Cape Winelands District Municipality

Risk Profile Report based on the GreenBook

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Acronyms

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

WUI	Wildland-Urban Interface

Glossary of Terms

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

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

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

1. Introduction

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

The GreenBook was initially co-funded by the International Development Research Centre (IDRC) and the Council for Scientific and Industrial Research (CSIR), i.e., from 2016-2019, and in partnership with the National Disaster Management Centre (NDMC). With more partners coming on board since 2019 to support further research and development, and the roll-out and uptake of the GreenBook. More recently, Santam, the Climate and Disaster Resilience Fund (CDRF), and the CSIR established the GreenBook Roll-out Initiative to facilitate the uptake of the GreenBook and support resilience-building within local government. The initiative aims to roll out the GreenBook to 32 District Municipalities (DMs) by 2025 by supporting each District's climate change response and adaptation planning and implementation efforts through the GreenBook. Each of the Districts targeted for support are guided along a value-chain towards the implementation of climate change response and adaptation plans in municipalities (See Figure 1 below). Thus, in fulfillment of steps four and five, each target DM is provided with a draft GreenBook Climate Risk Profile report, as well as a draft Climate Change Adaptation Plan.

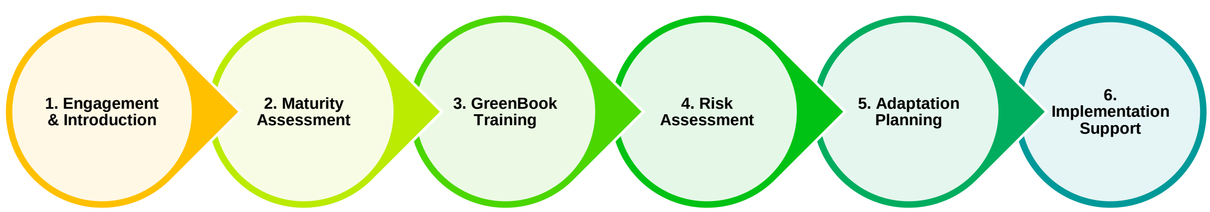

Figure 1: The Value-chain towards the implementation of climate change response and adaptation in municipalities

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

- Build and further the climate change response agenda,
- Inform strategy and planning in the District and Local Municipalities,
- Identify and prioritise risks and vulnerabilities,
- Identify and prioritise interventions and responses, and
- Guide and enable the mainstreaming of climate change response, particularly adaptation.

1.1. Approach followed

The approach used in the GreenBook, and the Climate Risk Profile is centred around understanding climate-related risk. Climate-related risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and the occurrence of a climate hazard (see Figure 2). "Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, and services (including ecosystem services, ecosystems and species)" (Chen, et al., 2021, p. 64). The components of risk are dynamic. Climate hazards are driven by natural climate variability and anthropogenic climate change. Human activity contributes to Greenhouse Gas emissions that increase temperatures, which in turn affects changes in the occurrence of climate hazards such as drought, flooding, coastal flooding, and heat extremes. Planned as well as unplanned development and growth of our settlements drive the exposure of people, as well as the built- and natural environment to climate hazards. Vulnerability includes the inherent characteristics that make systems sensitive to the effects and impacts of climate hazards. Municipal risk is driven by vulnerability and exposure to certain climate-related hazards.

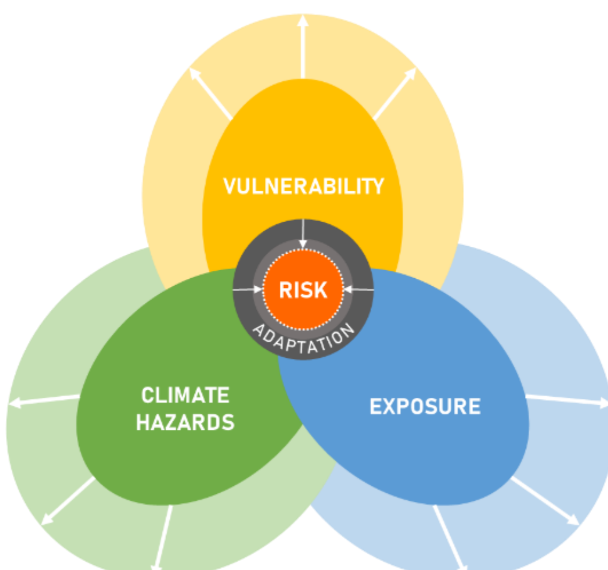

Figure 2: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

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

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

1.2. Policy framework

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

Furthermore, the National Climate Change Response White Paper – which outlines the country's comprehensive plan to transition to a climate resilient, globally competitive, equitable and low-carbon economy and society through climate change adaptation- and mitigation, while simultaneously addressing the country's key priorities, including job creation, poverty reduction, social equality and sustainable development, amongst others – identifies local governments as critical role players that can contribute towards effective climate change adaptation through their various functions, including "[the] planning [of] human settlements and urban development; the provision of municipal infrastructure and services; water and energy demand management; and local disaster response, amongst others." (Republic of South Africa, 2011, p. 38). The Climate Change Bill takes it further by setting out reporting requirements on climate change response needs and interventions for every municipality in the country. The Bill also sets out requirements for every district intergovernmental forum to serve as a Municipal Forum on climate change that coordinates climate response actions and activities in its respective municipality.

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

1.3. District Municipal context

The Cape Winelands District Municipality (CWDM) is one of five District Municipalities (DMs) within the Western Cape Province. It borders the Northern Cape District Municipality of Namakwa in the north and the Cape Metropolitan area in the south. The District encloses a land area of 22 309 km² and comprises of five Local Municipalities (LMs) namely Drakenstein, Stellenbosch, Witzenberg, Breede Valley and Langeberg (formally known as Breede River/Cape Winelands). The District has a total population of 968 667 which is the largest of the five DMs in the Western Cape Province. The population is estimated to have grown by an annual average growth rate of 2.20 % between 2014 and 2018 and projected to grow by 32.70 % between 2011 and 2030. The Drakenstein and Breede Valley are the most populous LMs in the District.

The Growth Domestic Product (GDP) was around R43.91 billion in 2018 and the finance, insurance, real estate and business services sector was the largest contributor to the GDP, accounting for 24.04 % of economic output. Agriculture is a key sector of the District's economy and contributed 10.17 % to the District's GDP in 2018 (Wesgro, 2019). The Cape Winelands District is a leading wine producer with nearly 70% of South Africa's wine coming from the area. The District's major employing sectors are the wholesale and retail trade, catering and accommodation sector employing 87,128 people in 2018. The agriculture, forestry and fishing sector is the second largest employer contributing 81,803 jobs to the labour force. The unemployment rate is 10.58 %, with 386,452 people employed from a working age population of 602,675 people (Wesgro, 2019).

Most of the District is covered by the Fynbos Biome but also includes areas of Succulent Karoo, Albany Thicket and Afro-temperate Forest biomes. The Fynbos Biome is part of the Cape Floristic Kingdom (one of six recognised floral kingdoms globally). The Fynbos Biome is made up of fynbos and renosterveld, and includes an extremely high number of species. A sizable area of Succulent Karoo Biome is found in the north and eastern areas of the Langeberg and Witzenberg LMs. Most of the land in the Cape Winelands District Municipal Area that is not either mountains or natural vegetation (i.e., fynbos and veld), is covered by commercial agriculture and some commercial forestry.

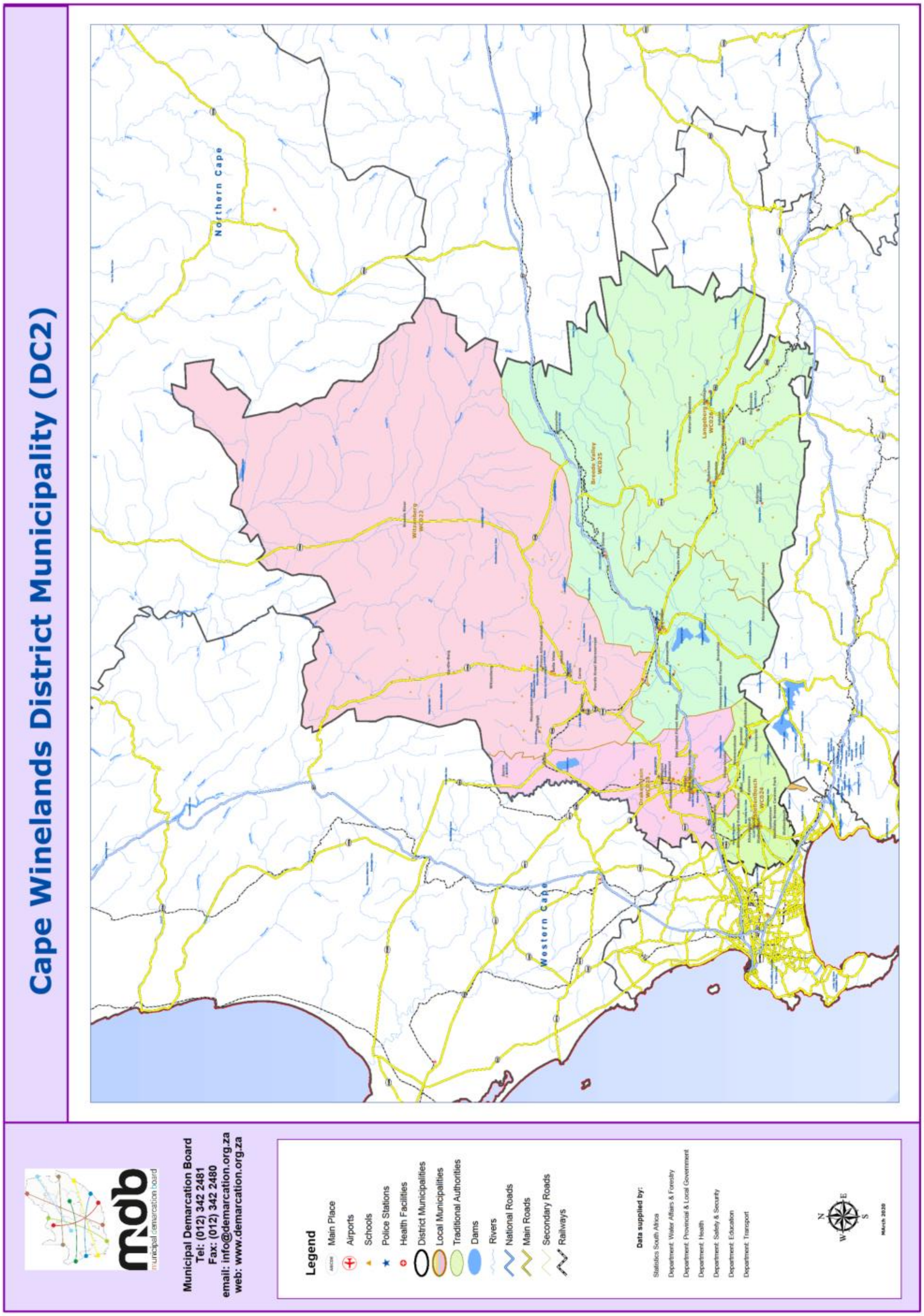

Figure 3: Cape Winelands District Municipality (Municipal Demarcation Board, 2022), with Local Municipalities shaded in different colours

2. Baseline and future climate risk

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

2.1. Vulnerability and population change

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

2.1.1. Municipal vulnerability

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

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

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

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

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

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

Table 1: Vulnerability indicators across Cape Winelands District Municipality for 1996 t0 2011

LOCAL MUNICIPALITY	SEVI 1996	SEV 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
Breede Valley	2.08	1.81	↘	4.63	3.43	↘	5.40	N/A	5.11	N/A
Drakenstein	1.72	1.24	↘	3.93	3.25	↘	4.43	N/A	7.26	N/A
Langeberg	3.13	2.10	↘	4.50	2.01	↘	5.80	N/A	4.14	N/A
Stellenbosch	1.95	1.77	↘	2.34	3.91	↗	5.17	N/A	9.21	N/A
Witzenberg	3.04	2.07	↘	4.25	1.79	↘	5.94	N/A	4.44	N/A

Socio-economic vulnerability has decreased (improved) across all LMs between 1996 and 2011. All LMs also experienced a downward trend in economic vulnerability except for Stellenbosch. This LM has the highest economic vulnerability in the District, and the 5th highest in the Western Cape Province. A population growth rate of 2.10 %, high population density and rising unemployment contribute to the economic vulnerability of Stellenbosch region (SEP, 2020). Moreover, Stellenbosch also has a very high environmental vulnerability, which is the second highest in the province after the City of Cape Town. Ecosystem services have come under severe threat in the Stellenbosch LM. Soil erosion, water pollution from local industries, wastewater and informal settlements, as well as the spread of alien invasive plants, land development and illegal harvesting of indigenous plants, have impacted on the biodiversity and natural beauty of the area.

2.1.2. Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlements within the Cape Winelands District and its Local Municipalities, with regards to six composite indicators. This enables the investigation of the relative vulnerabilities of settlements within the District.

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

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

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

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

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

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

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

A brief description of each Local Municipality within the DM follows below.

Breede Valley Local Municipality

The major settlements in this LM are Worcester, Rawsonville, De Doorns and Touwsrivier. The settlement facing the greatest growth pressure is Worcester, which also has very high environmental vulnerability. De Doorns and Touwsrivier have very high socio-economic vulnerability, while Touwsrivier also has the greatest regional connectivity vulnerability in the municipality.

Drakenstein Local Municipality

The major settlements in this LM are Paarl, Gouda and Saron. Paarl is facing the greatest growth pressure in the municipality and has very high service access vulnerability combined with a socio-economically vulnerable population. Both Gouda and Saron also have very high socio-economic and economic vulnerability.

Langeberg Local Municipality

The major settlements in this LM are Montagu, Bonnievale, McGregor, Robertson and Ashton. Bonnievale has very high service access vulnerability and together with McGregor and Montagu, is also subject to poor regional connectivity. Robertson faces the greatest growth pressure in the municipality.

Stellenbosch Local Municipality

The major settlements in this LM are Pniel, Franschhoek and Stellenbosch. Other smaller settlements are Klapmuts, Langrug, Languedoch, Kylemore, Koelenhof and Raithby. Klapmuts and Langrug have the greatest growth pressure, as well as high economic and socio-economic vulnerability. Languedoch has the highest environmental vulnerability.

Witzenberg Local Municipality

The major settlements in this LM are Wolseley, Ceres and Tulbagh. Wolseley experiences the highest growth pressure combined with socio-economic vulnerability. Tulbagh also faces high socio-economic vulnerability while Ceres has the highest environmental vulnerability within this LM.

2.1.3. Population growth pressure

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

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

Table 2: Settlement population growth pressure across Cape Winelands District Municipality

Population per municipality	2011	Medium Growth Scenario	
		2030	2050
Breede Valley	166 841	185 306	183 332
Drakenstein	251 262	327 789	390 897
Langeberg	97 714	119 274	132 492
Stellenbosch	155 732	210 894	262 383
Witzenberg	115 947	159 316	199 748
Cape Winelands DM Total	787 496	100 2579	1 168 852

The District's population is projected to increase by 48 % between 2011 and 2050, under a medium growth scenario. Most of this growth will take place in the settlements within Witzenberg and Stellenbosch LMs. Figure 4 depicts the growth pressures that the settlements across the District are likely to experience. The settlements that are likely to experience extreme growth pressures up to 2050, include Wolseley, Ceres, Tulbagh and Stellenbosch.

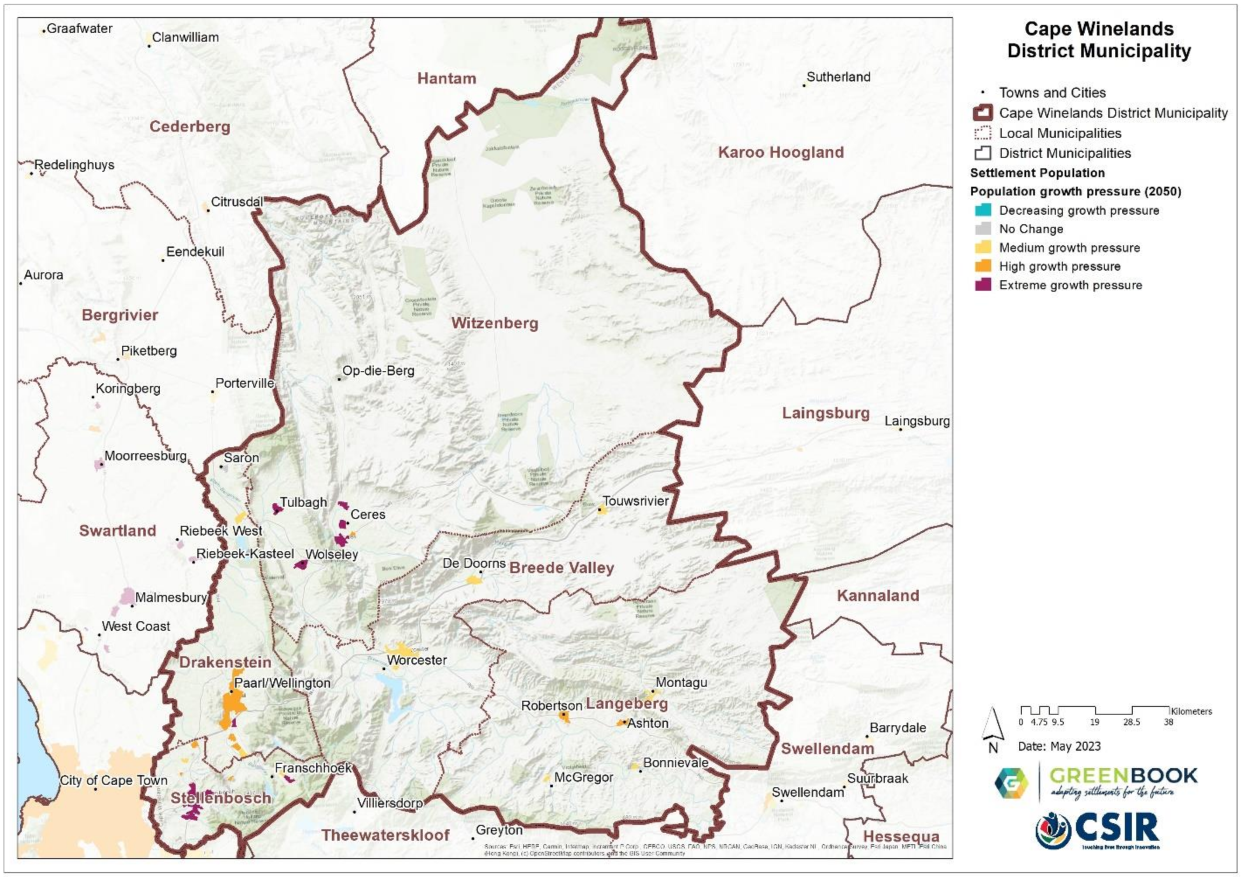

Figure 4: Settlement-level population growth pressure across Cape Winelands District Municipality

2.2. Climate

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

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

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

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

For each of the climate variables discussed below:

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

2.2.1.Temperature

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

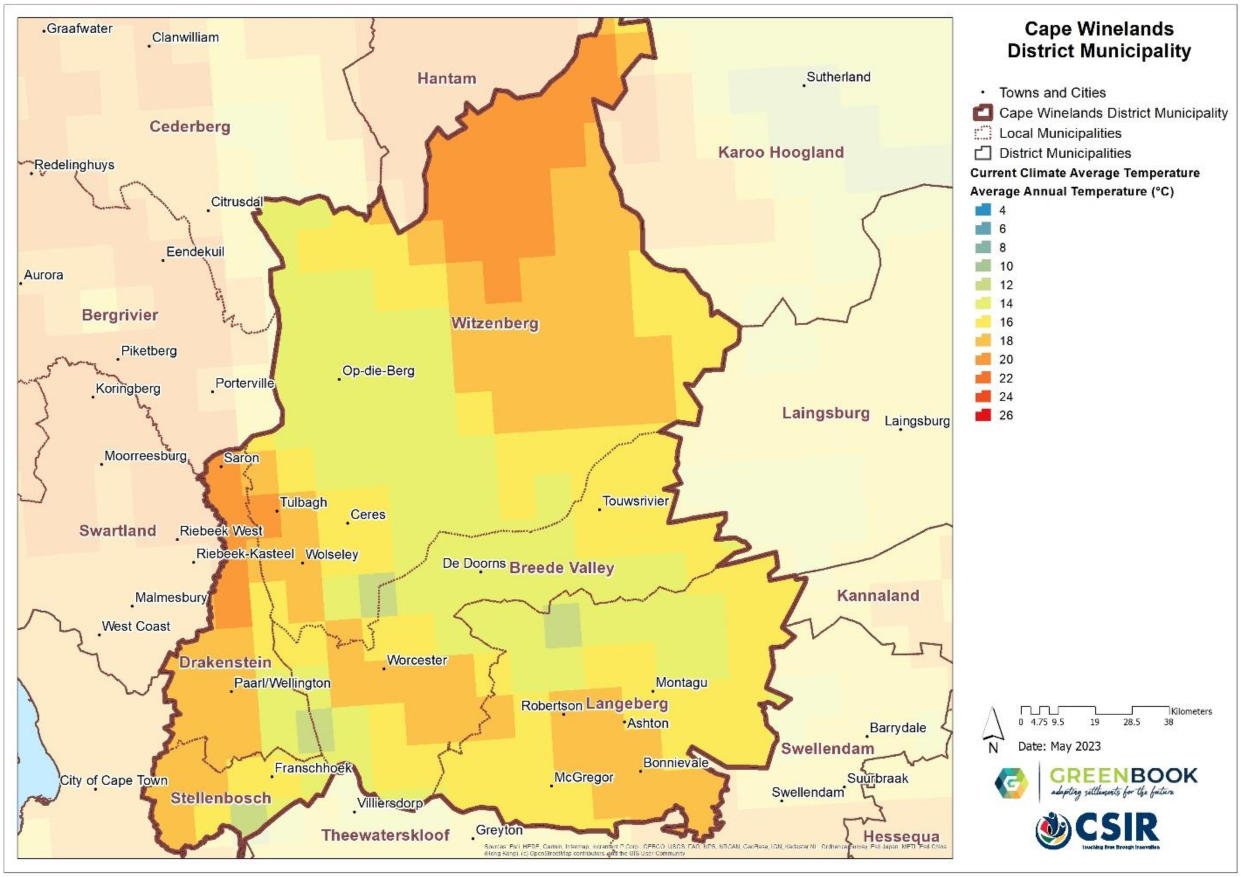

Figure 5: Average annual temperature (°C) for the baseline period 1961-1990 for Cape Winelands District Municipality

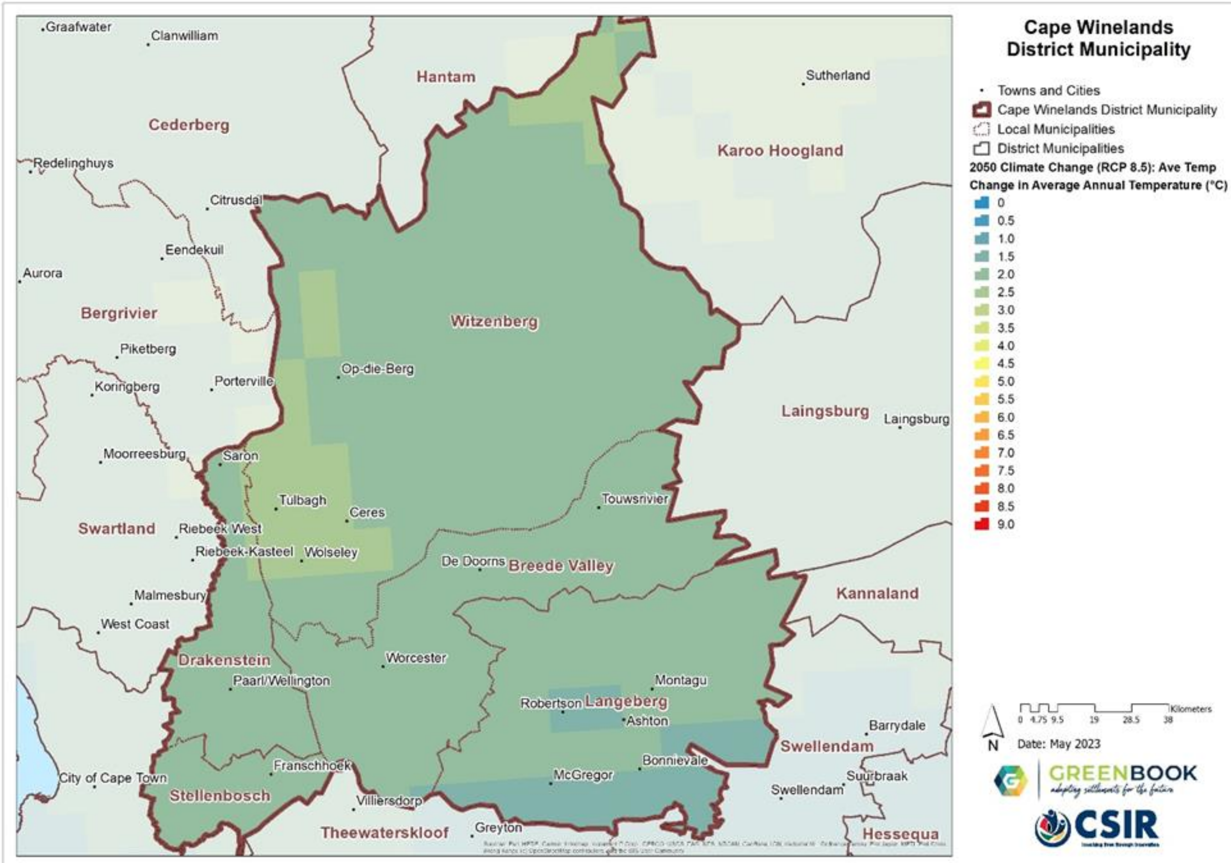

Figure 6: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for Cape Winelands District Municipality, assuming an RCP 8.5 emissions pathway

The CWDM experiences a wide range in average annual temperatures ranging between 12 and 20 °C, with lower averages found over the high lying areas north of Ceres as well as around De Doorns and Franschhoek. The projections show average annual temperature increases of between 2°C and 3°C across the District into the future, under a low mitigation, high emissions, scenario. The greatest increases are expected around the towns of Tulbagh, Ceres and Wolseley with lower increases in the far southeast of the District.

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.

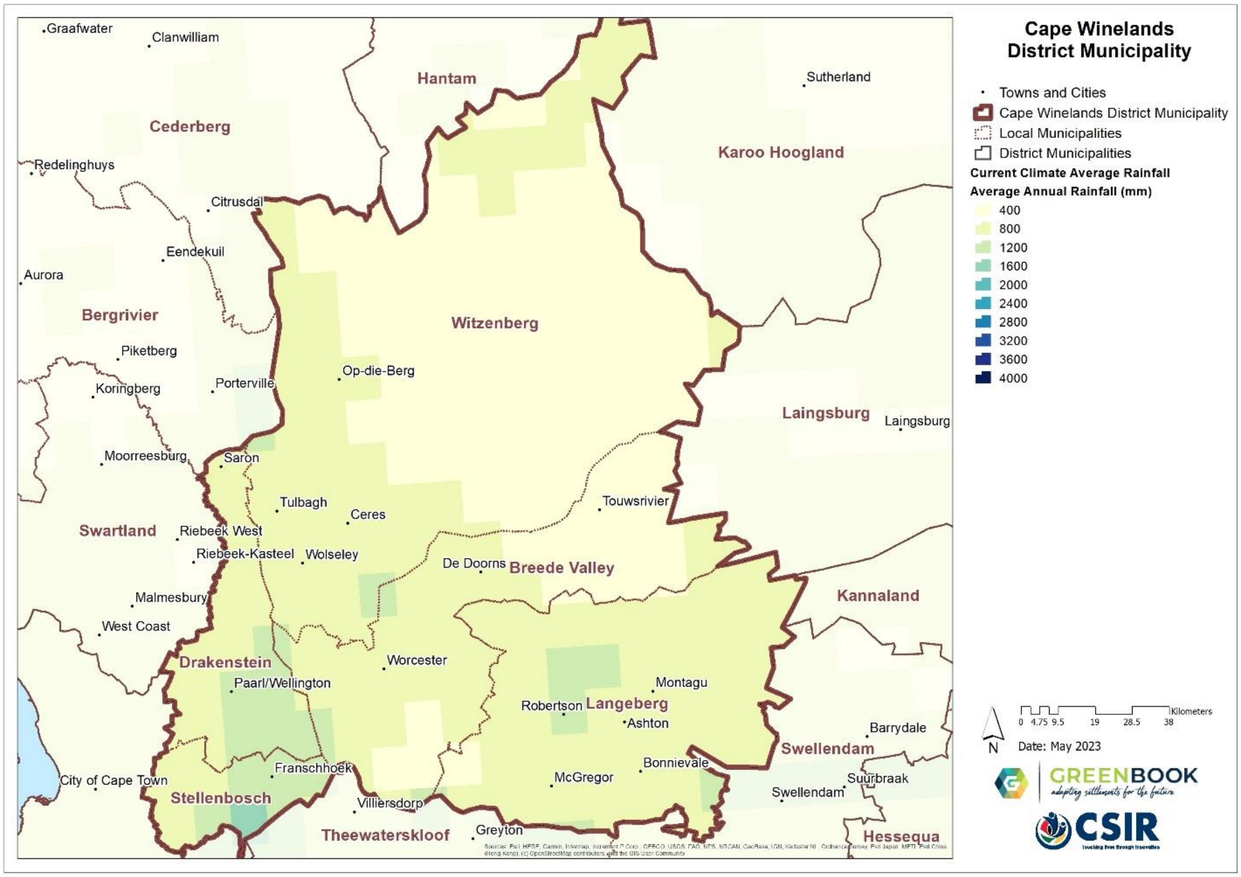

Figure 7: Average annual rainfall (mm) for the baseline period 1961-1990 for Cape Winelands District Municipality

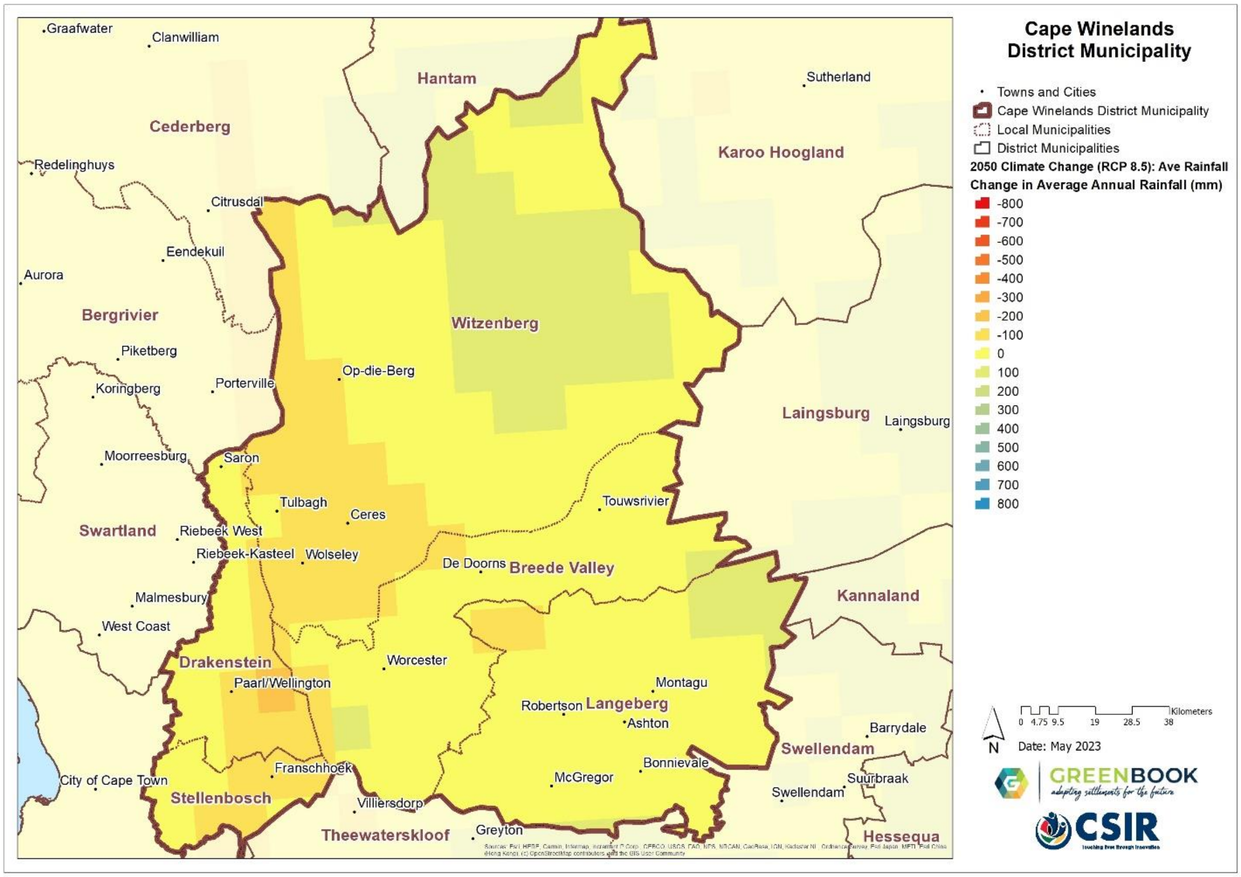

Figure 8: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for Cape Winelands District Municipality, assuming an RCP8.5 emission pathway

The CWDM experiences current GCM derived average annual rainfall of between 400 and 1600 mm, with higher averages found over the mountainous areas around the towns of Stellenbosch and Franschhoek. Lower rainfall is experienced in the northern parts of the Witzenberg LM towards the Northern Cape province. Future projections show an average annual rainfall decline of up to 200 mm over the western parts of the District, under a low mitigation, high emissions, scenario. A possible increase in rainfall is projected in the north eastern part of Witzenberg LM.

2.3. Climate Hazards

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

2.3.1.Drought

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

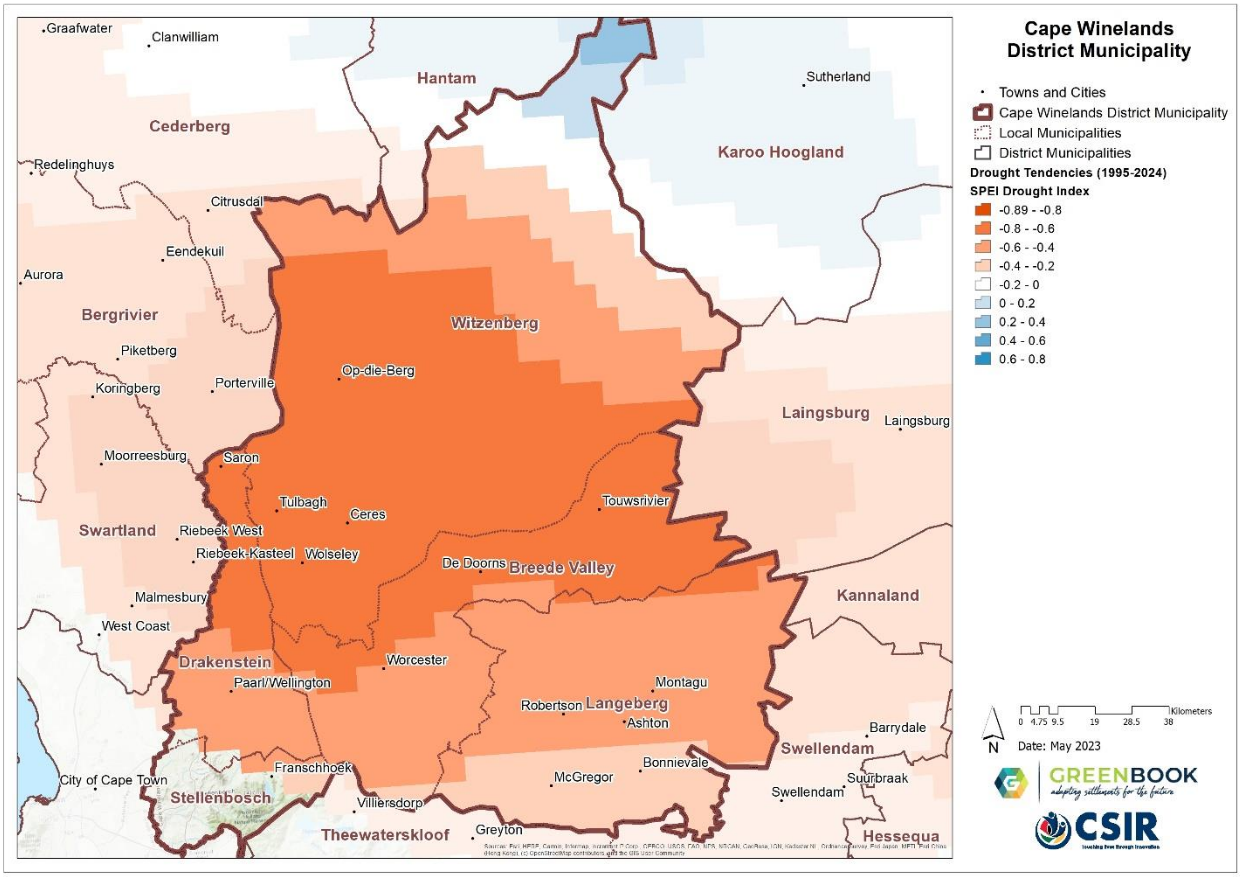

Figure 9: Projected changes in drought tendencies from the baseline period (1986–2005) to the current period (1995-2024) across Cape Winelands District Municipality

Figure 9 depicts the projected change in drought tendencies (i.e., the number of cases exceeding near-normal per decade) for the period 1995-2024, relative to the 1986-2005 baseline period, under an RCP 8.5 "business as usual" emissions scenario (RCP 8.5). A negative value is indicative of an increase in drought tendencies per 10 years (more frequent than the observed baseline) with a positive value indicative of a decrease in drought tendencies.

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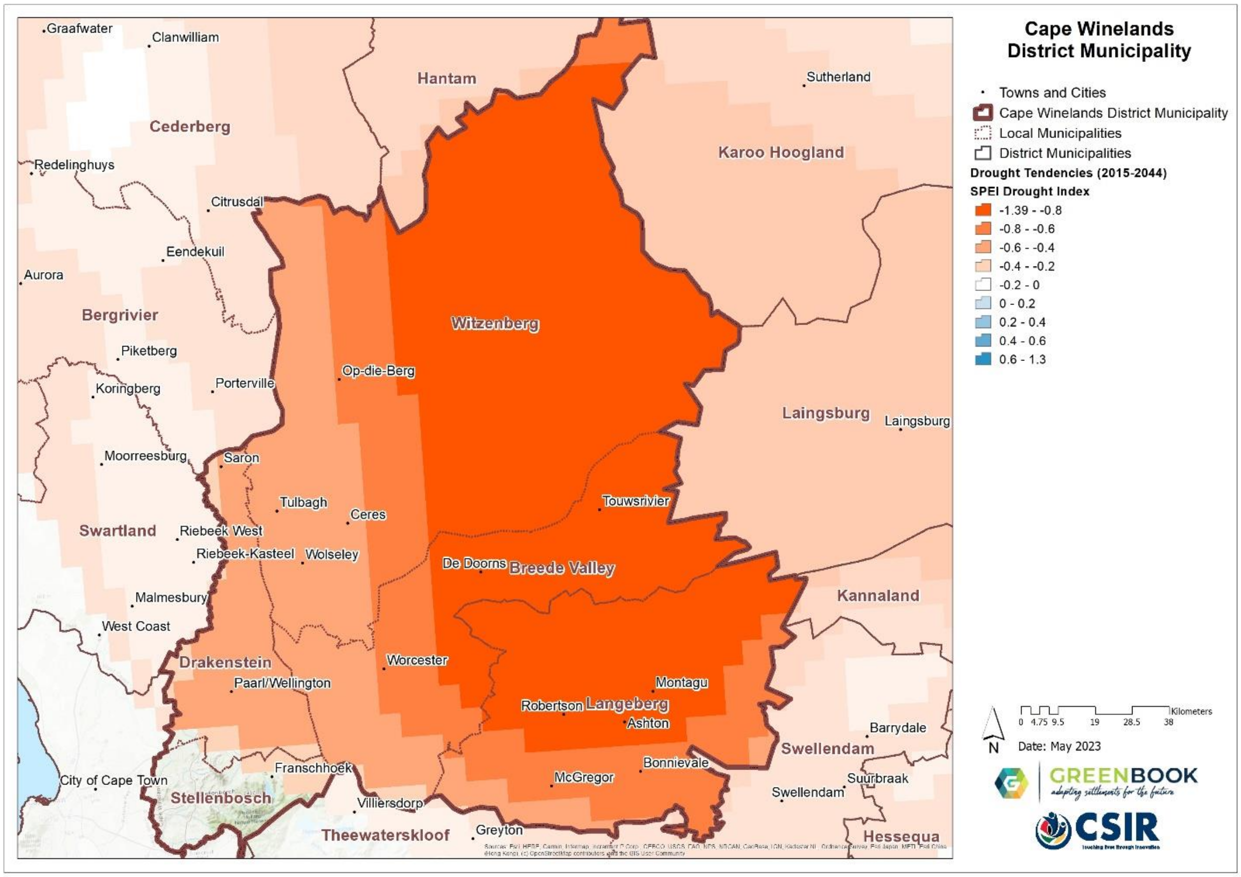

Figure 10: Projected changes in drought tendencies from the baseline period (1986–2005) to the future period 2015-2044 for Cape Winelands District Municipality

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

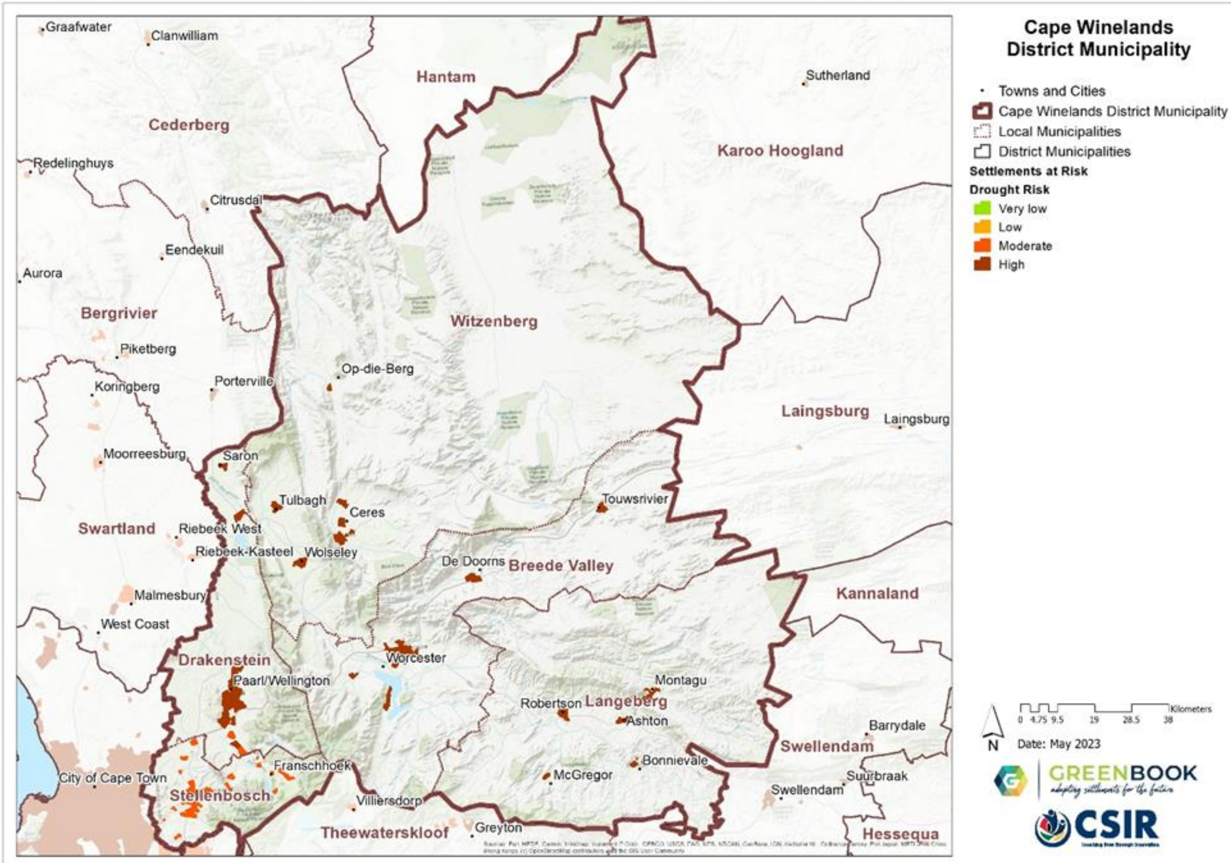

Figure 11: Settlement-level drought risk for Cape Winelands District Municipality

All settlements across the Cape Winelands District are at risk of drought. At the baseline, large parts of the District are exposed to higher drought tendencies, which are projected to increase into the future, as a tendency for more intense droughts is predicted into the future.

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 12), and for the projected changes for period 2021–2050.

The annual heatwave days map under baseline climatic 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, and that for a period of at least three consecutive days.

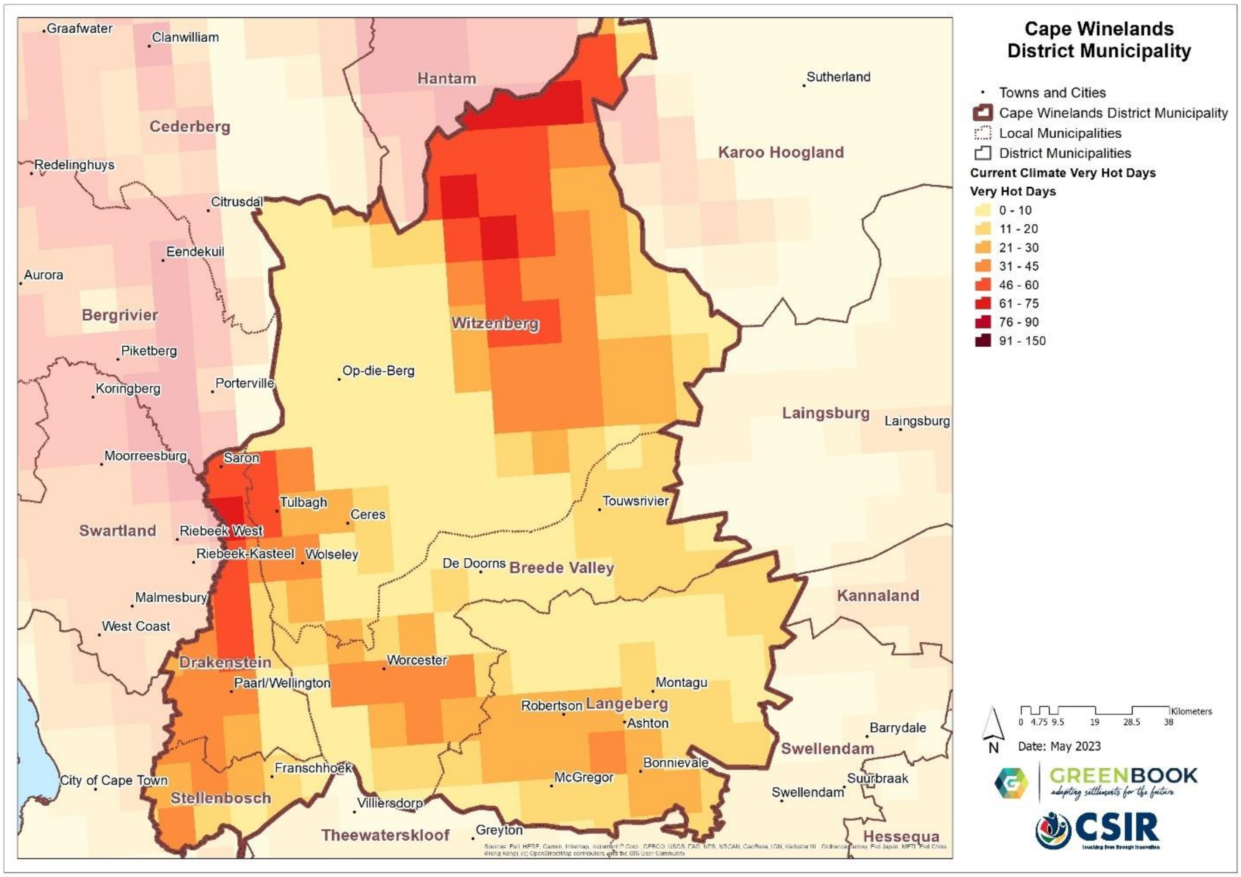

Figure 12: Annual number of very hot days across Cape Winelands District Municipality with daily temperature maxima exceeding 35°C

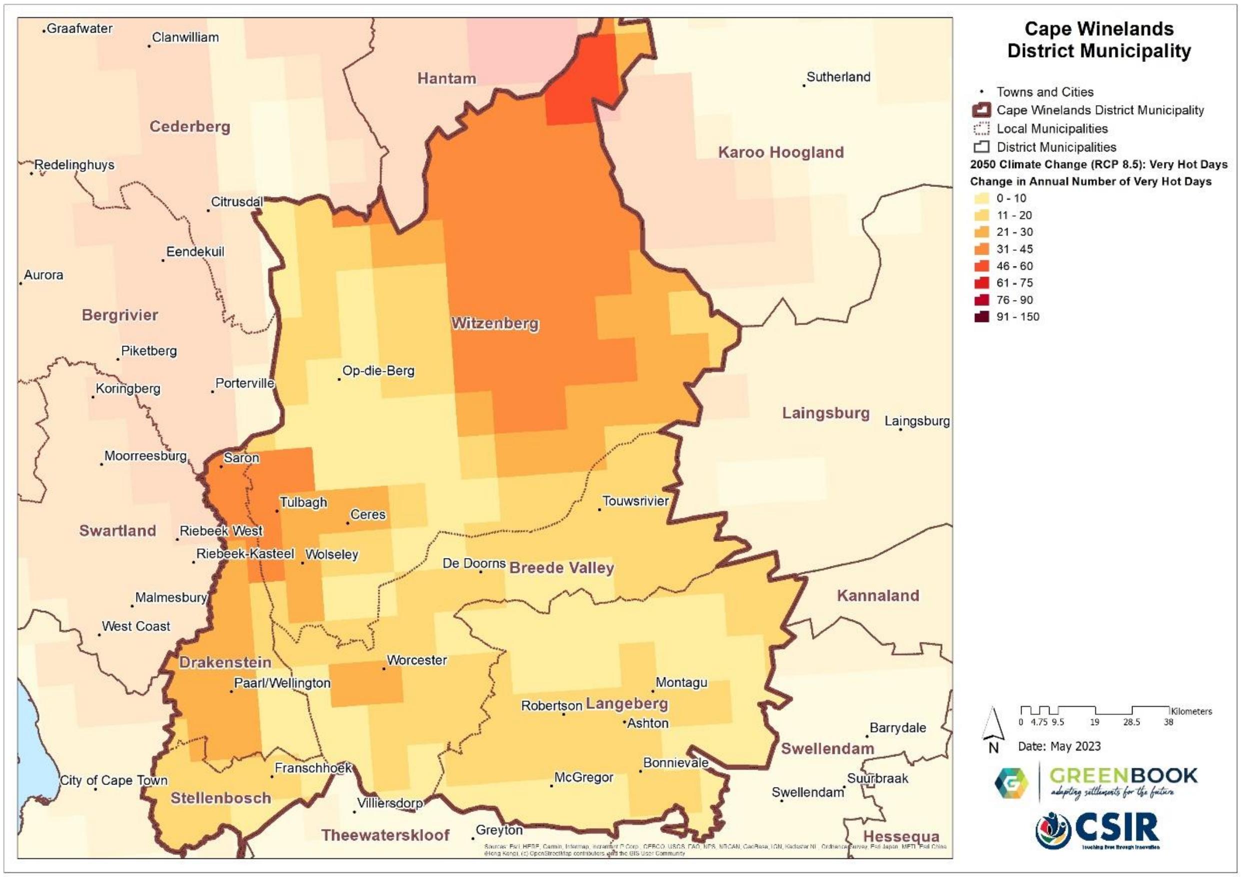

Figure 13: Annual number of very hot days across Cape Winelands District Municipality with daily temperature maxima exceeding 35°C

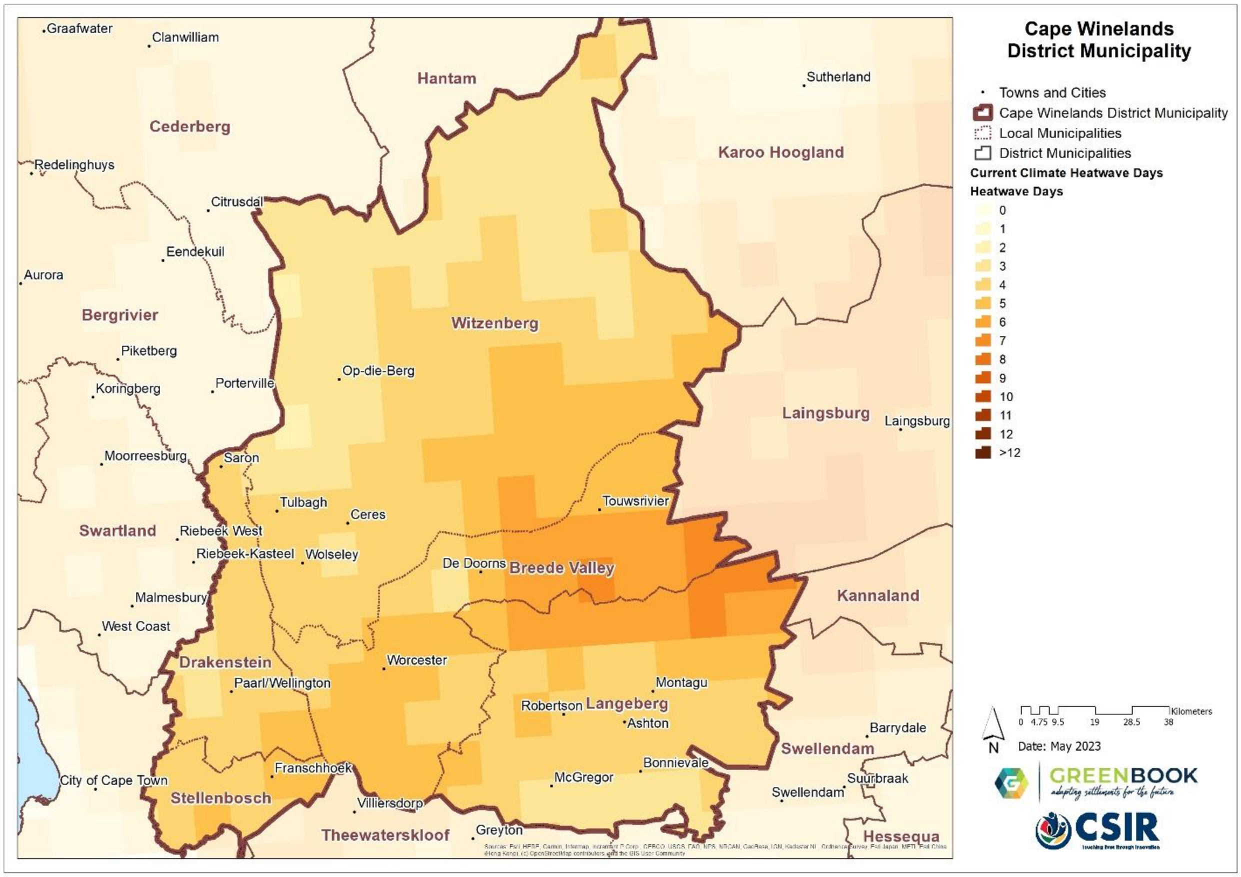

Figure 14: Number of baseline annual heatwave days across Cape Winelands District Municipality

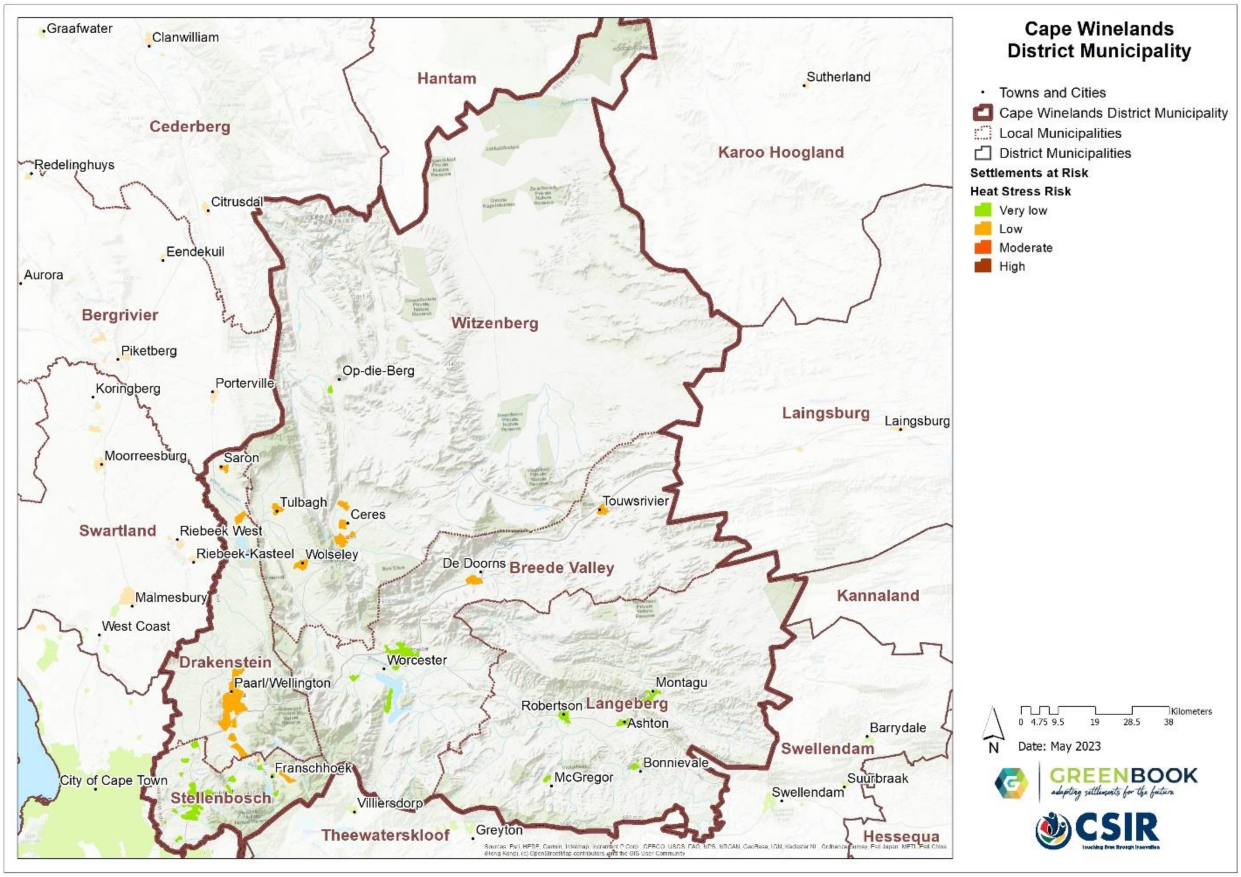

Figure 15: Settlement-level heat risk across Cape Winelands District Municipality

Under baseline climatic conditions, some areas over the far west and north of the District experience 46 to 60 very hot days annually, with daily maxima exceeding 35°C. Very hot days are more likely to be experienced near the settlements of Paarl, Wellington and Saron. Heatwave events are more likely to take place towards the east of the District, affecting areas north of Montagu. The number of very hot days are projected to increase in the areas that are already more likely to experience extreme heat.

Figure 15 depicts the settlements that are at risk of increases in heat stress. With the changing climate, it is expected that the impacts of heat will only increase in the future, and not decrease. The heat-absorbing qualities of built-up urban areas make them, and the people living inside them, especially vulnerable to increasingly high temperatures. The combination of the increasing number of very hot days and heatwave days over certain parts of this DM is likely to significantly increase the risk of extreme heat in several settlements. Some of the settlements that are projected to be most exposed to heat stress in the future in the District include Wellington, Paarl, Worcester and Saron.

2.3.3. Wildfire

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

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

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

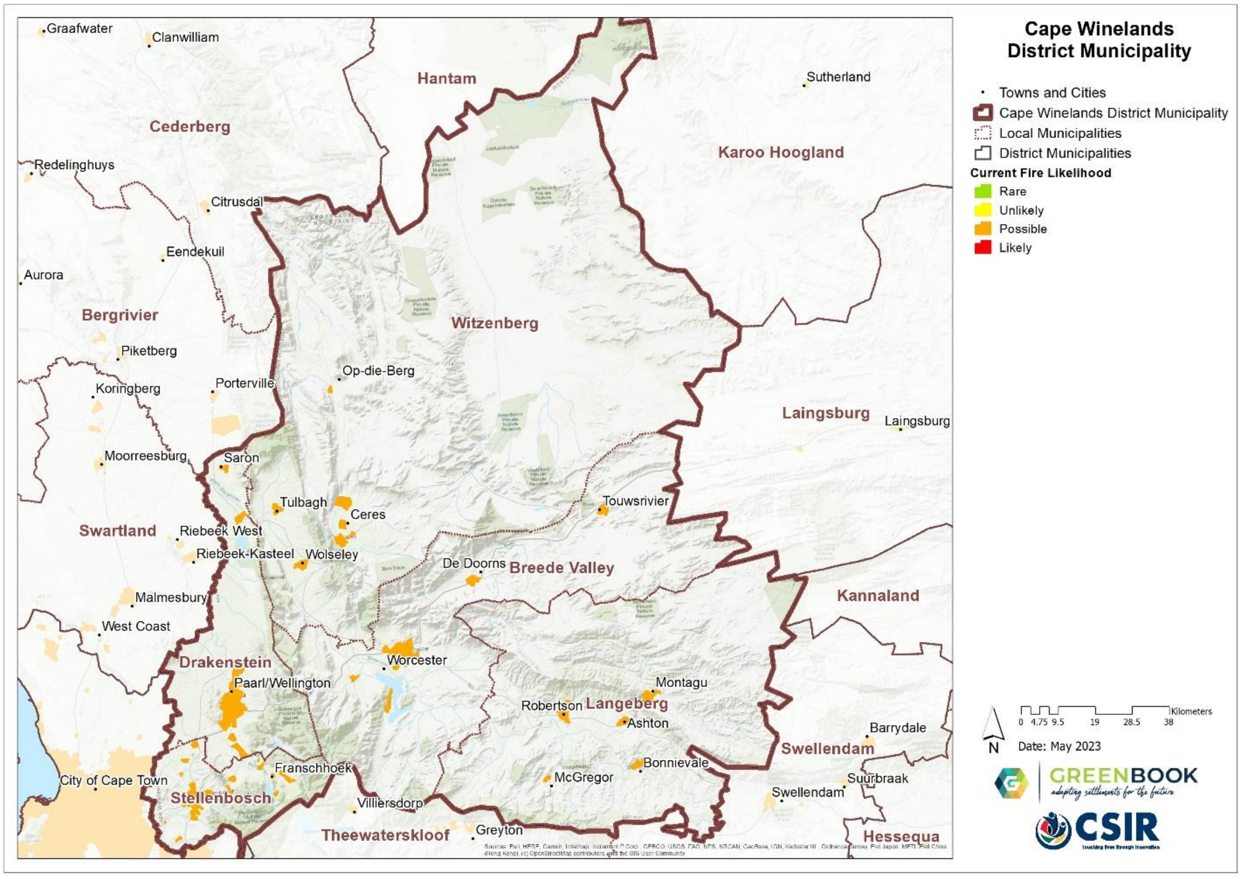

Figure 16 The likelihood of wildfires under current climatic conditions across settlements in Cape Winelands District Municipality

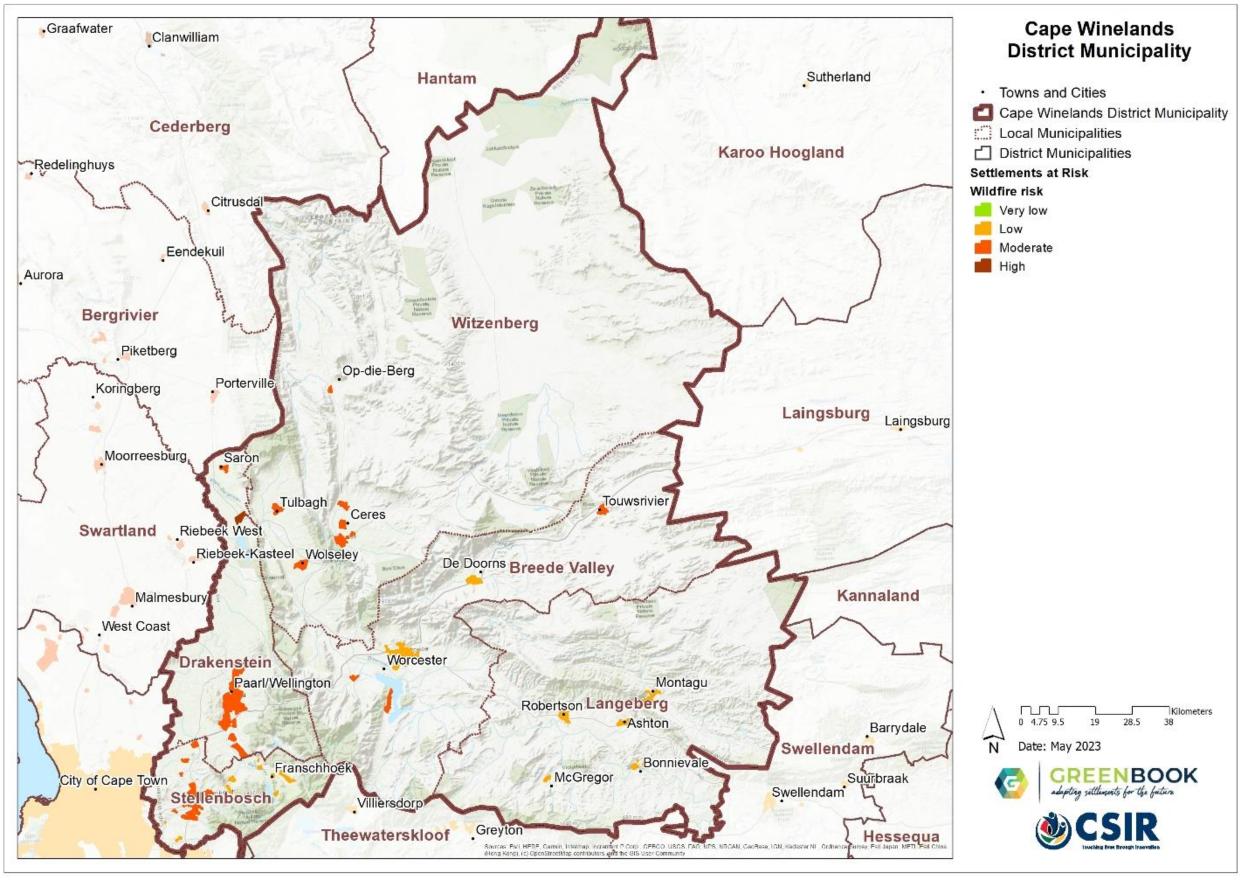

Figure 17: The likelihood of wildfires under projected future climatic conditions across settlements in Cape Winelands District Municipality

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, under current climatic conditions, while Figure 17 depicts the settlements that could be at risk of increases in wildfires by the year 2050. All settlements across the District are likely to experience wildfires on their wildland-urban interface. It is projected that of these settlements, Tulbagh, Ceres, Wolseley, Paarl and Stellenbosch could see an increase in risk of wildfires in the future.

2.3.4. Flooding

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

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

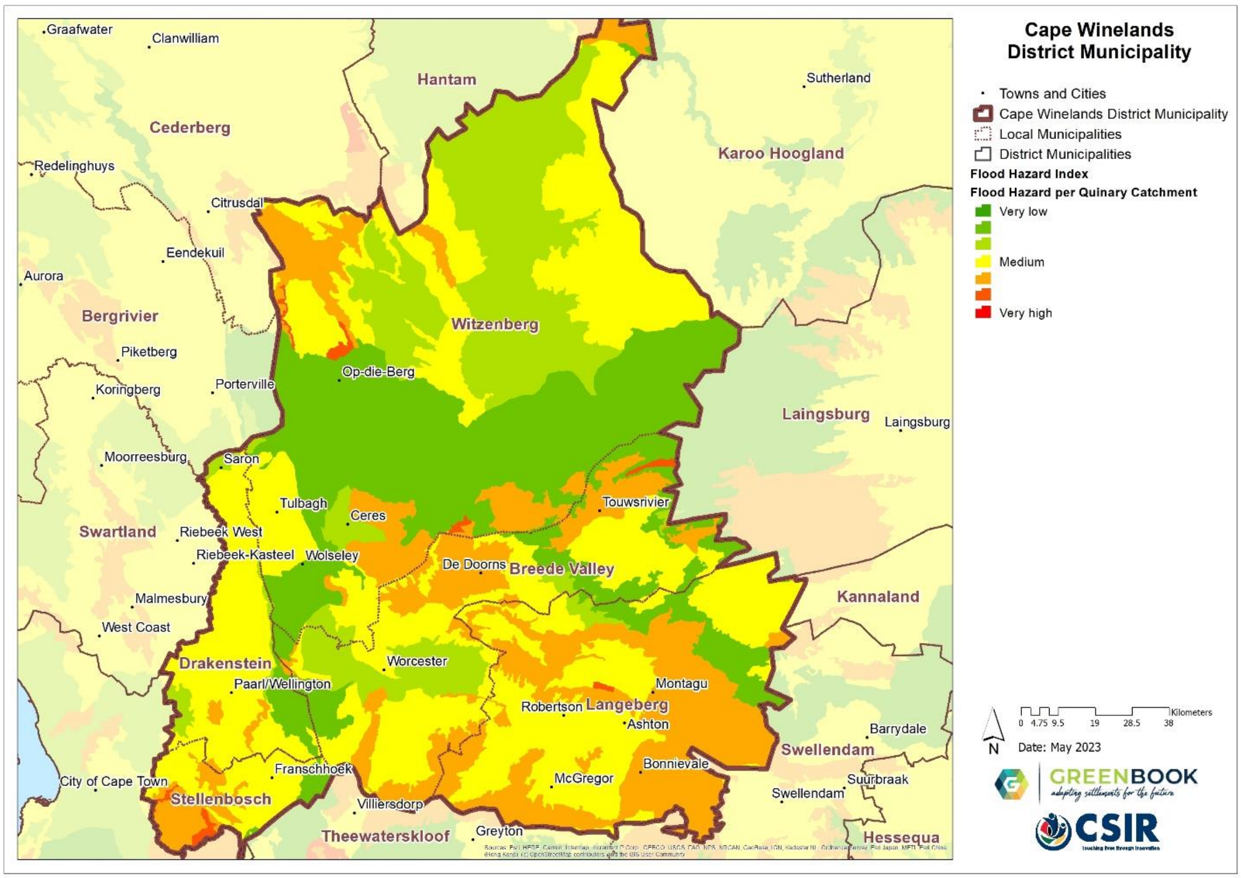

Figure 18: The current flood hazard index across Cape Winelands District Municipality under current (baseline) climatic conditions

Figure 18 depicts the flood hazard index of the individual Quinary catchments present or intersecting with the District. The flood hazard index is based on the catchment characteristics and design rainfall, averaged at the Quinary catchment level. Green indicates a low flooding hazard, while red indicates a high flood hazard. There is significant variation of the flood hazard index across the DM. Most parts of the District have a low to medium flooding hazard, with small pockets of very high flooding hazard.

Figure 19 depicts the projected change into the future in extreme rainfall days for an 8 x 8 km grid. This was calculated by assessing the degree of change when projected future rainfall extremes (e.g., 95th percentile of daily rainfall) are compared with those under the current rainfall extremes. A value of more than 1 indicates an increase in extreme daily rainfalls. Slight to significant decreases in the number of extreme rainfall days are expected over most parts of the DM, with areas in the north of Witzenberg LM that can expect a slight increase in extreme rainfall days.

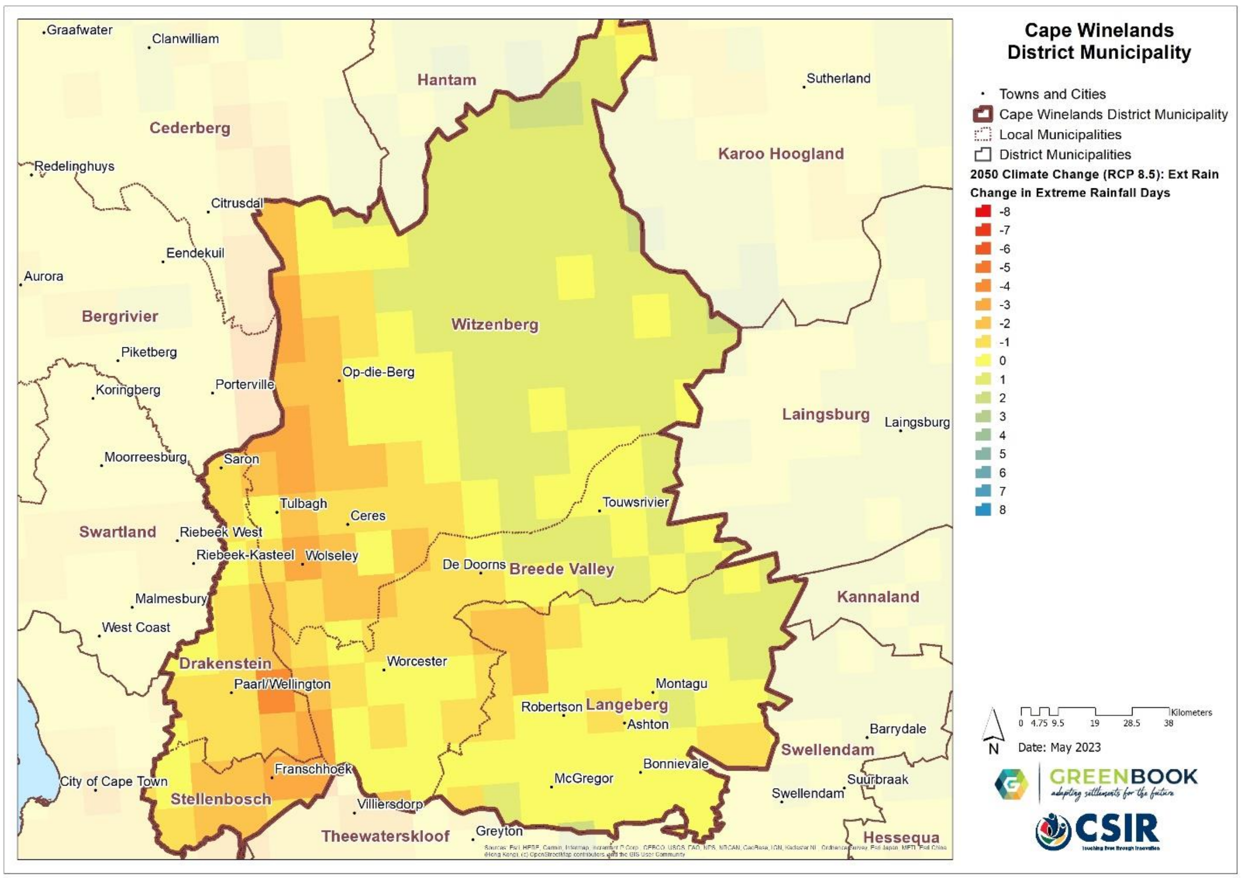

Figure 19: Projected changes into the future in extreme rainfall days across Cape Winelands District Municipality

Figure 20 depicts the settlements that are at increased risk of flooding under an RCP 8.5 low mitigation (worst case of greenhouse gas emissions) scenario, and these include Paarl, Stellenbosch, De Doorns, Touwsrivier and Montagu.

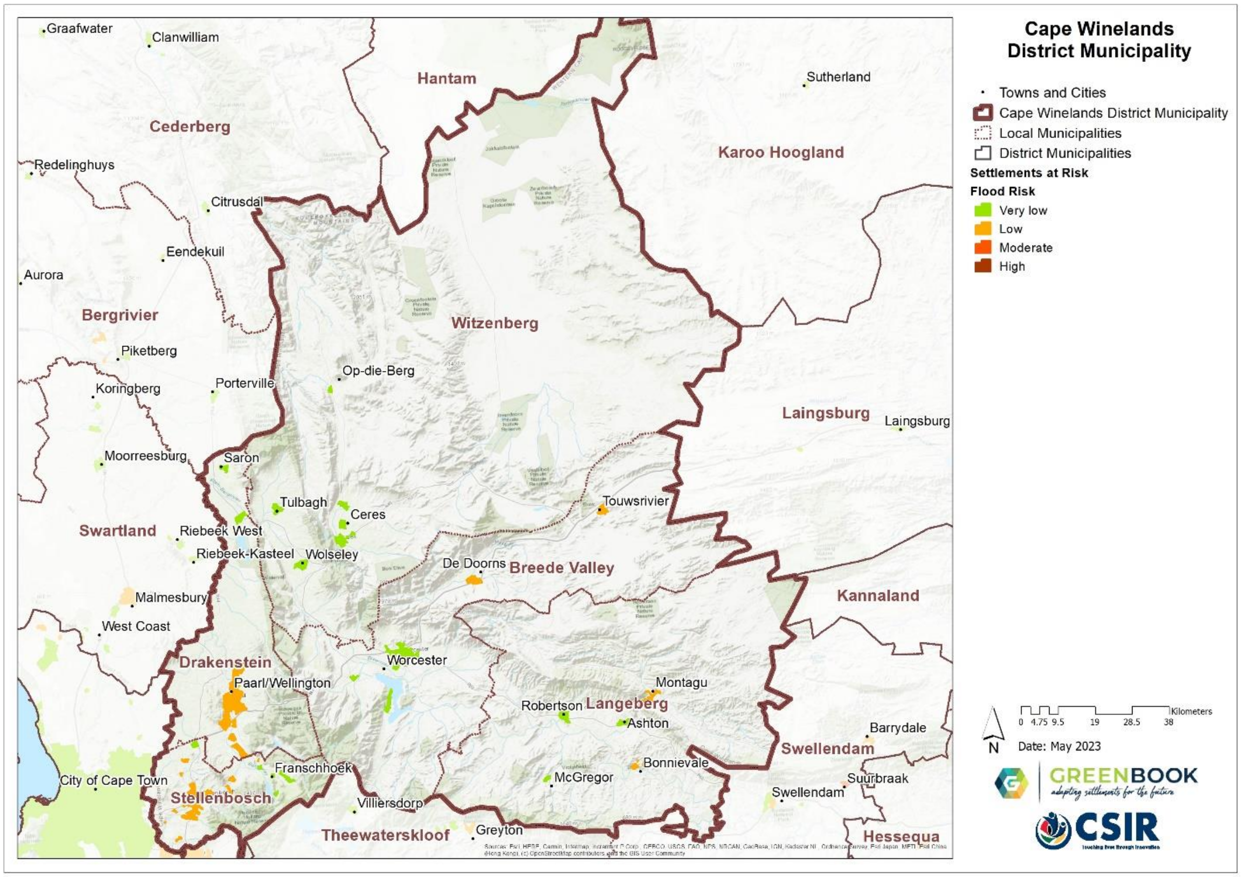

Figure 20: Flood risk into a climate change future at settlement level across Cape Winelands District Municipality.

2.4. Climate impacts on key resources and sectors

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

2.4.1. Water resources and supply vulnerability

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

Water availability is directly impacted by the climate and climate change. It is not just changes in precipitation that need to be considered, but also increasing temperatures that will lead to increased evaporation which could further reduce runoff and increase water losses from dams. Increasing temperatures will also impact on water demand, particularly for irrigation, but also from urban and industrial users. This could also contribute to reduced water security if existing systems are not able to meet these increasing demands. Increasing air temperatures will also increase water temperatures and hence increase pollution and water quality risks.

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

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

Figure 21 indicates where settlements get their main water supply from, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed to be groundwater dependent. In the Cape Winelands District, most towns are surface water dependent with a few that use a combination of surface water and groundwater sources.

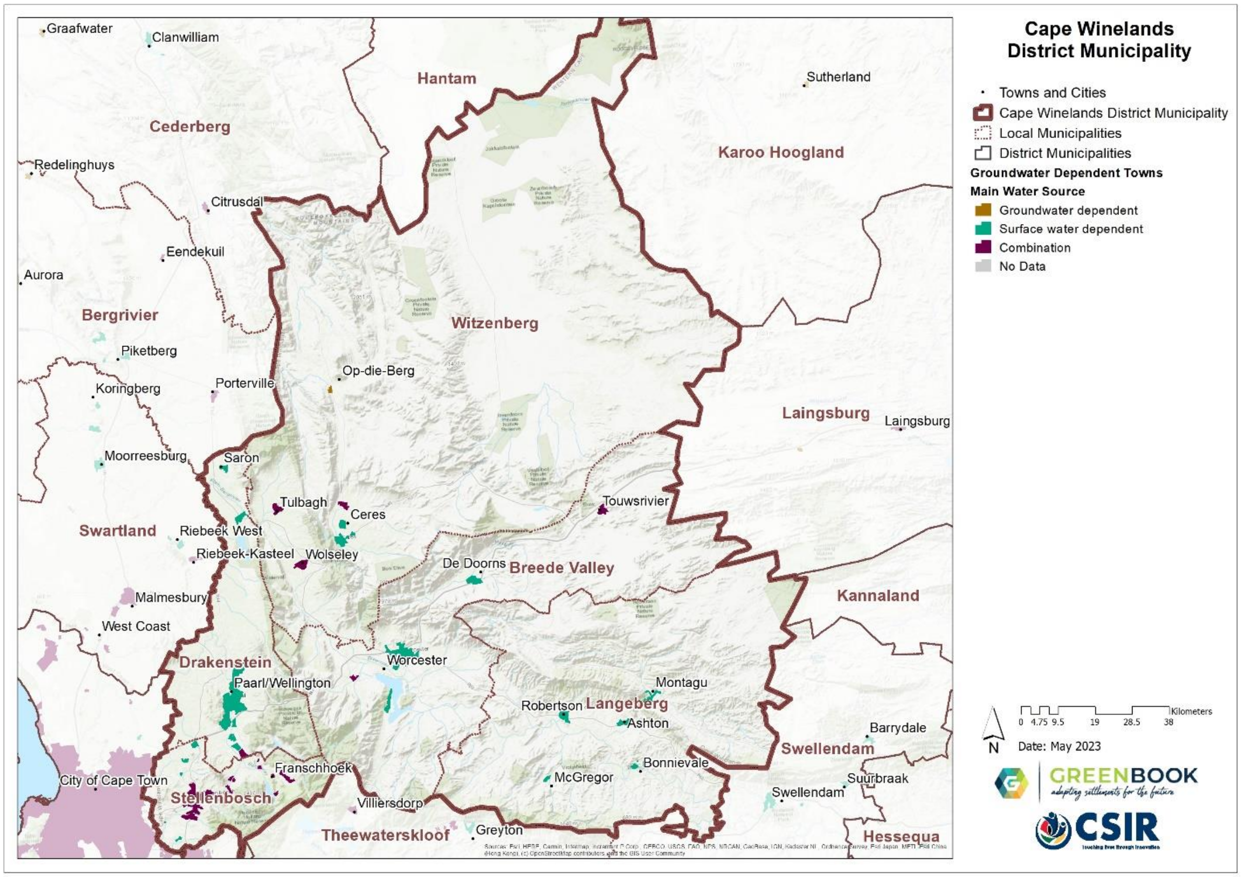

Figure 21: Main water source for settlements in the Cape Winelands District Municipality

Figure 22 indicates the occurrence and distribution of groundwater resources across the District Municipality, showing distinctive recharge potential zones, while Figure 23 indicates the projected change in groundwater potential. Figure 24 indicates which groundwater dependent settlements that may be most at risk of groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure into the future. As indicated in Figure 22, groundwater recharge potential is high in the high rainfall areas of Drakenstein and Stellenbosch, as well as around areas of Ceres and Bonnievale.

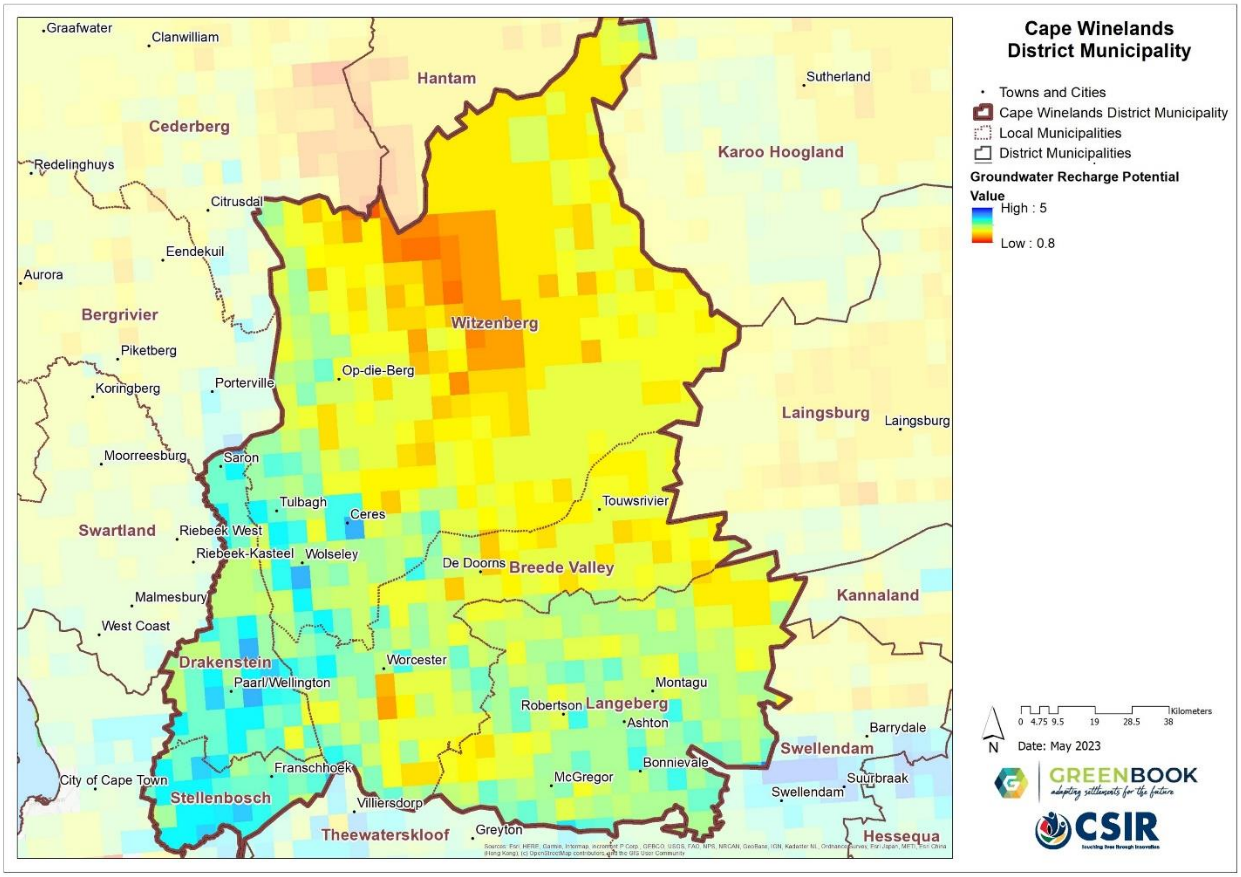

Figure 22: Groundwater recharge potential across Cape Winelands District Municipality under current (baseline) climatic conditions

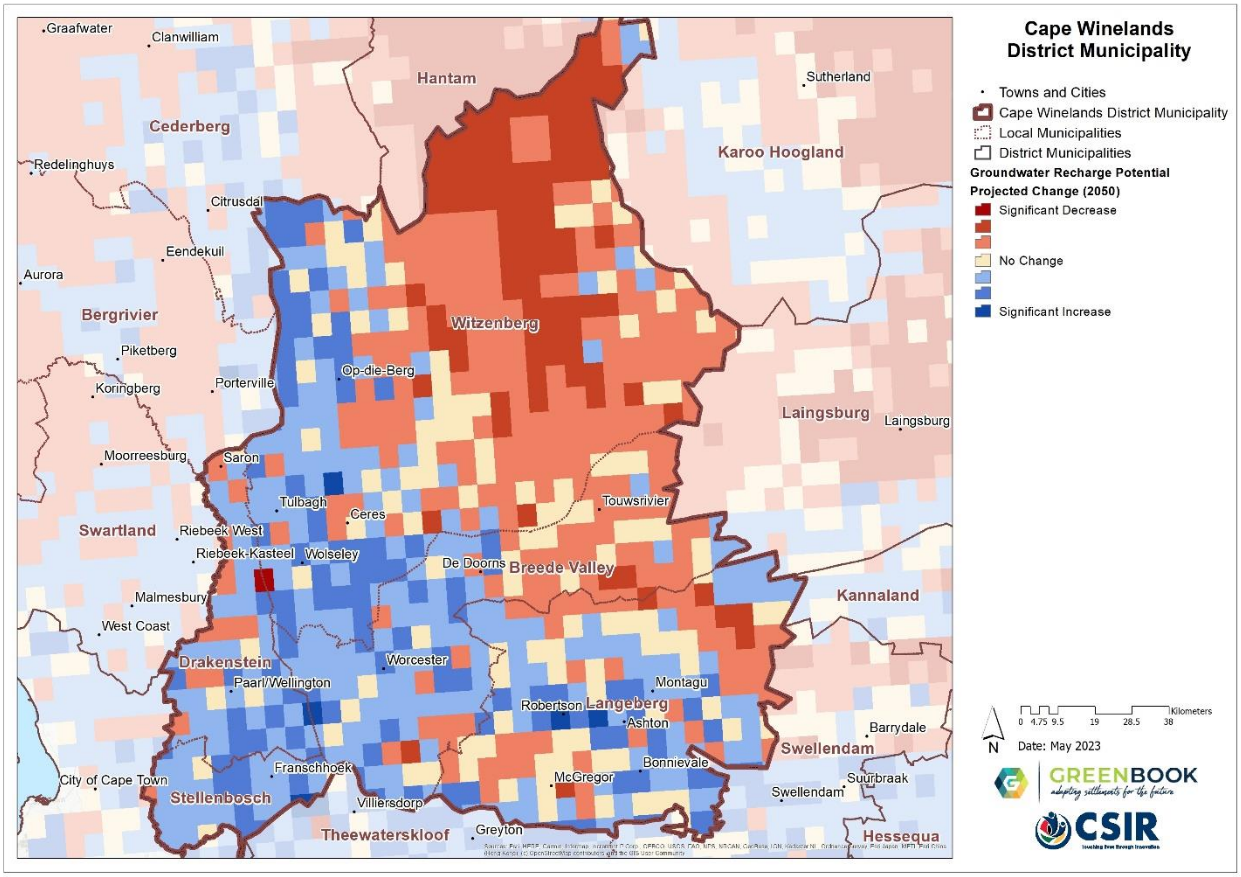

Figure 23: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across Cape Winelands District Municipality

Settlements in Stellenbosch LM have high risk of groundwater depletion (See Figure 24), considering expected pressure in terms of population growth. Other settlements that rely on groundwater that will face a medium risk to groundwater depletion include Wolseley, Tulbagh and Touwsrivier.

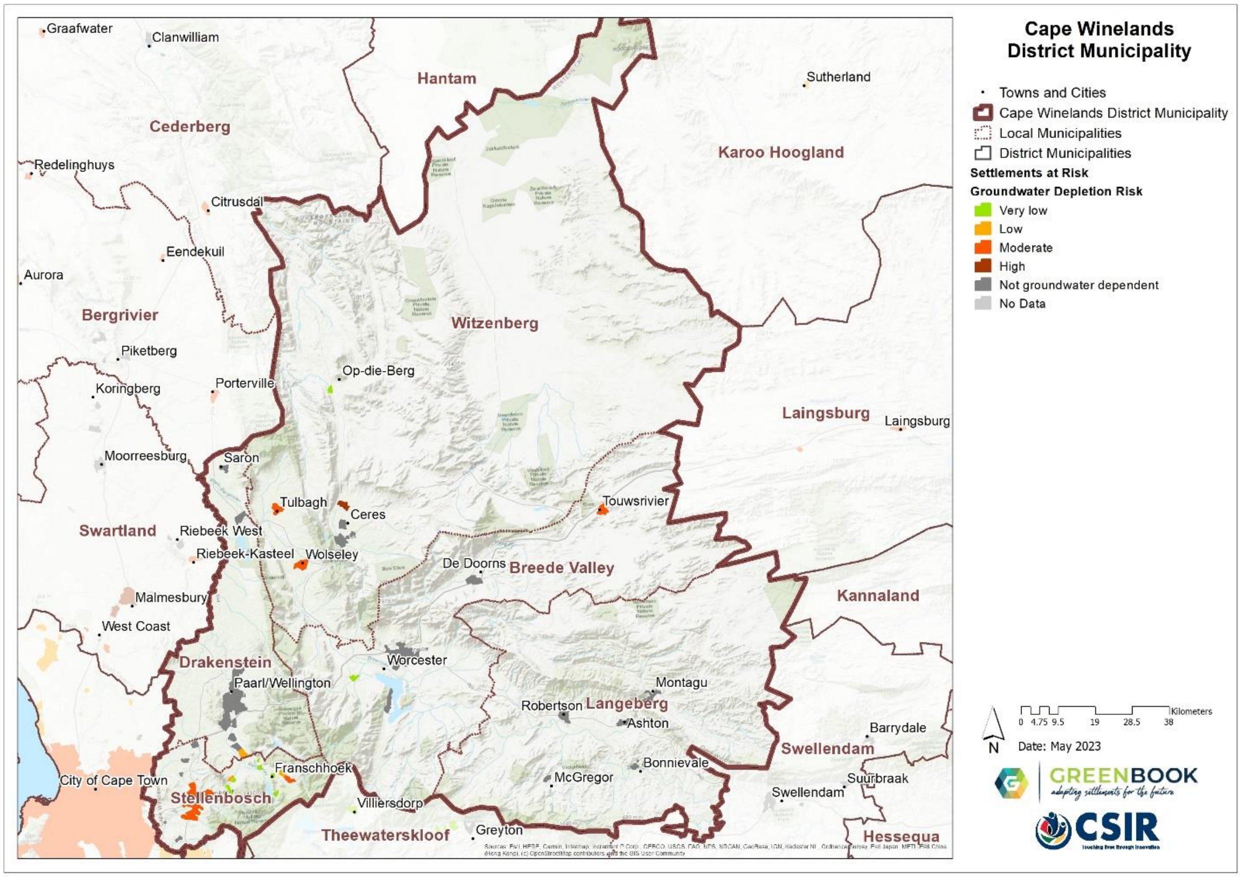

Figure 24: Groundwater depletion risk at settlement level across Cape Winelands District Municipality

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

Table 3: Current water supply and vulnerability across Cape Winelands District Municipality

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
Breede Valley	236.55	277.42	0.85
Drakenstein	174.36	268.19	0.65
Langeberg	185.42	341.06	0.54
Stellenbosch	190.63	226.15	0.84
Witzenberg	146.71	144.23	1.02

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

Breede Valley

Breede Valley LM water supply is currently higher than demand. Water supply vulnerability is however projected to increase into the future, because of the projected decline in rainfall, increase in temperature as well as expected population growth.

Drakenstein

Water supply vulnerability is currently relatively low in this LM, but because of a projected decline in mean annual runoff combined with very high population growth, water supply vulnerability will increase significantly.

Langeberg

Water supply vulnerability is low but is projected to increase into the future due to a mean annual runoff decline coupled with population growth.

Stellenbosch

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

Witzenberg

Water supply vulnerability is already high and is expected to significantly increase to 1.7 by 2050. Water supply vulnerability is driven by projected extreme population growth pressure, a decrease in average annual rainfall, increased evaporation, and a decrease in mean annual runoff.

2.4.2. Agriculture, forestry, and fisheries

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

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

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

The AFF sector contributes 10.17 % to the local GVA of the District (CoGTA, 2020). This is significantly higher than the agricultural sector's national average contribution of 2.50 % to GVA. Most of the District's contributions to the economy originate from the Witzenberg and Drakenstein LMs. Deciduous fruit (apricots, nectarines, pears and apples), table grapes, wine grapes and vegetables are the main commodities. The agricultural sector generates the second most employment opportunities (23 %) in the District. The potential impact of climate change and climate hazards on agriculture is notable considering the contribution this sector makes to support livelihoods of the local residents.

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

Breede Valley

In the Breede Valley LM, the AFF sector contributes 11.75 % to the local GVA, which is a contribution of 1.44 % to the national GVA for the AFF sector. Of the total employment, 25.73 % is within the AFF sector. The main agricultural commodities are wine grapes, wheat, stone fruit, pome fruit and broilers/egg layers. Climate projections show a generally hotter and drier climate, which could lead to reduced suitability for certain grape varieties. Warmer temperatures lead to reduction in available winter chill and increased summer heat stress, which can negatively affect quality of the grapes. Reduction in rainfall coupled with increased evapotranspiration will reduce water available for irrigation.

Drakenstein

In the Drakenstein LM, the AFF sector contributes 7.54 % to the local GVA, which is a contribution of 1.54 % to the national GVA for the AFF sector. Of the total employment, 17.80 % is within the AFF sector. The main agricultural commodities are wine and table grapes, broilers, egg layers, wheat and stone fruit. Climate projections show a generally hotter and drier climate which could lead to reduced suitability for certain grape varieties. Warmer temperatures lead to reduction in available winter chill and increased summer heat stress, which can negatively affect quality of grapes and stone fruit. Reduction in rainfall, coupled with increased evapotranspiration, will reduce water available for irrigation. For broilers, higher temperatures could increase production costs (and increased investment will be required in ventilation and cooling) to maintain optimal seasonal temperatures and reduce the risk of heat stress.

Langeberg

In the Langeberg LM, the AFF sector contributes 14.40% to the local GVA, which is a contribution of 0.94 % to the national GVA for the AFF sector. Of the total employment, 28.33 % is within the AFF sector. The main agricultural commodities are deciduous fruit, dried fruit, and milk and cream. Climate projections show a generally hotter and wetter climate, becoming drier into the future (at least up to 2050). Warmer temperatures lead to reduction in available winter chill, which affect the suitability of deciduous fruit production. Reduction in rainfall coupled with increased evapotranspiration will reduce water available for irrigation. Warmer temperatures can potentially increase heat stress in livestock which could negatively affect conception rates, milk yield and milk quality.

Stellenbosch

In the Stellenbosch LM, the AFF sector contributes 6.37 % to the local GVA, which is a contribution of 0.98 % to the national GVA for the AFF sector. Of the total employment, 14.78 % is within the AFF sector. The main agricultural activities are centred around wine making. Climate projections show a generally hotter and drier climate. Warmer temperatures will lead to reduction in available winter chill and increased summer heat stress. Insufficient winter chilling could result in uneven bud break. Warming can negatively affect quality of the grapes for winemaking.

Warmer and drier conditions will also lead to increased evapotranspiration and irrigation requirements. Reduced suitability for certain wine varieties.

Witzenberg

In the Witzenberg LM, the AFF sector contributes 16.44 % to the local GVA, which is a contribution of 1.38 % to the national GVA for the AFF sector. Of the total employment, 33.54 % is within the AFF sector. The Ceres area is the biggest apple and pear production area in the country and is a major exporter of these fruits. Climate projections show a generally hotter and drier climate. These climate conditions will contribute to a reduction in available winter chill and increased summer heat stress. High temperatures cause sunburn damage and reduce fruit quality while also increasing evapotranspiration and irrigation requirements. Hailstorms is a major hazard for pome fruit and have caused huge damage and a decline in export figures for the 2023 season.

3. Recommendations

The greatest risks faced across the Cape Winelands District are drought, increased temperatures, and more severe storms combined with population growth pressure, especially in the Stellenbosch and Ceres areas. The Stellenbosch LM already has the highest population density of 232 people/km^2. The towns that are seeing significant population growth are already experiencing service access pressure, and larger groups of people will become vulnerable and exposed to climate-related hazards.

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

The predictions for more frequent droughts pose a risk for water availability, especially in light of future population growth pressure. Agricultural activities in the District depend greatly on irrigation for production, and water availability for crop irrigation as well as human consumption will become more restricted. More than one-third (40%) of the Western Cape's agricultural exports emanate from the District, thus making the agricultural sector especially vulnerable to climate change.

Although annual rainfall is predicted to decrease, certain parts of the District could experience more extreme rainfall events after droughts. Increase in intensity of rainfall and flooding could lead to increased surface runoff, resulting in increased soil erosion, soil loss and degradation, as well as infrastructure damage especially in informal settlements.

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

1. To ensure water security for human consumption and irrigation under a changing climate: Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. Moreover, the projected increases in average temperatures, drought tendencies and population growth, are likely to result in adverse consequences that make it necessary for the District to take action to ensure water security for consumption and irrigation purposes in the face of climate change. Some of the actions that the District could take include prioritising infrastructure maintenance; investing in efficient water supply infrastructure to meet future demand; promoting water conservation practices by implementing strategies such as public awareness campaigns, leak detection and repairs, water metering and billing; as well as exploring measures to secure alternative water sources such as rainwater (harvesting), groundwater (recharge and extraction) and wastewater (reuse).

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

3. To increase resilience of the agricultural sector to more extreme events such as drought and storms as well as indirect risks such as pests and diseases: The District's agricultural sector contributes significantly to the livelihoods of local residents, as well as the District's and the province's economies. As previously mentioned, the agricultural sector generates the second most employment opportunities (23 %) in the District, while more than 40% of the Western Cape Province's agricultural exports emanate from the CWDM. And because agriculture is arguably one of the most vulnerable sectors to the impacts of climate change, at least in South Africa, it is essential to increase its resilience to these anticipated changes, and their impacts. This can be done by providing farmers with access to (i) resilient crop varieties and efficient irrigation systems; (ii) training in sustainable farming techniques; (iii) financial risk management tools; and (iv) market opportunities, i.e., to help the agricultural sector withstand shocks and stresses such as climate change impacts, market fluctuations, and pests.

4. To increase the adaptive capacity of human settlements to climate change and extreme events: To reduce the vulnerability of human settlements to climate-related hazards and extreme events, it is essential to increase their capacity to adapt to such impacts and events. The District could increase the adaptive capacity of settlements by adopting design standards and practices that take into account future climate change impacts, to ensure that Cape Wineland's urban/settlement fabric is resilient to the anticipated climate conditions and extreme events (e.g., climate proofing infrastructure and buildings).

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

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