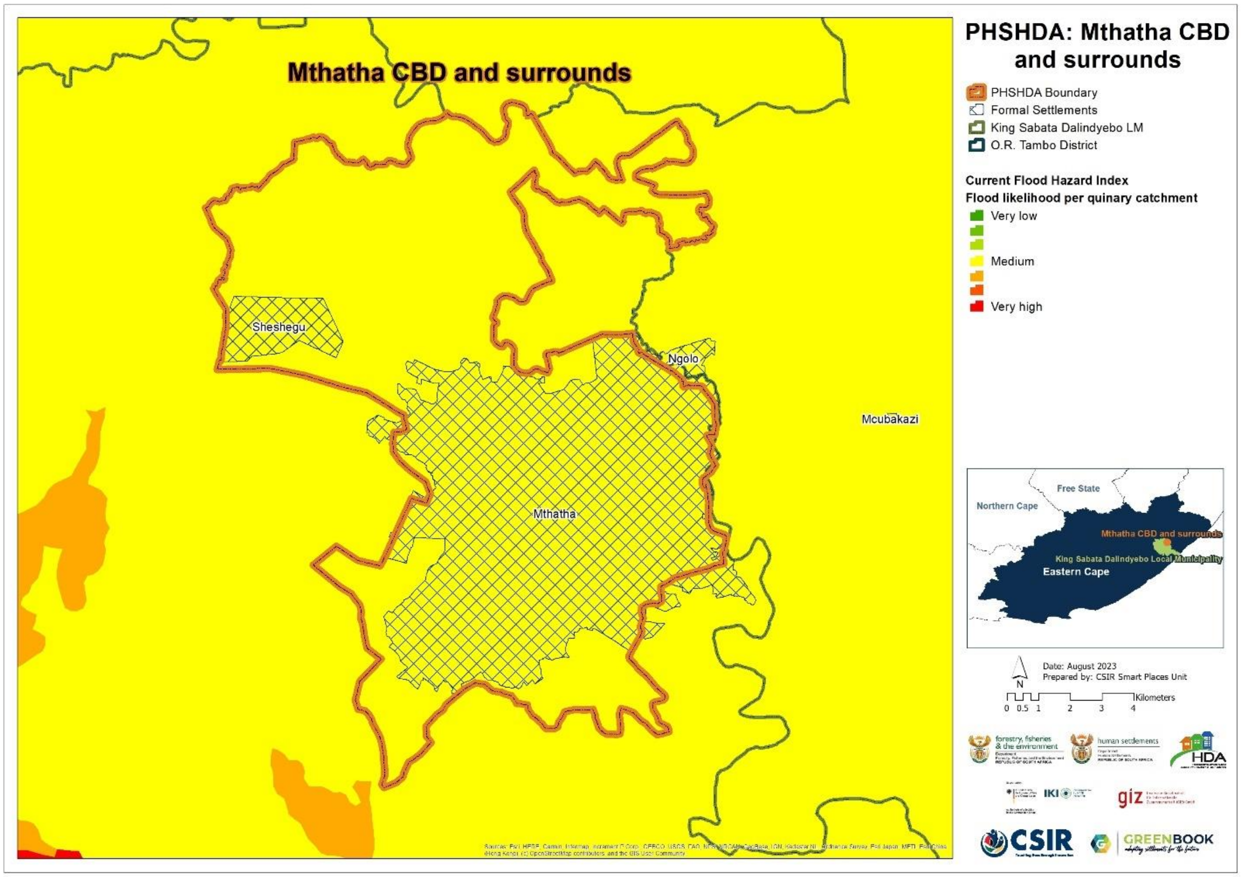


Figure 18: The flood hazard index across Mthatha CBD and surrounds under current (baseline) climatic conditions.

Figure 18 depicts the flood hazard index of the individual quinary catchments present or intersecting with the local municipality. 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. Under current baseline conditions the flood hazard index for Mthatha and surrounds indicate a medium flood risk across all settlements.

Figure 19 depicts the projected change for the year 2050 in extreme rainfall days for an 8 x 8 km grid. This was calculated by assessing the degree of change when future rainfall extremes (e.g., 95th percentile of daily rainfall) are compared with those under the current rainfall. A value of more than one indicates an increase in extreme daily rainfalls.

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

Green Book 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.

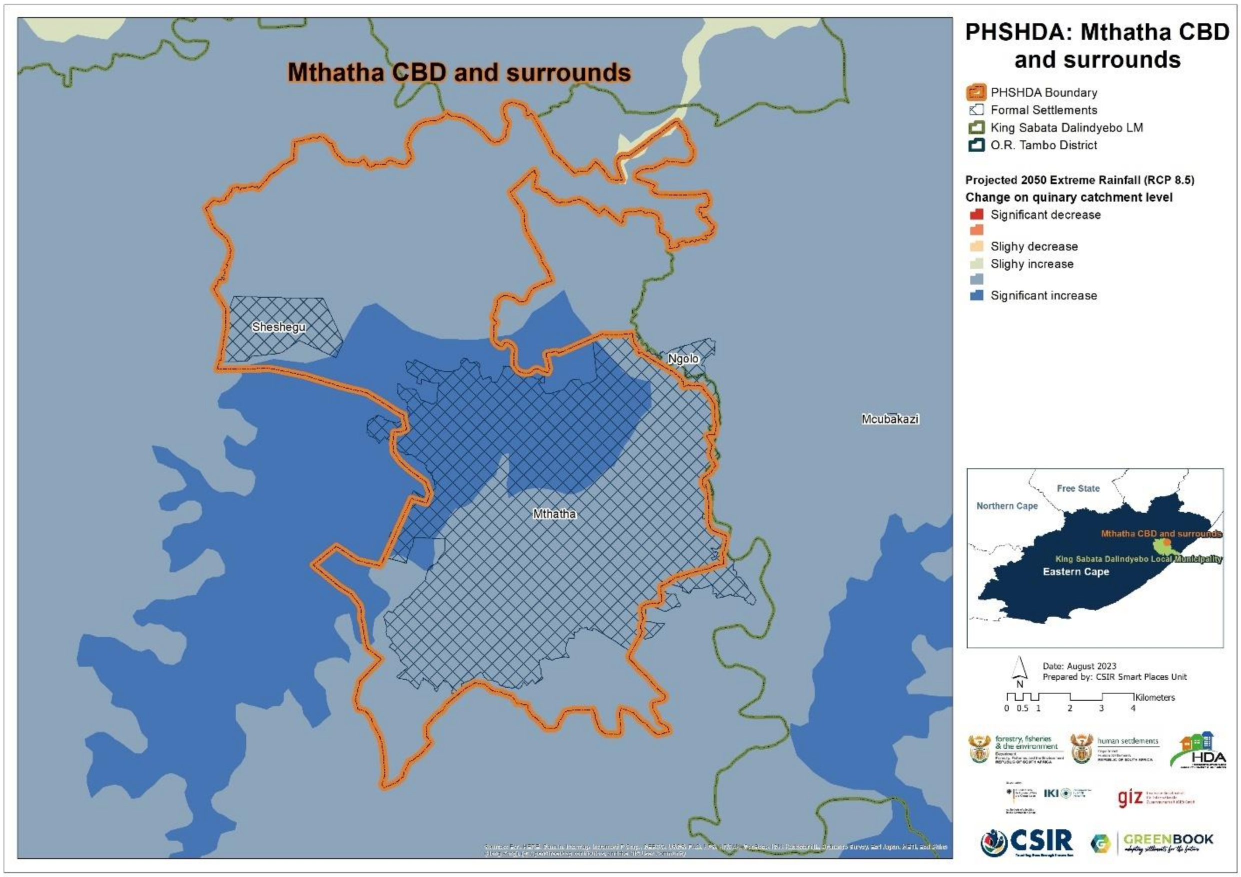


Figure 19: Projected change into the future in extreme rainfall days across Mthatha CBD and surrounds

The projected change in future rainfall days across Mthatha CBD and surrounds indicates a significant increase in extreme rainfall days (Figure 19) and reveals that high risk is mainly distributed along the north and northwestern parts of Mthatha extending outside the boundaries of the PHSHDA south-westerly. The projected number of increased extreme rainfall days correlates with the projected high likelihood of an increase in flooding (Figure 20) across the PHSHDA, marking the area as a high flood risk area. Figure 20 depicts the settlements that are at increased risk of urban flooding under an RCP 8.5 low mitigation (worst case of greenhouse gas emissions) scenario.

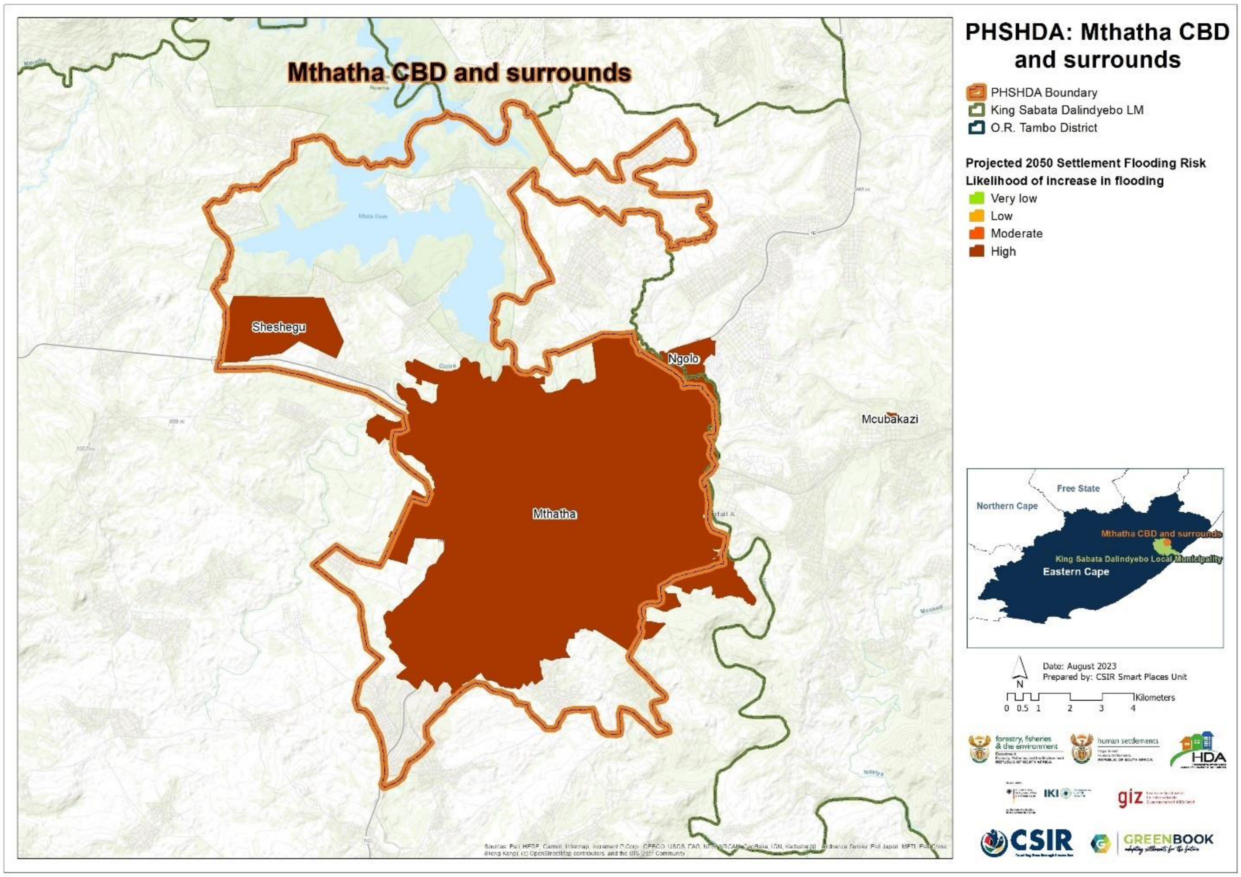


Figure 20: Flood risk into a climate change future at settlement level across Mthatha CBD and surrounds

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 King Sabata Dalindyebo Local 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 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. 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 water 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) in which the KSD Local Municipality is located. The primary catchment serving the municipality is Mzimvubu Tsitsikamma primary catchment. This water management area (WMA) is among the most disadvantaged catchments in the country with high levels of poverty and unemployment. This catchment is also prone to water shortages and droughts particularly in the western part of the WMA. Another prevalent challenge in catchment areas is the technical challenges such as high salinity and eutrophication in several rivers, and a high concentration of alien invasive plants. This is further exacerbated by the significant information gaps which hinders proper management of the resource.

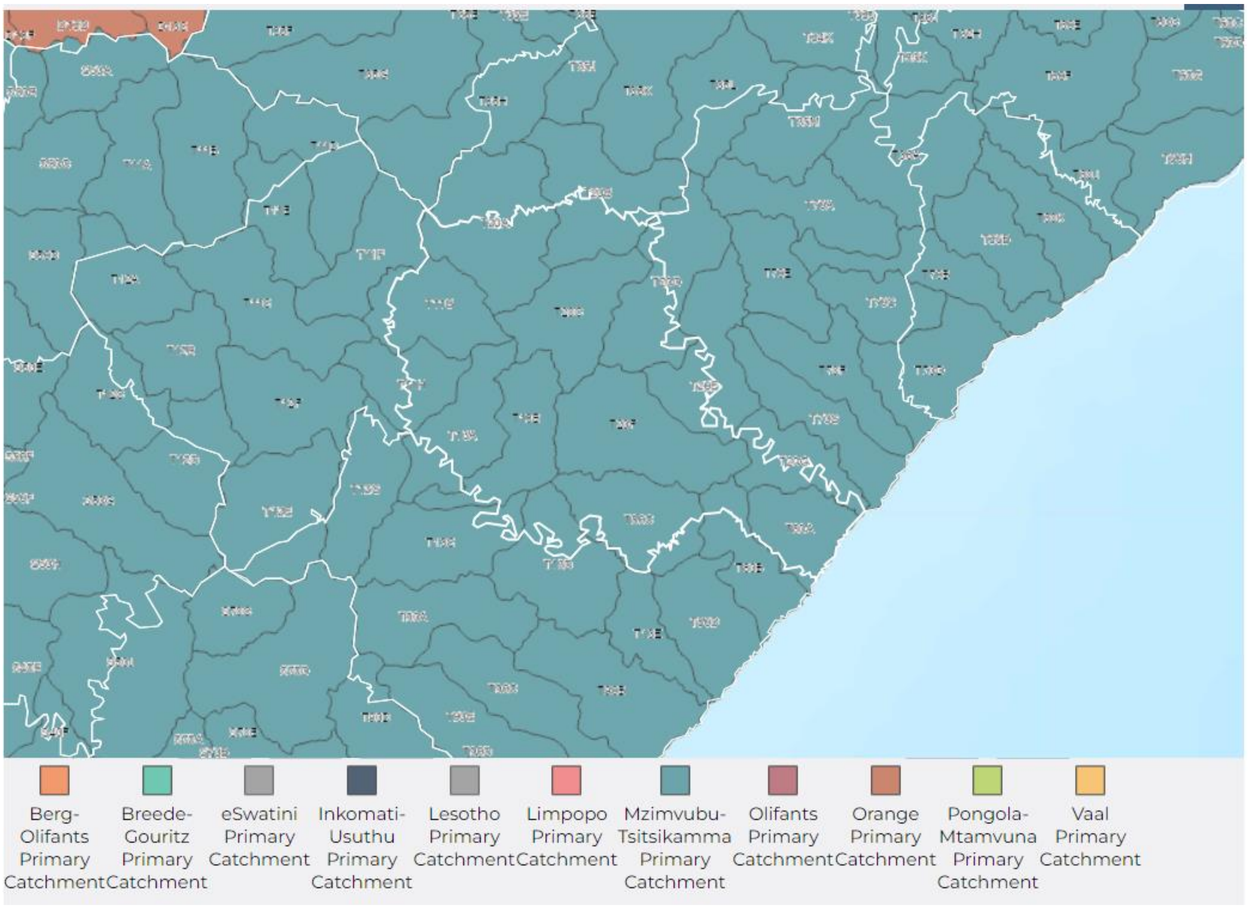


Figure 21: Quaternary catchments found in King Sabata Dalindyebo Local Municipality.

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 groundwater dependent. The PHSHDA is 100% reliant on surface water. If groundwater is present, it is an opportunity to be explored as part of the strategy to diversify the water mix in the catchment given the limitations in surface water availability.

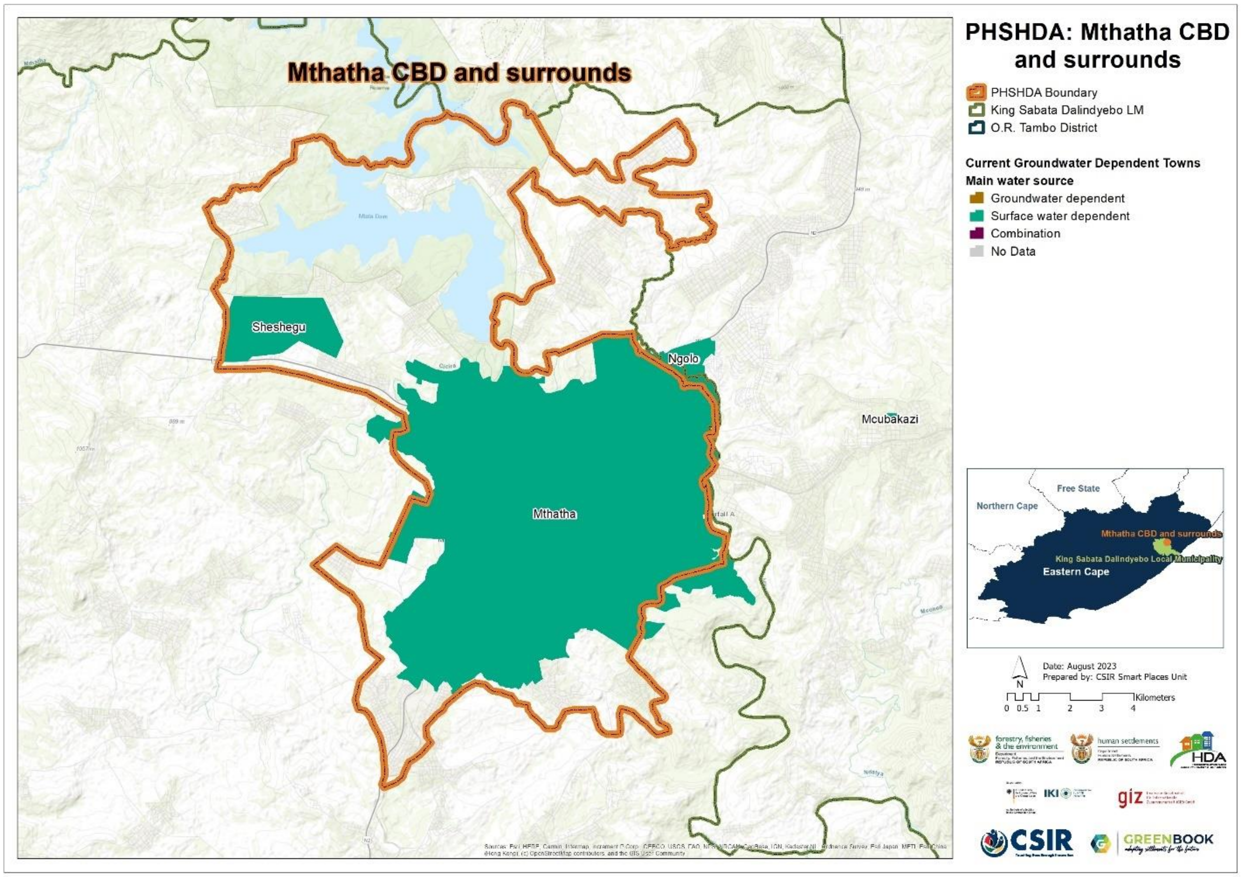


Figure 222: Main water source for settlements in Mthatha CBD and Surrounds.

Figure 23 indicates the occurrence and distribution of groundwater resources across the local municipality, showing distinctive recharge potential zones, while Figure 24 indicates the projected change in groundwater potential. There PHSHDA shows high potential for groundwater aquifer recharge across Mthatha CBD and surrounds (Figure 23) under current climatic conditions. Similarly, significant increases in groundwater discharge potential are anticipated in the future (Figure 24). "The utilisation of water in the catchment is mainly underground water abstraction via boreholes. There are a multitude of boreholes pumping into a number of reservoirs and tanks of various sizes in the municipal area. This aquifer is under threat from two major pollution sources, namely, the King Sabata Dalindyebo Cemetery and the Seshego Sewerage Works" (PLM, 2021, p. 193-194).

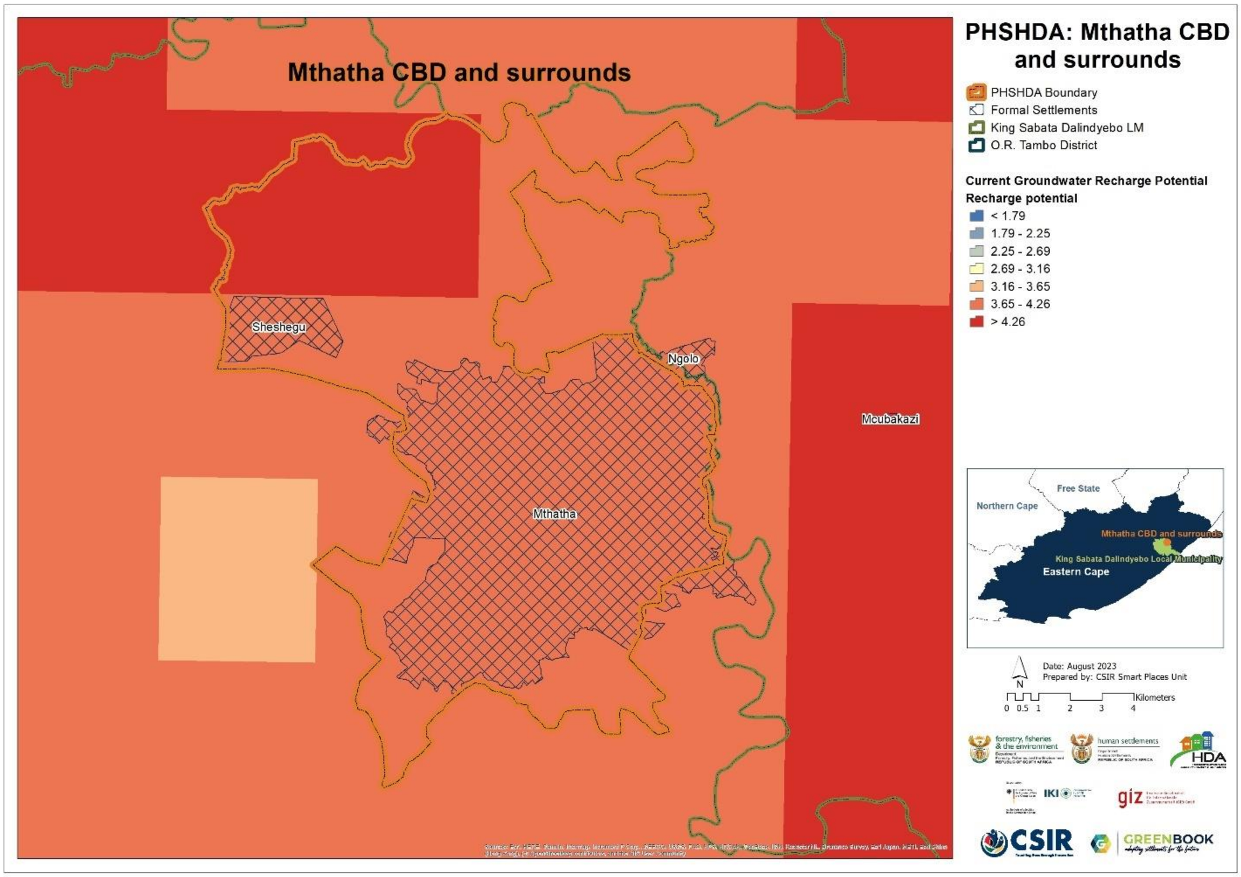


Figure 23: Groundwater recharge potential across Mthatha CBD and surrounds under current (baseline) climatic conditions.

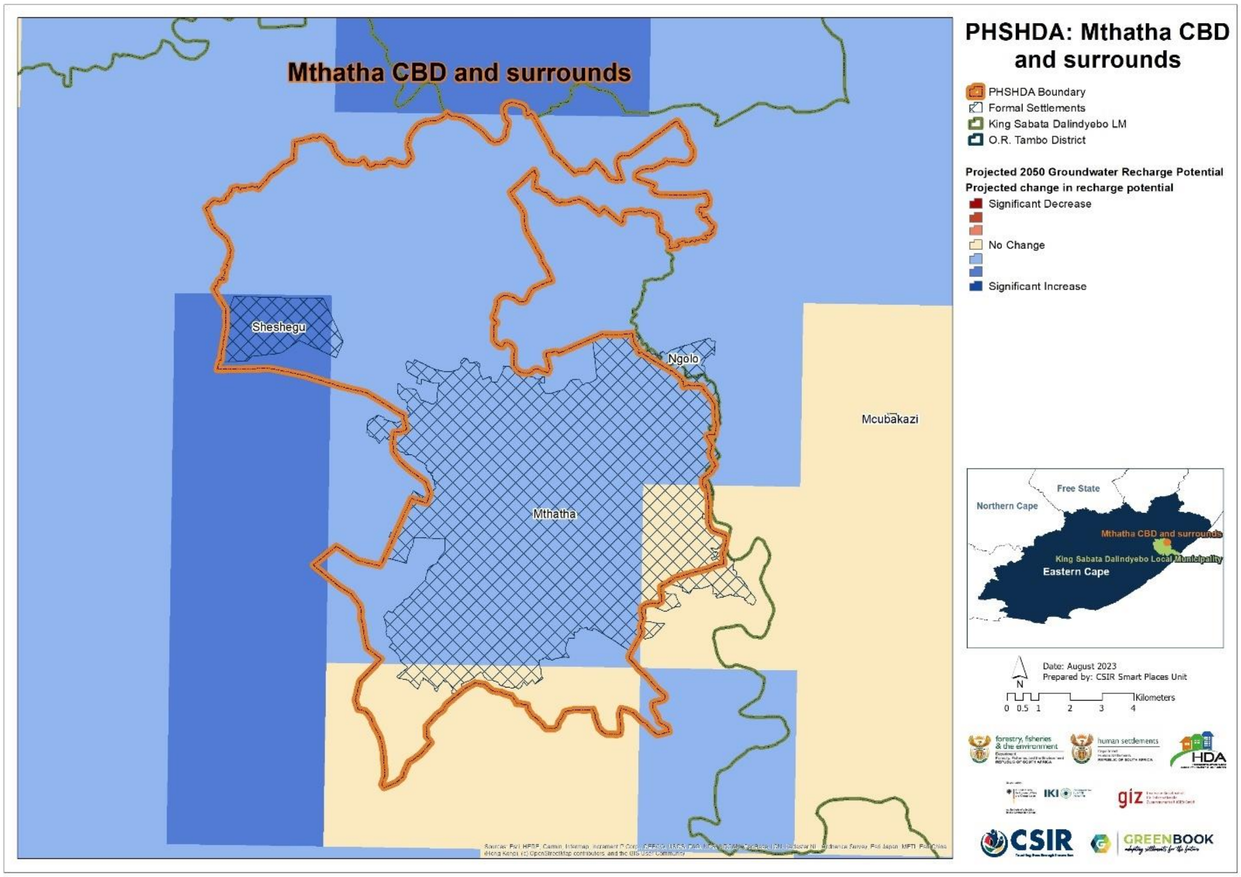


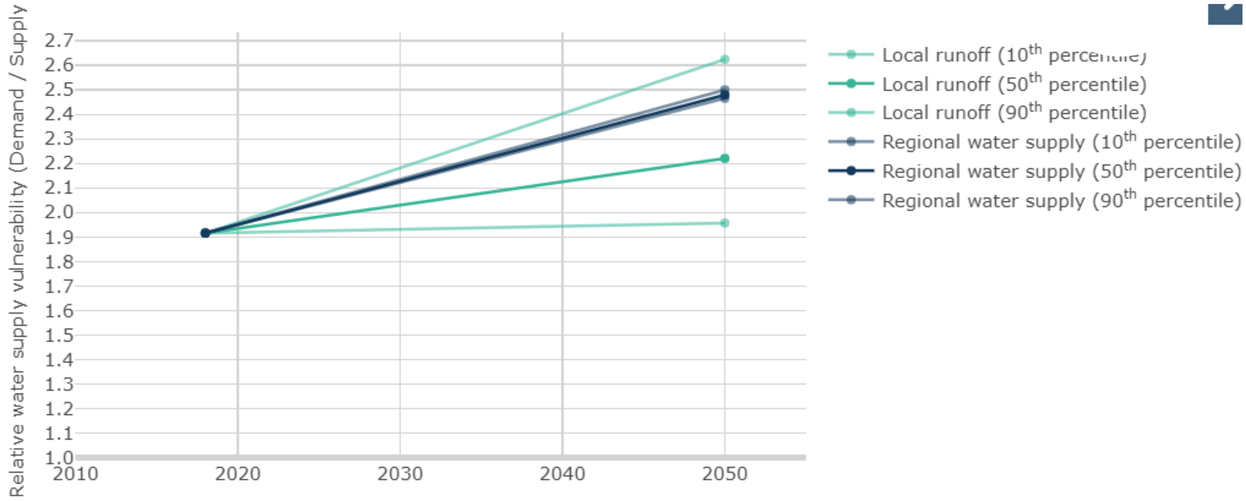
Figure 24: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across Mthatha CBD and surrounds.

Table 3 provides and overview of current water supply vulnerability (i.e., demand versus supply) in the KSD Local Municipality 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 4: Current water supply and vulnerability across King Sabata Dalindyebo Local Municipality

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
King Sabata Dalindyebo	173.29	90.48	1.92

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 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. The water supply vulnerability of KSD Local Municipality is discussed below. Figure 28 shows the Local Municipality's estimated current and future water supply vulnerability, under the two estimation scenarios.



VULNERABILITY CONTRIBUTION FACTORS		PERCENTAGE CHANGE
Mean annual precipitation	▲	2.39%
Mean annual evaporation	▲	4.18%
Mean annual runoff	▲	16.4%
Regional urban water supply	▼	-0.15%
Population growth	▲	24.99%

Figure 25: Future water supply vulnerability in King Sabata Dalindyebo Local Municipality

King Sebata Dalindyebo LM's water demand is currently higher than supply (Table 4). Furthermore, the LM's water supply vulnerability is projected to increase to between 1.92 to 2.62 (Figure 25) due to the projected increase in mean annual evaporation, a decrease regional water supply and population growth.

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 in relation to the industries served, and 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 we have 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.

In KSD Local Municipality the AFF sector contributes 0.56% to the local GVA, which is a contribution of 0.09% to the national GVA for the AFF sector. Of the total employment, less than 1% is within the AFF sector. Agriculture in the area consist primarily of small-scale and communal livestock farmers. Livestock is a priority at a subsistence and livelihood scale. According to the IDP, the district has the largest livestock communal farming practice in the country. Climate projections show a warmer and wetter climate with more extreme rainfall events. These conditions are advantageous to livestock farming, increasing water availability and grazing potential. However, hot and moist conditions could cause increased spread of disease and parasites, which in turn contribute to reduced growth & reproduction performance due to heat stress.

3. Recommendations

One of the greatest climate risks identified for King Sabata Dalindyebo LM and Mthatha CBD and surrounds is that rainfall will become more uneven and intense. The combination of more intense precipitation and an increased frequency of extreme events can lead to changes in overall precipitation levels. The increase in extreme rainfall translates into a higher risk for flooding as well as landslides. Most directly, changing extreme precipitation events will affect stormwater management, water quality, public health, and transportation causing a higher risk of damage to infrastructure. These can be exacerbated in the absence of appropriate levels of adaptation, protection and/or recovery procedures. For example, poor stormwater maintenance can cause relatively minor rainstorms to become flooding events and therefore meteorological hazards that historically hasn't posed a threat may pose a significant risk in the absence of proper maintenance.

Coupled with the increased rainfall variability is an increase in temperatures. Higher temperatures for long periods contribute to the urban heat island effect and increases the demand for cooling and water, which in turn increase overall electricity demand. Higher temperatures are also associated with health hazards such as heat stress and the spread of vector borne diseases in both humans and livestock.

The King Sabatha Dalindyebo LM area is also predicted to experience significant population growth, leading to increased pressure on service delivery and competition for resources. Under current climate conditions, water demand is already higher than water supply. High population growth coupled with increasing temperatures will further increase water supply vulnerability.

The mentioned risks should not be viewed in isolation, but cognizance should be taken of the likelihood of overlapping risks such as increased flood and heat risk. These compounding risks significantly increase the vulnerability of settlements to climate change.

In response to these climate risks and impacts the following adaptation goals are recommended:

1. To ensure water security and protect water resources under a changing climate.
2. To protect and increase the resilience of critical municipal infrastructure.
3. To invest in green infrastructure, rehabilitate and protect natural resources and biodiversity to improve ecosystem services.
4. To build capacity of the public health sector and protect human health.
5. To support resilient commercial, small-scale and subsistence farming systems (these contribute to food security and employment in the area).

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Annexure A: Sector specific impacts

Climate hazards and climate events can have far-reaching impacts across a range of sectors. Some of the sectors are discussed and the various climate impacts are summarised in the tables below.

Ecosystem services

Urban areas are dependent on natural ecosystems in and around towns to provide communities with services such as safe and plentiful drinking water, increased food security, better health, decreased exposure to natural disasters and extreme weather, and increased recreational opportunities. For these ecosystems to continue to provide these services they need to be in a healthy condition. Unfortunately, many ecosystems have been degraded because of misuse and overuse of soil, water, plant, and animal species. At the same time global climate change is aggravating the vulnerabilities of these ecosystems and therefore diminishing the benefits that ecological infrastructure can provide. It is therefore critical to rehabilitate and maintain ecological infrastructure in the urban environment to help residents adapt to risks posed by future climate change.

Increased temperatures and heat extremes	Drought and decreased rainfall	Increase in rainfall, inland flooding, and coastal flooding
• Increased risks of water shortages increasing demand for irrigation of gardens and agriculture. • Increased evapotranspiration rates with rising temperatures, reducing the water available in reservoirs and water available for reliant ecosystems. • Increase in temperature leading to water loss via evapotranspiration resulting in decreased water quality and loss of wetlands. • Loss or degradation of indigenous species, including threatened species or ecosystems.	• Decreased amounts of rainfall reaching ecosystems as settlements use rainwater harvesting techniques for increased household use. • Increased reliance on irrigation and greater demand for water to maintain public open space and gardens. • Reduced planting and pollination leading to greater risk of erosion and soil loss. • Increasing temperatures together with increased intensity of drought will potentially increase the occurrence of algal	• Rainfall in shorter and more violent spells making recharging groundwater difficult. • Increase in intensity of rainfall and flooding leading to increased surface runoff, resulting in increased soil erosion, soil loss and degradation. • Increasingly saturated soils leading to more standing water (ponding) which can result in more insect (pest) activity and their potential to carry diseases. • Increased wave energy and run-up (sea level rise and more storms) causing degradation of

• Increased threat from invasive species as competition for water increases. • Dieback or death of susceptible plants (e.g. street trees) and animals (e.g. fish). • Increased water temperature leading to increased growth of aquatic weeds which increases breeding of disease vectors and reduces water oxygen levels. • Milder winters and reduced frost increase the duration of the growing season, increasing the survival rate of insects and diseases.	blooms in reservoirs and dams which are damaging to ecosystem functioning and water services. • Drought and decreased rainfall causing wetland habitat loss. • Reduced soil moisture availability increasing moisture stress leading to dieback and death of plants and the loss or degradation of indigenous communities, including threatened species or ecosystems. • Drying up of aquatic systems, perennial systems will become seasonal and seasonal systems will die off and be replaced by terrestrial plants. • Increased spread of drought-adapted alien invasive plant species.	natural coastal defence structures.

Stormwater

A stormwater drainage system collects, conveys and discharges stormwater with the aim to reduce the risk of flooding in settlements and control water quality (traditional pollutants that are commonly associated with municipal and industrial discharges, e.g., nutrients, sediment, and metals). Conventionally rainwater falling onto a hard surface will be collected and drained through surface channels to a collection point or culvert where it will enter a storm water pipe. The pipe will use gravity to discharge the water into a watercourse or a dam. Where a gravity-fed system cannot be used the water will be collected into a storage dam and pumped to the discharge location. Sustainable Urban Drainage Systems (SUDS) seeks to minimize the volume of storm water entering the drainage system. It does this in three ways: first, collect and store as much rainwater at source as possible; second, filtrate as much surface water into the ground as possible as close to the source as possible; third, collect storm water at grade in various storage systems (weirs, wetlands, attenuation ponds, etc.).

Increased temperatures, heat extremes, and drought	Increase in rainfall, inland flooding, and coastal flooding
• Potential risk of undermining the temperature regime of temperature-sensitive stormwater ponds and receiving waters, resulting in a decrease in water quality. • Increased corrosion in stormwater drains due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids. • Increased shrinking soils increasing the potential for cracking, increased infiltration and exfiltration of water mains and sewers, which in turn exacerbates treatment and groundwater or storm water contamination.	• Increased risk of flooding due to pressure on stormwater systems. • Increased risk of litter entering the stormwater systems. • Increased risk of damage and failure of stormwater systems due to overloading • during floods and intense rainfall events. • Failure of stormwater treatment devices during high flow events leading to by-pass • and / or flushing of contaminated water. • High wet-weather hydraulic loads and bottle-necks in stormwater and networks due • to inflow and sewer infiltration, leading to local inundation and overflows of • untreated wastewater. • Increased rainfall causes soil erosion thus damaging underground stormwater • systems. • Increased surface and stream erosion causing deposition of sediments in receiving • environments. • Stream morphology for undeveloped, developing and fully developed urban areas, • may change, hence affecting existing outfall structures and potential stormwater • pond locations.

Solid waste

Human settlements generate massive amounts of solid waste that needs to be managed effectively so as not to cause air, water, and soil pollution.

As cities grow and need more land, suitable collection and disposal sites can be difficult to acquire and develop. Most households in South Africa (64% in 2015) receive a waste removal service at least once a week, but there are still households that rely on their own or communal rubbish dump sites. Illegal dumping and littering are problems in most municipalities resulting in solid waste often accumulating in waterways and areas otherwise intended for water run-off and flood control. These conditions make municipalities vulnerable to flooding, contamination of water resources, adverse health effects and rehabilitation costs that may overwhelm the resilience of cities.

Increased temperatures and heat extremes	Increase in rainfall, inland flooding, and coastal flooding
• Increased risk of combustion at open waste disposal sites and illegal dumps, and increase in explosion risk associated with methane gas. • Increased rate of decay of putrescible waste resulting in increased odour, breeding of flies, and attracting of vermin. • Increased health and safety concern regarding heat stroke to staff collecting waste. • Increased risk of landfill site instability and failure due to changes in consumption patterns with increased waste creation (i.e., glass, plastic and paper cups).	• Increased risk of flooding due to pressure on stormwater and leachate management systems at landfills. • Increased demand for capacity to cope with large volumes of waste generated by flood events. • Increase in soil saturation causing decreased stability of slopes and landfills linings (if clay or soil based) at waste management facilities. • Inundation of waste releasing contaminants to waterways, pathways an low elevation zones. • Potential loss of value and degradation of paper and cardboard for recycling due to increased moisture content. • Increased flooding causing the risk of localised disruption of waste collection rounds. • Flooding in areas with untreated, dumped waste causing the risk of groundwater contamination. • Increased flooding causing the risk of litter entering the storm water systems.

Sanitation

Sanitation and wastewater management poses several operational challenges to governments and settlements. Managing water resources involves contributions from various stakeholders at different points in the value chain. The sanitation value chain comprises eight broadly defined stages, as follows: collection/containment; storage; transport; treatment; distribution; wastewater treatment; and discharge. Re-use of wastewater is becoming more acceptable and feasible because of increasing water shortages, improved purification technology and decreasing treatment costs. A water reuse strategy that is forward thinking over ten to twenty years needs to take these possible changes into account. The direct re-use of treated wastewater can pose a risk to public health and safety and thus must be managed carefully and be subject to water quality management and control. Advanced treatment technologies, sufficient operating capacity and proper monitoring of all processes, and quality of potable water produced is essential.

Increased temperatures and heat extremes Drought and decreased rainfall	Increase in rainfall, inland flooding, and coastal flooding
• Increased heat waves, accompanied by dry weather, can exacerbate already stressed water supply systems leading to competition between sectors for water services; affecting sanitation. • Decrease in water supply for sanitation through decrease in available water to flush sewage systems adequately. • Declining annual rainfall threatening the viability of water-borne sanitation systems, and the capacity of surface water to dilute, attenuate and remove pollution. • Sewers are structurally vulnerable to drying, hence shrinking soils increase the potential for cracking, increased infiltration and exfiltration, which in turn exacerbates treatment and groundwater or storm water contamination. Increased corrosion in sewers due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids.	• Increased wet-weather hydraulic loads and bottlenecks in stormwater and sanitary sewer networks due to inflow and sewer infiltration, causing local inundation and overflows of untreated wastewater. • Increased rainfall and heavy rainfall events increasing the washing of faecal matter into water sources due to flooding of wastewater treatment works. • Increased risk of flooding resulting in both infrastructure damage and contamination of surface and groundwater supplies. • Increased groundwater levels due to flooding or sea-level rise, putting as risk sewage treatment plants (which are often positioned on low-lying ground as sewerage systems rely on gravity). • Increased vulnerability of sewerage pipe systems due to their size and complexity, and their exposure to multiple flood damage threats from source, through treatment, to delivery. • Increased vulnerability of pit toilets (widely used in rural areas) due to flooding, causing serious environmental contamination. • Increase in groundwater recharge and groundwater levels causing flooding of subsurface infrastructure such as pit toilets or septic tanks.

	• Sea level rise posing a threat to coastal zones in terms of saline intrusion, and damage to/contamination of water systems and wastewater treatment works from inundation during coastal storms.

Energy

South Africa's energy mix is primarily dominated by the use of fossil fuels to derive grid supplied electricity and imported crude oil and petroleum products. Regarding access to energy within our human settlements, grid-supplied electricity is transmitted from power stations to sub-stations to settlements typically through overhead powerlines. Electricity supply is not equally distributed within the country with many people within informal settlements still not connected to the electricity grid. Many thus rely on the combustion of fuels within or near their homes to meet their cooking, heating, and lighting needs. Electricity infrastructure is exposed to weather and climate and is vulnerable to the effects of climate change. Variations in temperature (hotter and colder days) will increase the demand for energy for both cooling and heating within homes and buildings, as will urban growth. Thus, both the electricity supply and demand of a settlement are likely to be impacted by climate change.

Increased temperatures and heat extremes	Increase in rainfall, inland flooding, and coastal flooding
• Increased heat causing expansion of overhead cables, and cable sag. Sagging below a certain amount result in a reduction in the amount of electricity transmitted. • Increased heat stress on electricity transmission networks (overhead cables). • Increase in heat island effect increasing energy demand for cooling, leading to grid stress. • Increased threat of wildfires causing widespread damage to infrastructure and causing disruptions to service provision.	• Increase in flooding causing damage to electricity transmission and distribution infrastructure, poles, lines and sub-stations • Increase in frequency and cost of maintenance of concrete structures due to frequent and intense rainfall, flooding, or sea level rise. • Increased repair events increasing stress put on service crews and resulting in delays to power restoration.

Information and communication technology

Information and communications technology (ICT), or telecommunications, plays a critical role in society and is central to the operations of every industry and sector, and society relies on it for social and leisure purposes as well as work. Climate change impacts on ICT infrastructure in settlements include the impacts of increased warming and precipitation, extreme weather events, strong winds, and sea-level rise and storm surges. The ICT industry experiences weather-related impacts which are expected to worsen due to ongoing climate variability and climate change. Compared to 'heavy' infrastructure sectors like energy, water or transportation, the ICT sector has smaller infrastructure and shorter lifetimes, reliance on a combined network instead of individual structures, redundancy of service and infrastructure and service providers, and fast-paced technological change and innovation. While technologies in the ICT sector in the future may converge towards wireless technologies and reduce dependence on current infrastructure, this will not negate the need for infrastructure altogether, for example, there will still be a requirement for equipment such as mobile or fixed wireless towers to operate this technology.

Increased temperatures and heat extremes	Increase in rainfall, inland flooding, and coastal flooding
• Increased weathering and deterioration of infrastructure resulting in increased maintenance and repair costs. • Heat stress causing structural damage to infrastructure. • Increased energy demands during heatwaves resulting in power outages which can impact on delivery of telecommunications services. • Increases in temperature and higher frequency, duration, and intensity of heat waves increasing the risk of overheating in data centres, exchanges, and base stations, which can result in increased failure rates of equipment. • Increased mean temperature increasing operating temperature of network equipment which may cause malfunctions if it surpasses design limits. • Decreased precipitation leading to land subsidence and heave, reducing the stability of telecommunications infrastructure above and below ground (foundations and tower structures).	• Increased risk of flooding of low-lying infrastructure, access holes and underground facilities. • Increases in storm frequency or intensity increasing the risk of damage to aboveground transmission infrastructure and impacting on telecommunications service delivery. • Increases in storm frequency leading to more lightning strikes, consequently damaging transmitters and overhead cables, causing power outages. • Increased cost of insurance for infrastructure in areas with repeated incidents of flooding, as well as withdrawal of risk coverage in vulnerable areas by private insurers. • Road closures due to flooding thus inhibiting service and/or restoration efforts. • Rising sea levels and corresponding increases in storm surges, increasing the risk of saline corrosion of coastal telecommunications infrastructure, and leading to erosion or inundation of coastal and underground infrastructure.

Transport and mobility

Within settlements, transport networks comprise of nodes (e.g., buildings and public transport stops and stations) and various connector links (e.g., walkways, roads, bridges, railways, tunnels, and waterways). Apart from being a large asset base in themselves, these networks are indispensable conduits for the movement of people and goods for social, economic, political, health and recreational purposes. Within the context of climate change, therefore, climate resilient transport networks are necessary to ensure unimpeded functioning of society. Vulnerability of transport networks to climate change depends on infrastructure age, its materials, construction practices, design features, and maintenance history. Societal level of risk to infrastructure failure is dependent on individual functions of different parts of the transport network. Therefore, spatial differentiation should be an integral component of adaptation strategies. Disruption to transport networks due to climatic extreme events may lead to social exclusion, trade interruption, and consequently social disorder. It is imperative, therefore, that the design and in-situ upgrading of transport networks and their operations be responsive to threats posed by climate change, especially in high-risk areas. It is equally important to ensure transport networks do not add to landscape vulnerability – for example increasing erosion of steep slopes, landslides or increasing vulnerability of natural habitats to fragmentation and overharvesting.

Increased temperatures and heat extremes	Increase in rainfall, inland flooding, and coastal flooding
• Increased rate of infrastructure deterioration leading to pavement failure including cracking, rutting, potholes, flushing, and stripping. • Increased stress on bridges, particularly expansion joints, through thermal expansion and increased movement. • Corrosion of steel reinforcing in concrete structures due to increase in surface salt levels in some locations. • Increased infrastructure maintenance cost for road repair and reconstruction work, causing traffic delays and emergency service response delays. • Increased frequency and intensity of wildfires leading to more road closures. • Increased vehicle accidents, due to low pavement adhesion, leading to higher rates of transport-related fatalities.	• Increased rate of infrastructure deterioration, especially in areas with poor infrastructure maintenance history. • Temporary and permanent flooding of road, rail, port and airport infrastructure. • Structural integrity of roads, bridges and tunnels could be compromised by higher soil moisture levels. • Potential destruction of bridges and culverts. • Erosion of embankments and road bases leading to undermining of roads or railways. • Increased risk of landslides, slope failures, road washouts and closures. • Undermining of bridge structures (scouring). • Closure of roadways and tunnels leading to traffic delays.

	• Transportation system disruptions, impacts to traffic signalling and low water crossings. • Increased weather-related accidents.

Human health

Settlements are faced with a variety of challenges, which may include rapid unplanned urbanization, climate-related pressures such as floods and heat waves, as well as unequal economic growth between different communities. This affects the health and development status within settlements. Climate-health linkages are complex and multi-faceted, and it can confidently be stated that climate change will amplify some of the existing health threats that are already faced by communities. Certain people and communities are especially vulnerable, including children, the elderly, the sick and the poor. Natural disasters (e.g., floods, drought, fires) can have immediate and long-term impacts on health. Poor emergency service delivery immediately after disaster can impact health, as well as damage to services such as water reticulation can have longer-lasting impacts on public health. Natural disasters can also create a conducive environment for the occurrence of mental health problems.

Increased temperatures and heat extremes	Drought and decreased rainfall	Increase in rainfall, inland flooding, and coastal flooding
• More exposure to high temperatures causing increased health risks including heat strokes. • Heat waves increase threat of cardiovascular, kidney, and respiratory disorders. • Increase in fire danger days causing increased loss of life and damage to health infrastructure. • Wildfire smoke significantly reducing air quality, both locally and in areas downwind of fires. Smoke exposure increases respiratory and cardiovascular hospitalizations; emergency department visits; medication	• Decreased soil moisture potentially creating more wind-blown dust which has negative impacts on air quality. • Increase in water-washed diseases and diarrhoeal diseases due to inadequate water availability. • Decreased precipitation causing changes in salinity of water, resulting in an increase in algal blooms which can likely lead to increases in food- and waterborne exposures. • Increase in stagnant air, decreasing air quality.	• Wetter climate combined with increased temperatures may have negative health impacts as many diarrheal diseases vary seasonally, typically peaking during the rainy season. • Extreme rainfall and higher temperatures increasing the prevalence of fungi and mould indoors, with increased associated health concerns. • Increased flooding increasing the risk of drinking and wastewater treatment facilities being flooded, meaning that diarrhoeal diseases can be transmitted as

dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, and respiratory infections; and medical visits for lung illnesses. • Increased emissions in biogenic volatile organic compounds from vegetation causing increases in air pollution. • Increase in evaporative emissions from cars contributing to exposure to, and health impacts from, air pollution. • Increase in distribution of vector-borne diseases in warmer areas. • Increased water temperatures leading to an increase in algal blooms which can likely lead to increases in food- and waterborne exposures. • Increased temperatures combined with fewer clouds (e.g., from increased subsidence that is projected for parts of South Africa) causing increased exposure to UVR which will have negative impacts on health. • Increased temperatures increasing the reaction between certain pollutants and sunlight and heat, resulting in		wastewater systems overflow or drinking water treatment systems are breached. • Increase in natural disasters (e.g. floods) creating a conducive environment for the occurrence of mental health problems.

more severe hazardous smog events.		

Culture and heritage

Culture refers to the dynamic totality of distinctive spiritual, material, intellectual, emotional and aesthetic features that characterise a society or social group, including its arts, but also intangible aspects such as values, worldviews, ideas and beliefs, and the expression of these in individual and social behaviour, relationships, organisational and societal forms, and in economic, political, educational and judicial systems. The variance between these groups, known as cultural diversity, is illustrated by the many ways in which the cultures of groups and societies find expression. Within an urban context, culture may manifest itself spatially through heritage sites and resources. These areas are vulnerable to the effects of climate change and require particular management and sensitivity within planning. This heritage may include wildlife and scenic parks, sites of scientific or historic importance, national monuments, historic buildings, works of art, literature and music, oral traditions and museum collections together with their documentation. Due to the sensitive nature of culture and heritage, the physical and cultural value associated with these sites and resources is vulnerable to any aesthetic and functional changes caused by climate change. Potential physical impacts may have indirect social consequences.

Increased temperatures and heat extremes	Drought and decreased rainfall	Increase in rainfall, inland flooding, and coastal flooding
• Increased temperature having significant impacts on the comfort levels of built heritage resources, resulting in the building no longer being fit-for-purpose. • Increased demand for additional heating and cooling resulting in the installation of • heating, ventilation and air-conditioning systems with potential negative consequences on the heritage value. • Increased heat stress potentially impacting on the materials and structural integrity of	• Decreased rainfall impacting negatively on ground moisture levels and thus the geological conditions of sensitive heritage resources. Drying out clays, for example, will shrink and potentially undermine founding conditions.	• Increased rainfall in areas with clay soils resulting in swelling which poses a threat to the structural integrity of heritage resources. • Increased floods and changes in precipitation resulting in increasing vulnerability of archaeological evidences buried underground due to changing stratigraphic integrity of the soils. • Increased threat to properties listed as cultural heritage in coastal lowlands due to increased precipitation,

- heritage resources. - Migration of several plant species due to changing climate patterns, posing a threat to the conservation of biodiversity hotspots, and potentially altering heritage places. - Increase in veld and forest fires raising the threat of fire to all heritage resources, natural and built, as well as posing health risks to heritage resource dwellers from exposure to smoke and ash pollution.		sea level and coastal erosion. - Increased threat to materials and structural integrity of heritage resources exposed to higher humidity/ precipitation levels.