Overberg District Municipality

Climate Risk Profile Report based on the GreenBook

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Acronyms

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

Glossary of Terms

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

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

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

1. Introduction

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

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

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

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

1.1. Approach followed

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

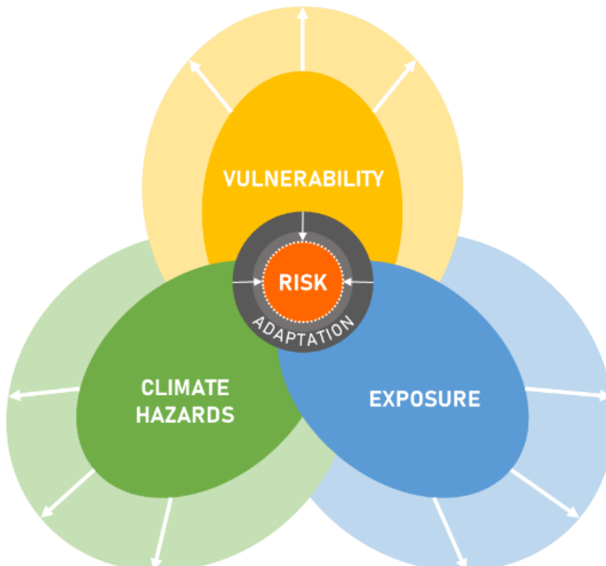

Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

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

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

1.2. Policy framework

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

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

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

On a provincial level, in March 2023 the Western Cape Province published their Climate Change Response Strategy (WC 2023). The Strategy is envisaged as a transversal strategy providing policy direction in response to climate-related risks and potential opportunities, through either creating or leveraging systemic innovative response programmes that tackle the region's vulnerability to droughts, heat and floods and take advantage of opportunities that will enable climate resilient development which fosters economic growth that is low-carbon and further creates an advanced Green Economy. On a district level, in 2017, the Overberg DM published their Climate Change Response Framework (ODM, 2017).

1.3. District Municipal context

The Overberg district municipality is located in the Western Cape Province at the southern-most tip of South Africa. It comprises the local municipalities of Theewaterskloof, Overstrand, Cape Agulhas and Swellendam. Its total area is 12 240.8 km^2, and, based on the 2022 Census (StatsSA, 2022), Overberg District has a total population of 359 446. Within this population, young children (0-14 years) make up 25.1% of the total population (Figure 2). The working-age population (15-64 years) accounts for 67.7%, while the elderly (65+ years) constitute 7.2%. The district's dependency ratio is reported at 44,3 with a sex ratio of 97,0. Education indicators reveal that 2,9% of individuals aged 20 and above have no formal schooling, while 13,6% have attained higher education qualifications. With regards to housing, the district hosts 134 798 households, with an average household size of 2,7. Formal dwellings dominate the housing landscape, representing 87,5% of the housing stock. Sanitation and waste management services are accessible, with 93,8% of formal dwellings equipped with flushing toilets connected to sewerage, and 84,9% receiving weekly refuse disposal services. Moreover, 84,6% of households enjoy access to piped water within their dwellings, while 95,6% have electricity for lighting (StatsSA 2022).

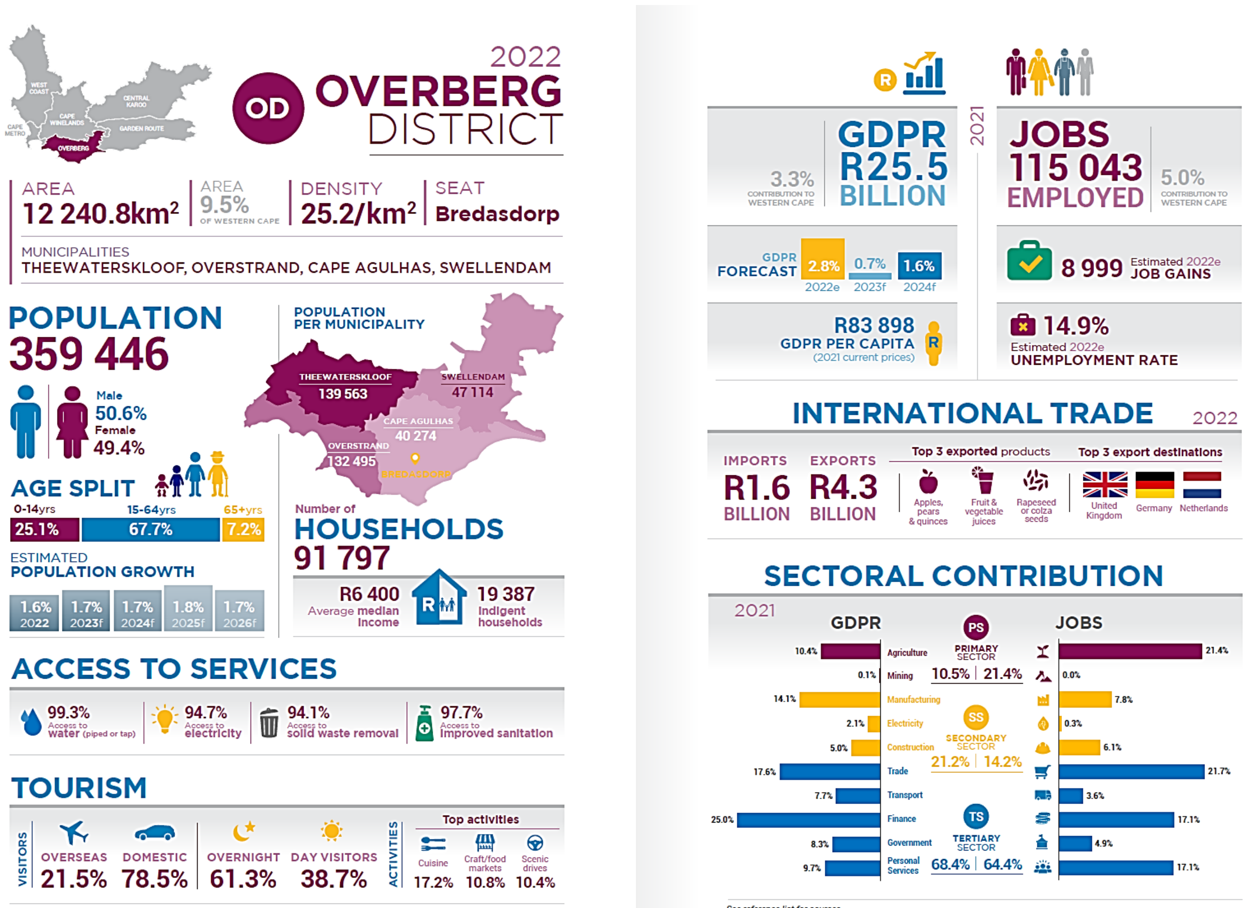

Figure 2: Infographic on key social and economic parameters of the Overberg DM (Source: Western Cape Government, 2023).

The Overberg has rugged mountain ranges, fynbos, rolling wheat and canola fields, and splendid coastal vistas. The Overberg is a region that stretches along coasts with beautiful beaches, and over mountain ranges with interesting geological formations, abundant birdlife and fynbos. The Overberg has always been considered as the breadbasket of the Cape and is largely given to grain farming, mainly wheat. The wheat fields are a major breeding ground for South Africa's national bird, the blue crane. Another important food farmed in the Overberg is fruit, with Grabouw being the second largest supplier of fruit in South Africa. Nestled in the Overberg, one can find the Kogelberg Biosphere Reserve (recognised and registered with UNESCO) populated with a large diversity of flowering plants not found anywhere else in the fynbos biome. The landscape is dominated by gently to moderately undulating hills enclosed by mountains and the ocean (COGTA 2020).

Most of the District is covered by the Fynbos Biome. The Fynbos Biome is part of the Cape Floristic Kingdom (one of six recognised floral kingdoms globally) which is a global biodiversity hotspot. The Overberg District has an about 300 km long coastline which includes the southernmost point of South Africa, Cape Agulhas. Most of Overstrand LM's settlements are located on its about 160 km long coastline. The LM's economy depends to a high degree on coastal tourism and natural coastal resources, and its coastal settlements are under high to extreme development pressure. In contrast, Cape Agulhas LM's coastline is more than 130 km long, with its few coastal settlements depending on tourism and fisheries. Swellendam LM's coastline is about 10 km long and harbours only few scattered residential or holiday properties.

In 2019, the economic sectors that contributed the most to employment in the Overberg DM were the trade sector with 25.9%. The finance sector with 18.7% employed the second highest number of people relative to the rest of the sectors. Agriculture, forestry and fisheries contribute 10.4%. The mining sector is the sector that employs the least number of people in Overberg District Municipality (0.1%), followed by the electricity sector (0.4%).

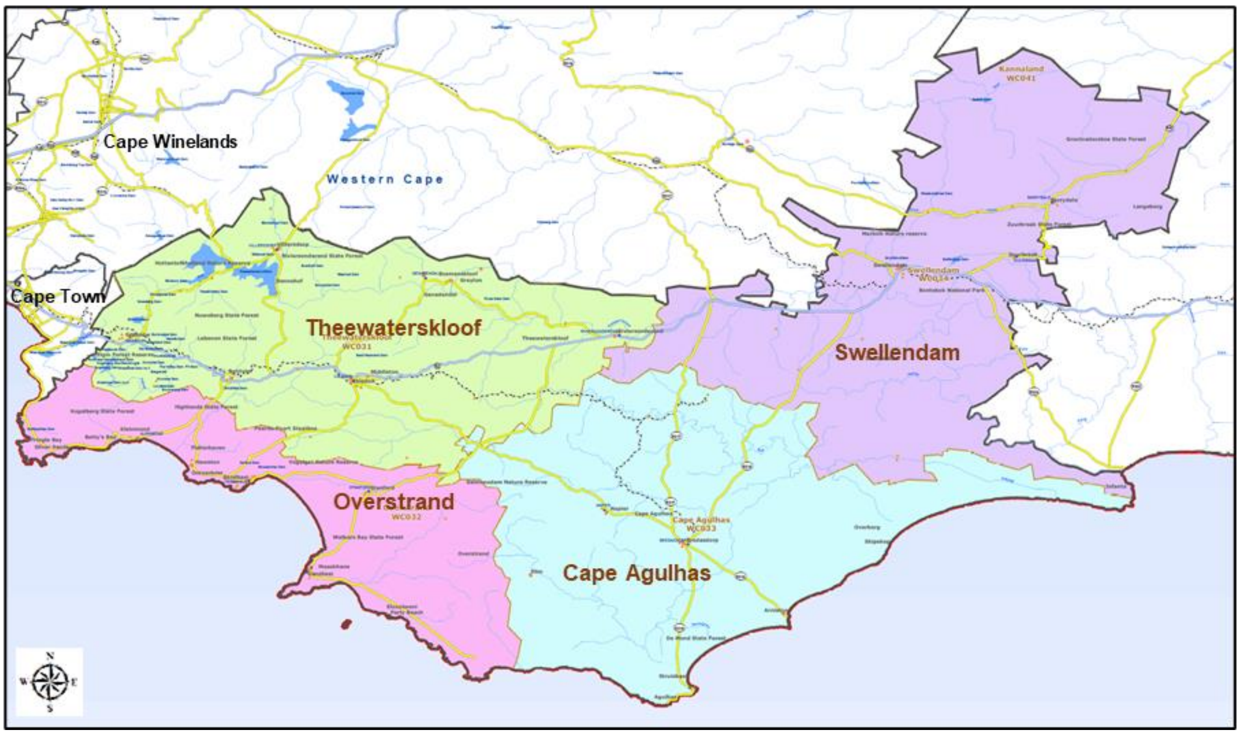

Figure 3: Overberg District Municipality (Municipal Demarcation Board, 2022), with Local Municipalities shaded in different colours

According to COGTA (2020), the tertiary sector contributes the most to the Gross Value Added (GVA) within the Overberg District Municipality at 56.8% in 2019. This is significantly lower than the national economy (68.7%). The secondary sector contributed a total of 28.5% (ranking second), while the primary sector contributed the least at 14.7%.

The community services sector is the largest within Overberg District Municipality accounting for R 4.19 billion or 18.2% of the total GVA in the district municipality's economy in 2019. The community sector, which includes the government services, is generally a large contributor towards GVA in smaller and more rural local municipalities. The sector that contributes the second most to the GVA of the Overberg District Municipality is the trade sector at 16.6%. The finance and transport sectors contributed 13% and 8% respectively in 2018.

On local level, the Theewaterskloof LM made the largest contribution to the community services sector at 42.03% of the district municipality. As a whole, the Theewaterskloof Local Municipality contributed R 9.51 billion or 41.41% to the GVA of the Overberg District Municipality, making it the largest contributor to the overall GVA of the Overberg District Municipality (COGTA 2020).

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 Overberg 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 Overberg 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 the Overberg 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 Overberg 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 the Overberg District Municipality for 1996 t0 2011

LOCAL MUNICIPALITY	SEVI 1996	SEVI 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
Theewaterskloof	3.2	2.8	↘	4.5	3.3	↘	5.6	N/A	6.2	N/A
Overstrand	1.7	1.5	↘	2.3	4.1	↗	6.4	N/A	5.3	N/A
Cape Agulhas	1.7	1.4	↘	2.7	1.0	↘	6.0	N/A	4.3	N/A
Swellendam	2.6	1.7	↘	3.6	1.0	↘	5.6	N/A	5.1	N/A

All four local municipalities in the Overberg has very low socio-economic vulnerability index values, in national comparison, and continued to improve between 1996 and 2011. However, given the generally very strong Western Cape Province, the socio-economic vulnerability of 2.8 ranks Theewaterskloof 4th most vulnerable out of 25 local municipalities in the Province, while Cape Agulhas ranks 6th least vulnerable.

As for economic vulnerability, Cape Agulhas and Swellendam rank the least and second least vulnerable LMs in the province and country. Overstrand's economic vulnerability, however, increased significantly between 1996 and 2011 (and is likely to increase further), due to the high in-migration of people from other provinces, putting pressure on infrastructure and service delivery and increasing unemployment rates.

The relative remoteness of the district and its coastal location lead to physical vulnerability above the national average of 5.0 in all four LMs. Overstrand and Cape Agulhas physical vulnerability are the 3rd and 5th highest in the province. As for environmental vulnerability, Theewaterskloof is the 6th most vulnerable LM in the province, while Capa Agulhas, given its large extent and low population ranks 7th least vulnerable in the province.

2.1.2. Settlement vulnerability

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

Figure 4 gives an overview of the vulnerability indices for all settlements in Overberg's local municipalities. For each vulnerability component, a ranking of 5 indicates the national average, while rankings towards 10 indicate extreme vulnerability. Least vulnerable settlements would have their coloured ranking polygons being very small. Settlement-level vulnerability is assessed within the context of a specific local municipality, comparing vulnerabilities among the settlements within that municipality rather than with settlements outside of it.

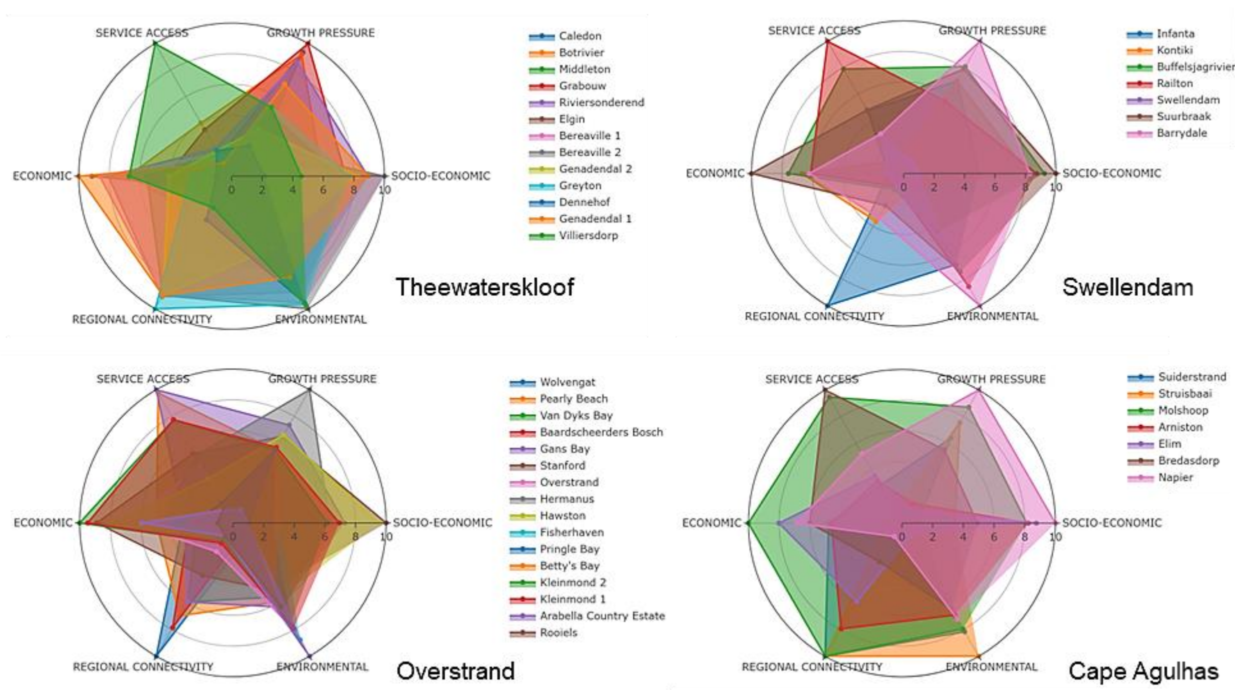

Figure 4: Settlement vulnerability Indicators for settlements in the four LMs in the Overberg DM

The diagrams show that Theewaterskloof and Overstrand inhabit the highest number of settlements in the district. Further, each of the 44 settlements in the district displays its own individual vulnerability profile. For instance, in Theewaterskloof Grabouw faces the highest growth pressure, while Greyton faces the highest regional connectivity vulnerability, as well as very high environmental vulnerability. In Overstrand, Hawston has the highest socio-economic vulnerability while Van Dyks Bay has the highest economic vulnerability. In Cape Agulhas, Napier has both the greatest growth pressure and socio-economic vulnerability, while it is well connected and serviced.

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 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 the Overberg District Municipality

Population per LM	2011	2022	High Growth Scenario		% Growth 2011-2050
			2030	2050	
Theewaterskloof	108 830	139 563	131 877	138 296	27
Overstrand	80 363	132 495	137 057	212 973	165
Cape Agulhas	33 051	40 274	42 256	47 534	44
Swellendam	35 905	47 114	48 425	58 362	63
Overberg DM Total	258 149	359 446	359 620	457 167	101

The 2022 Census shows that the district has already reached the projected population numbers for the medium growth scenario. Table 2 captures the projections under a high growth scenario. The districts total population is expected to grow by 101% under the high growth scenario between 2011 and 2050. Especially in the Overstrand the explosive population growth by 165% will put an enormous pressure on infrastructure, service delivery and the natural environment and resources. Figure 4 depicts the growth pressures that the settlements across the district are likely to experience. Settlements with the highest growth pressure here are Hermanus, Gans Bay, Hawston and Stanford.

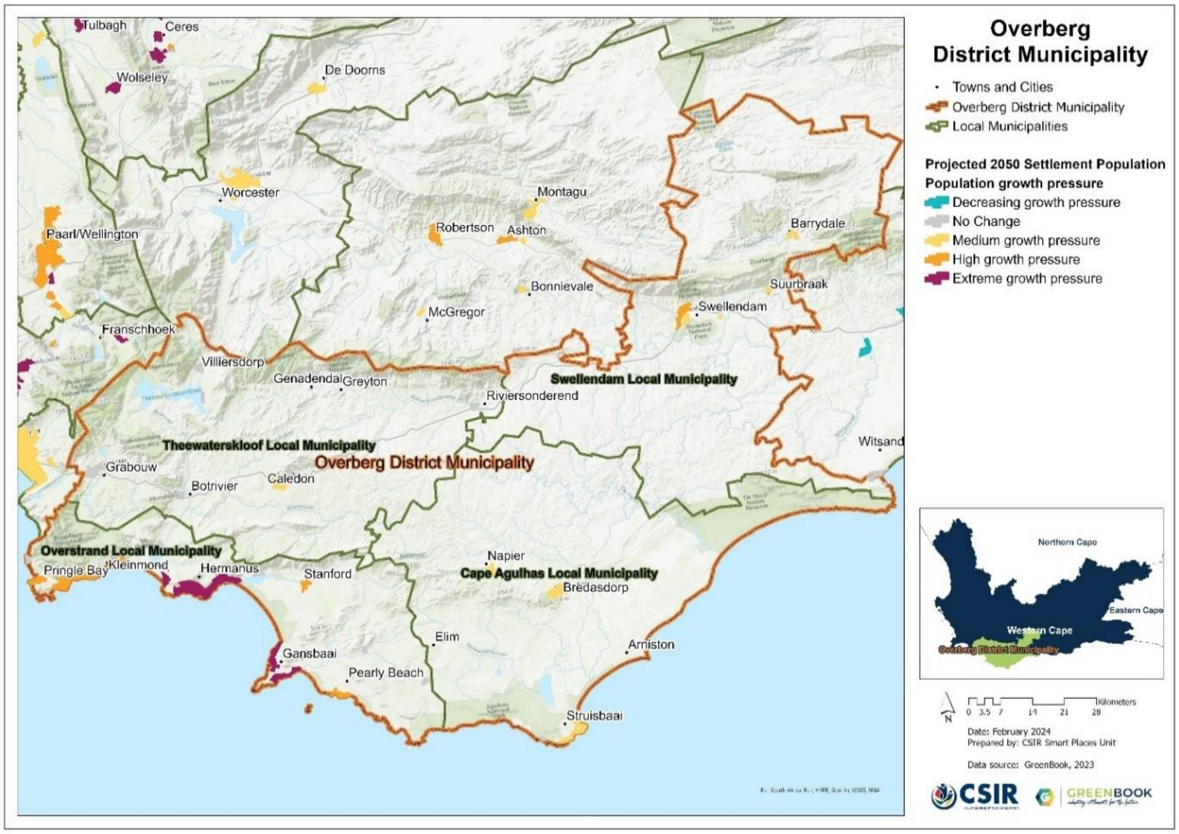

Figure 5: Settlement-level population growth pressure across the Overberg District Municipality

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. According to these data, between 1961-1990 the average annual temperature for most of the Theewaterskloof LM, Overstrand and the northern part of the Swellendam LM was about 16°C, with the eastern parts of the DM with an average of 18°C slightly warmer and the Villiersdorp-Genadendal area and the northern Swellendam LM with 14°C slightly cooler (Figure 6). Assuming a "worst-case" climate future, i.e. RCP8.5, for most of the district average annual temperatures are expected to be about 2°C higher for most of the district, with an average temperature increase of 2.5°C for the northern area of the Swellendam LM, the central area of Overstrand and the western part of Theewaterskloof (Figure 7).

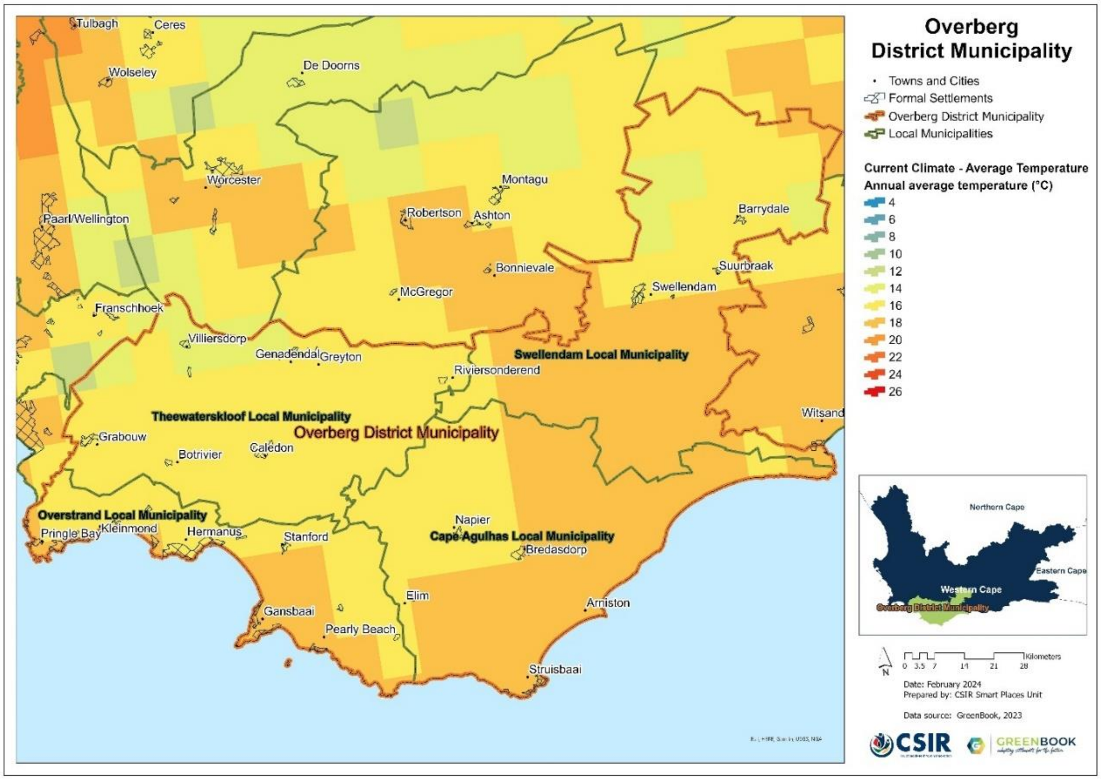

Figure 6: Average annual temperature (°C) for the baseline period 1961-1990 for the Overberg District Municipality

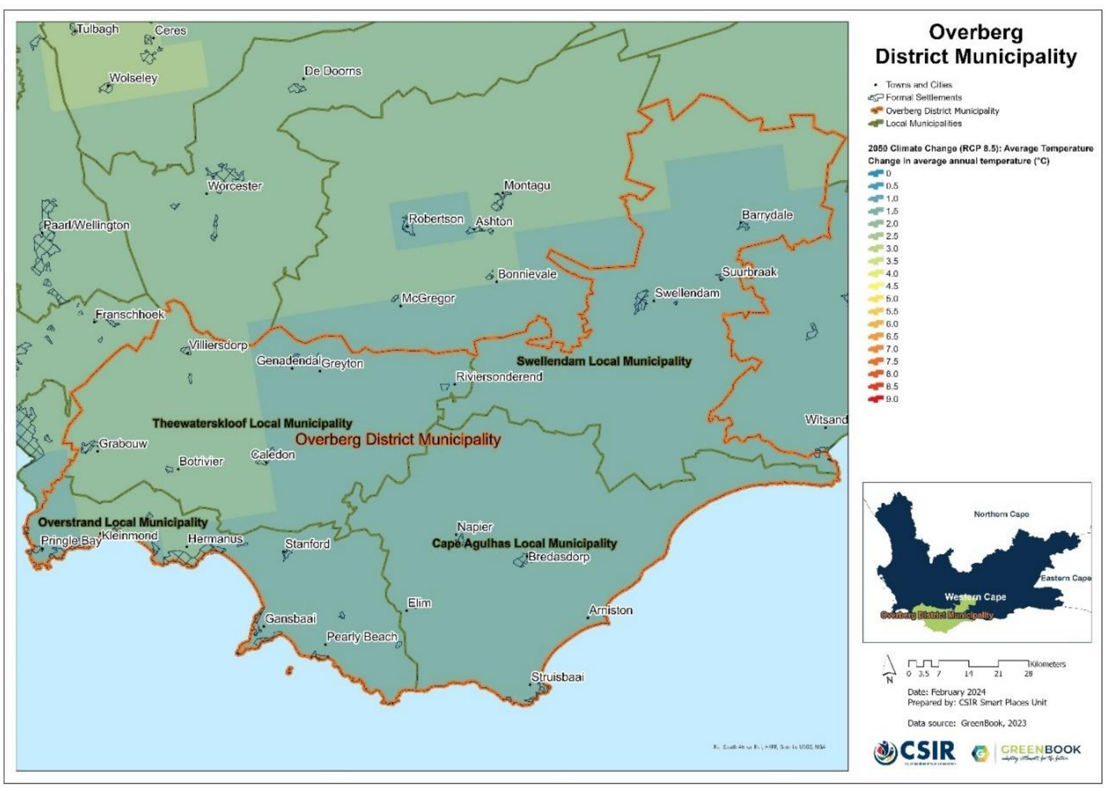

Figure 7: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for the Overberg District Municipality, assuming an RCP 8.5 emissions pathway

2.2.2. Rainfall

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

According to the data, the average annual rainfall received in most of the DM until 1990 ranged between 400-800 mm, more rain of 800-1000mm in the mountainous areas and 300-400mm in some of the inland areas (Figure 8). Assuming an RCP8.5 scenario, only a slight decrease of <100mm is expected for most of the Overberg district until 2050, with a tendency of a slight increase of annual rainfall (<100mm) towards the east and a potential decrease of up to 200mm towards the west (Figure 9).

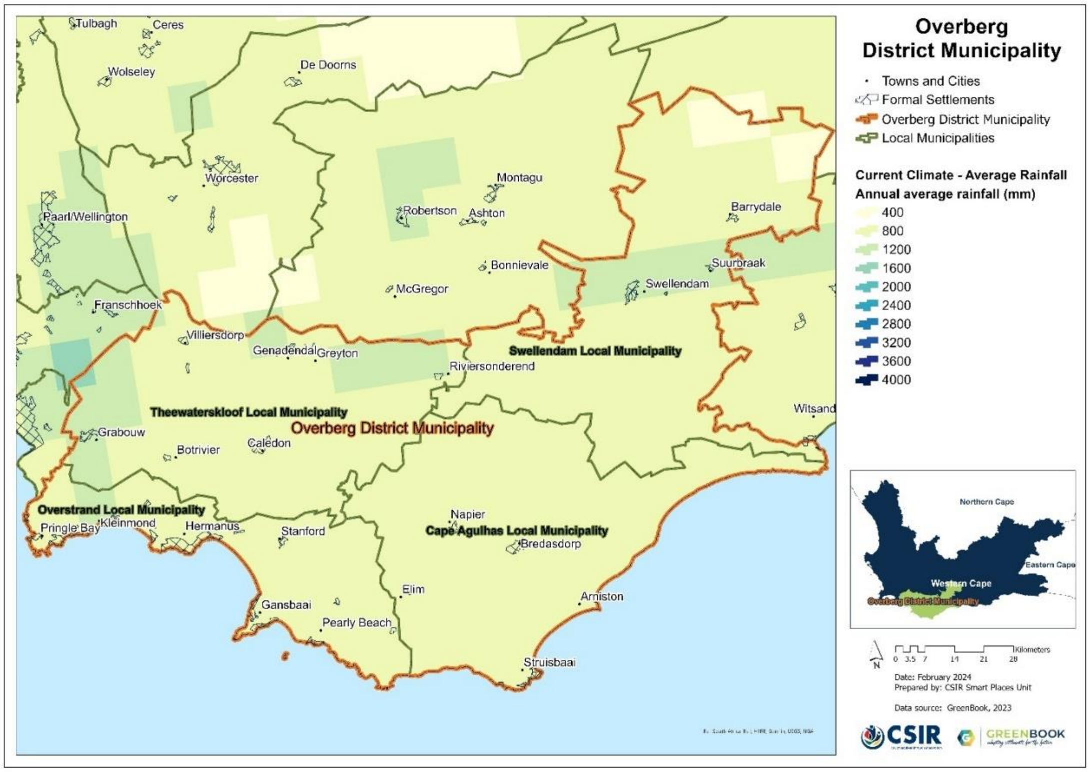

Figure 8: Average annual rainfall (mm) for the baseline period 1961-1990 for the Overberg District Municipality

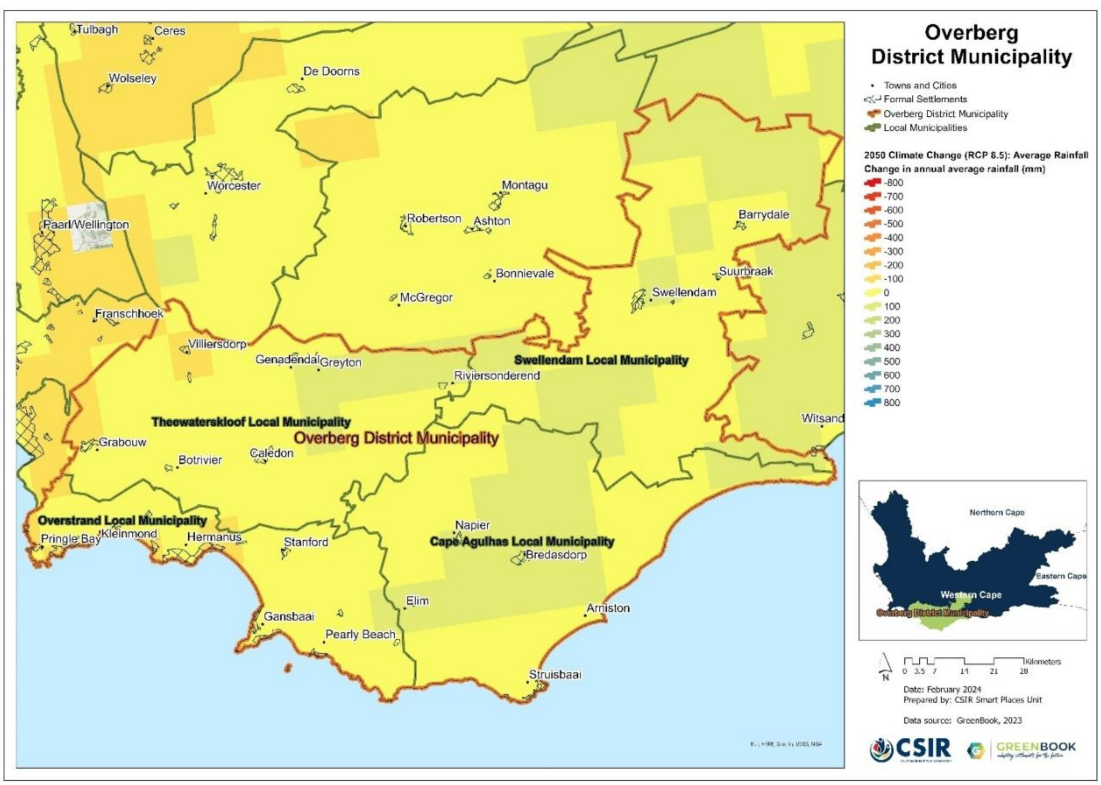

Figure 9: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for the Overberg District Municipality, assuming an RCP8.5 emission pathway

2.3. Climate Hazards

This section showcases information with regards to the Overberg 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. According to the data, the Overberg DM experienced some increase in drought tendencies (i.e., the number of cases exceeding near-normal per decade) between 1995 and 2024 relative to the 1986-2005 baseline period, under an RCP 8.5 "business as usual" emissions scenario (RCP 8.5).

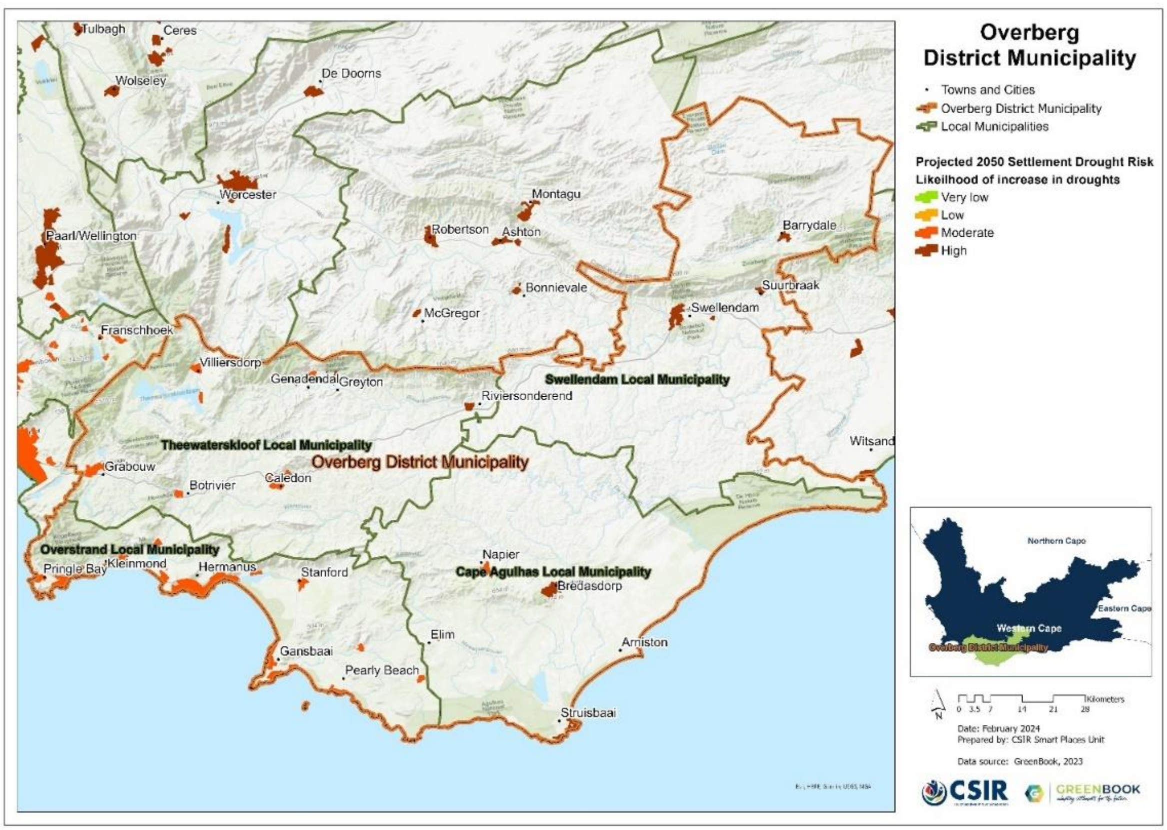

Figure 10: Settlement-level drought risk for the Overberg District Municipality

The Western Cape has seen numerous drought events in the past and the 2015-2017 drought has been, in part, attributed to climate change although natural variability remains high (Western Cape Province, 2023). It is expected that during the period 2015–2044 relative to the 1986–2005 baseline period, under the low mitigation "business as usual" emissions scenario (RCP 8.5) the tendency for droughts will further increase, particularly for the Swellendam LM. On a settlement level, Theewaterskloof and Overstrand settlements are at moderate risk of increase in drought tendencies while most Cape Agulhas and Swellendam settlements are at high risk of drought tendencies (Figure 10).

2.3.2. Heat

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

The GCMs were used to simulate bias-corrected, annual average number of very hot days, defined as days when the maximum temperature exceeds 35°C per GCM grid point for the baseline (current) period of 1961–1990 (Figure 11), and for the projected changes for period 2021–2050 (11). According to these data, currently most of the Overberg DM experience 0-10 very hots days per year, with some central region experiencing 11-20 very hot days. In 2050, the DM will see up to 10 more very hot days per year (Figure 12).

The annual heatwave days map under baseline conditions (Figure 13) depicts the number of days (per 8x8 km grid point) where the maximum temperature exceeds the average maximum temperature of the warmest month of the year at that location by at least 5°C for a period of at least three consecutive days. The projected change in the number of days belonging to a heatwave for the period 2021–2050 (Figure 14), assuming a "business as usual" (RCP 8.5) emissions pathway is also shown.

Under baseline conditions, Overberg's coastal zone is currently experiencing zero to one heatwave days per year, ranging to 6 heatwave days per year in the northern parts of the DM (Figure 13). For most of the DM, only a slight increase in heatwave days (<4 days) is expected for 2050 (Figure 14).

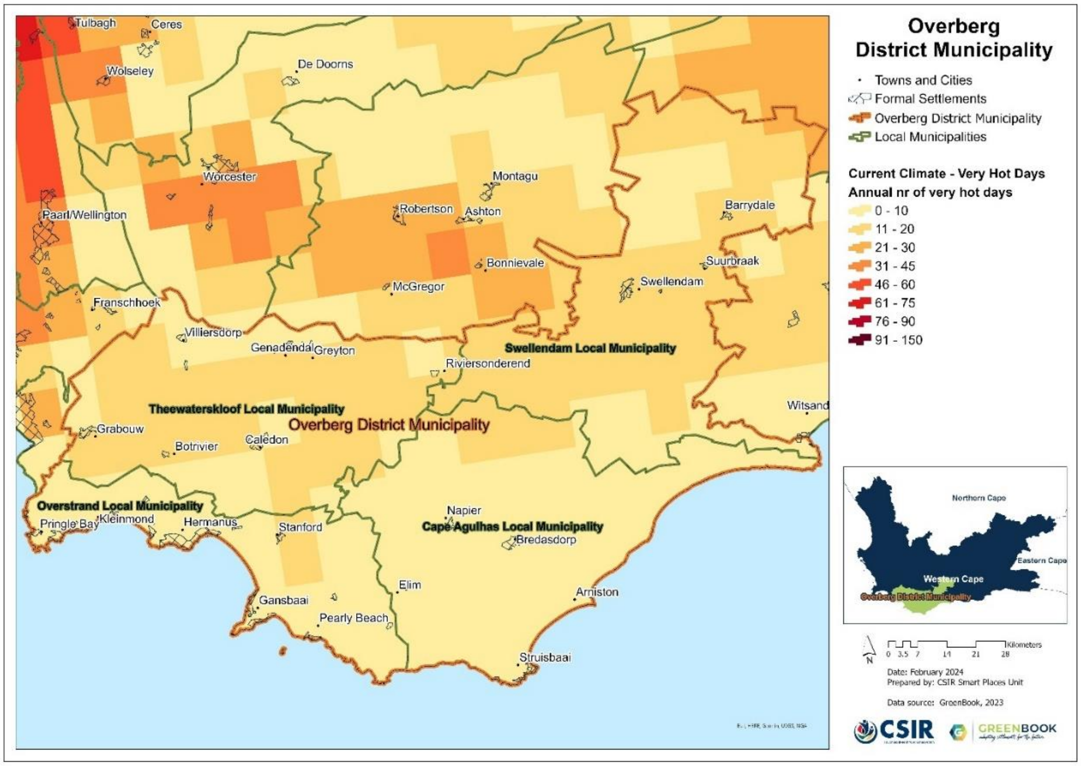

Figure 11: Annual number of very hot days under baseline climatic conditions across the Overberg District Municipality with daily temperature maxima exceeding 35°C

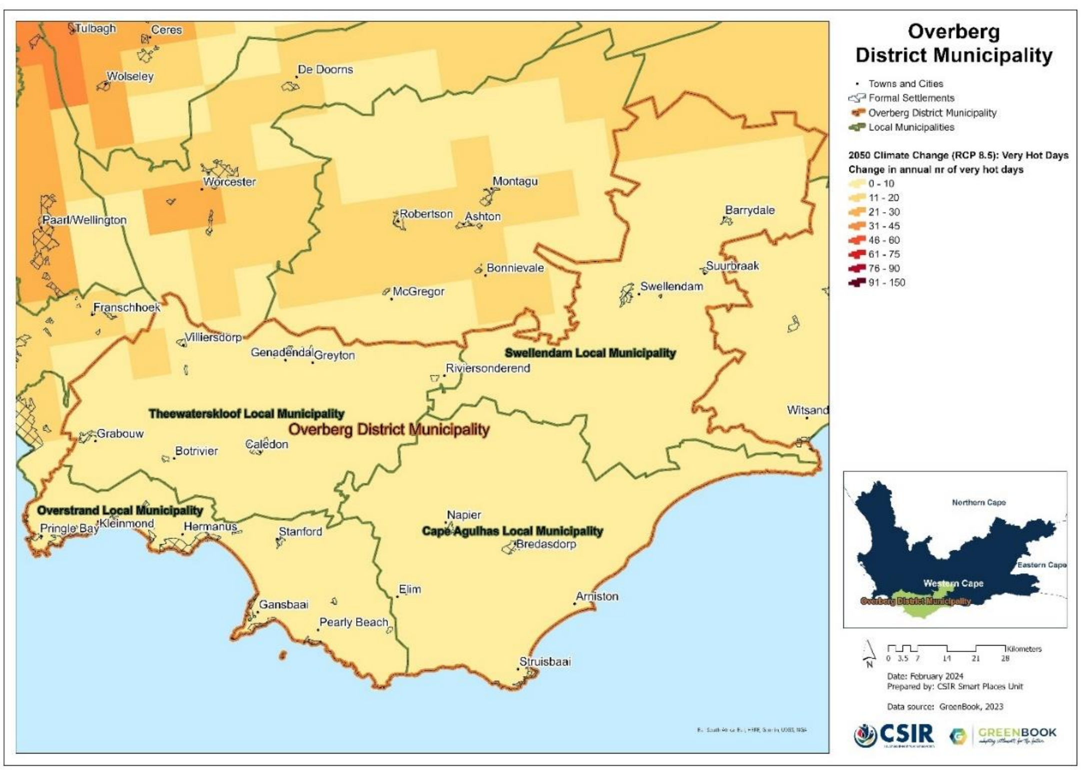

Figure 12: Projected change in annual number of very hot days across the Overberg District Municipality with daily temperature maxima exceeding 35°C, assuming and RCP 8.5 emissions pathway

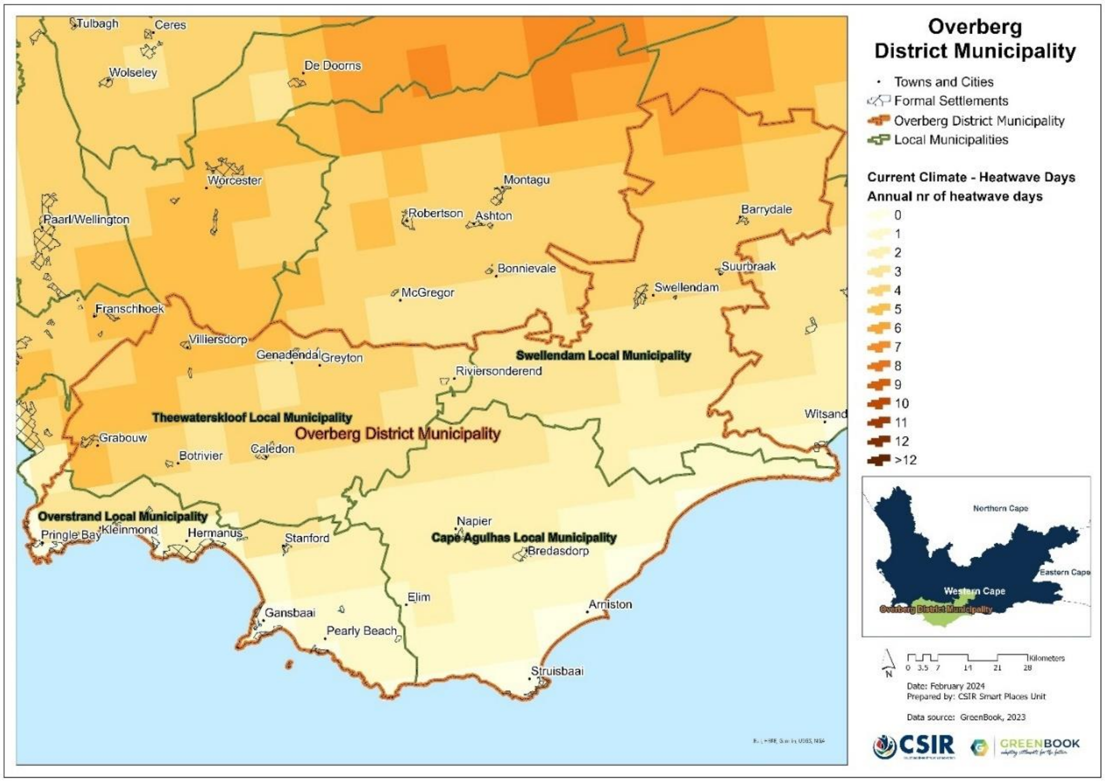

Figure 13: Number of heatwave days under baseline climatic conditions across the Overberg District Municipality

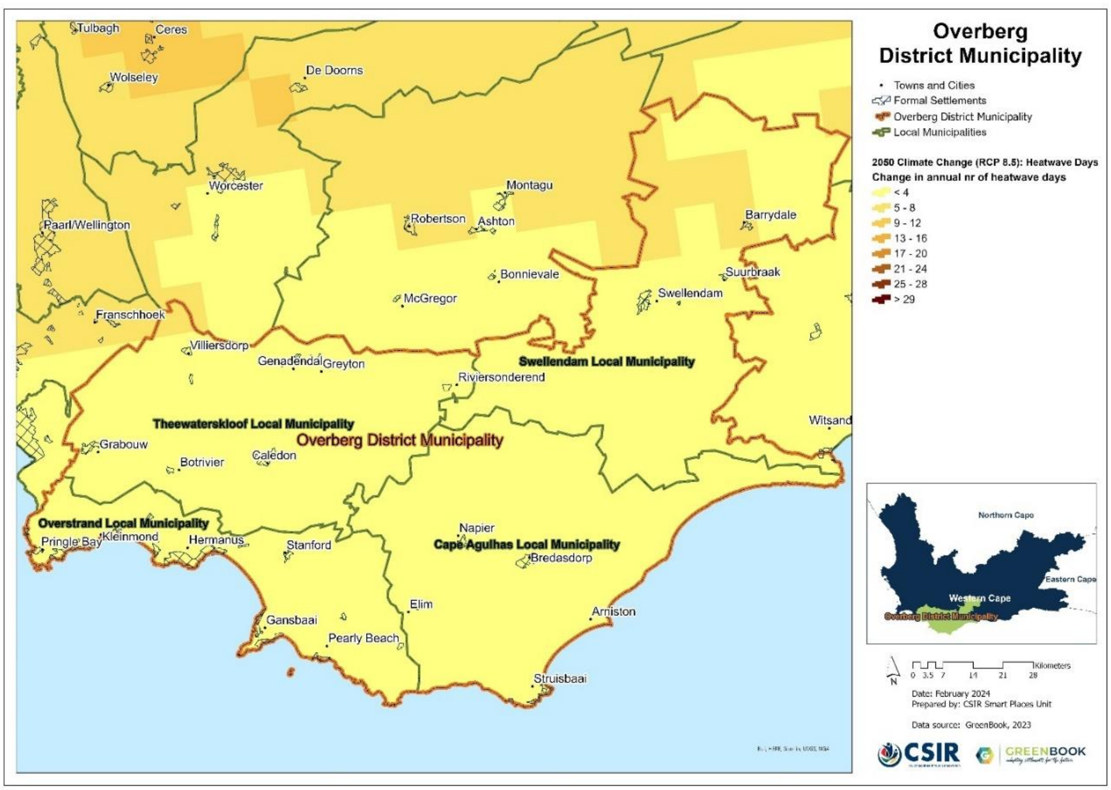

Figure 14: Projected change in annual number of heatwave days across the Overberg District Municipality, assuming an (RCP 8.5) emissions pathway

Figure 15 depicts the settlements that are at risk of increases in heat stress. Although average annual temperature is increasing over the district (Figure 7), in national comparison, given the altogether very low number of very hot days and heatwave days, the heat risk likelihood for all settlements in Overberg is very low.

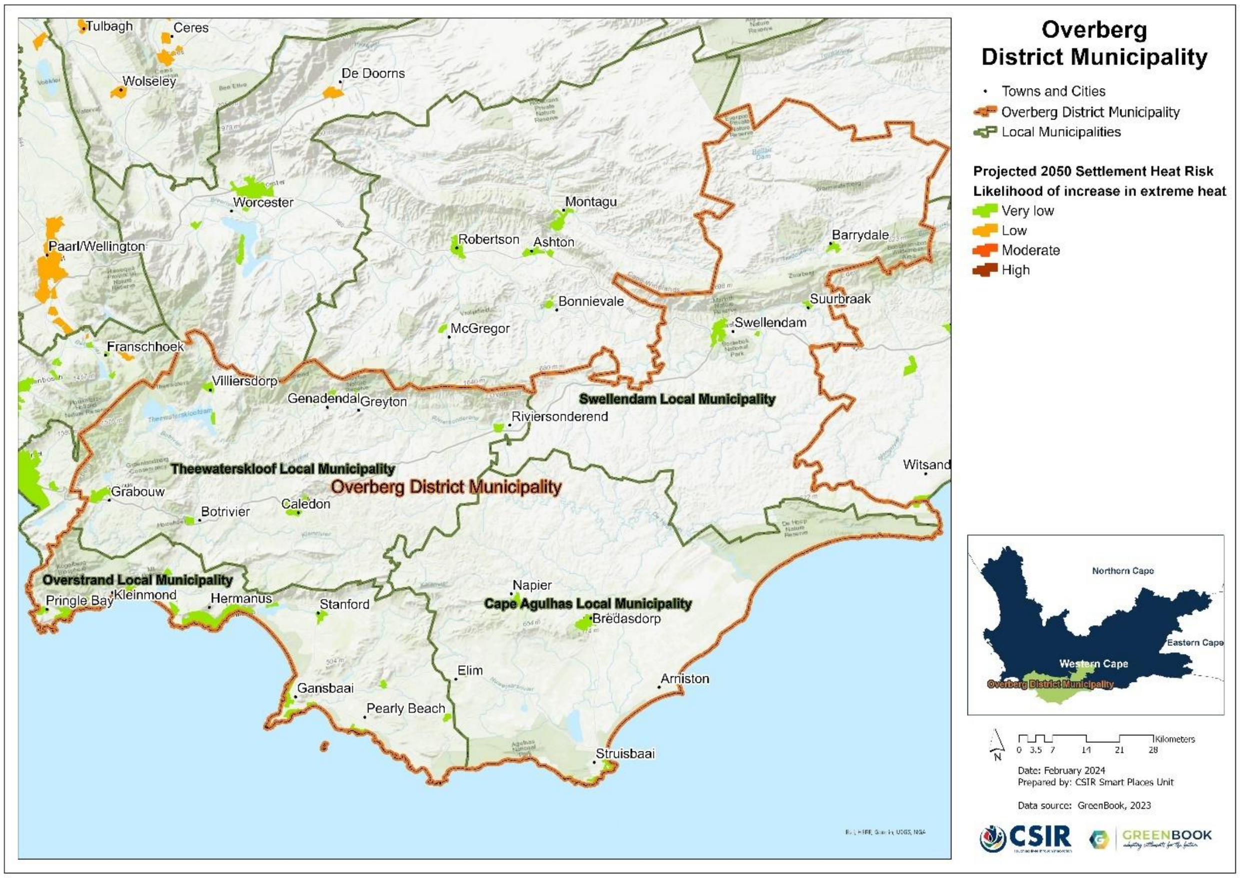

Figure 15: Settlement-level heat risk across the Overberg District Municipality

2.3.3. Wildfire

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

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

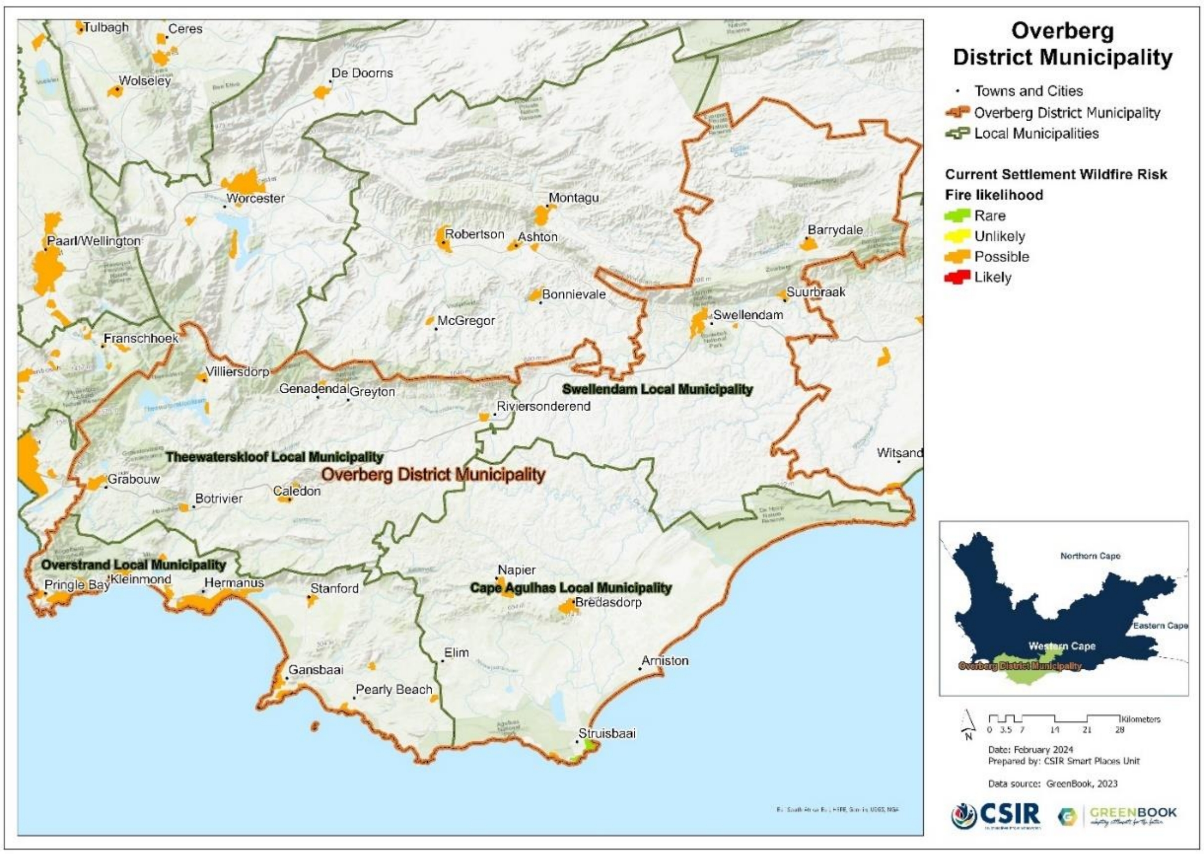

Figure 16 The likelihood of wildfires under current climatic conditions across settlements in the Overberg District Municipality

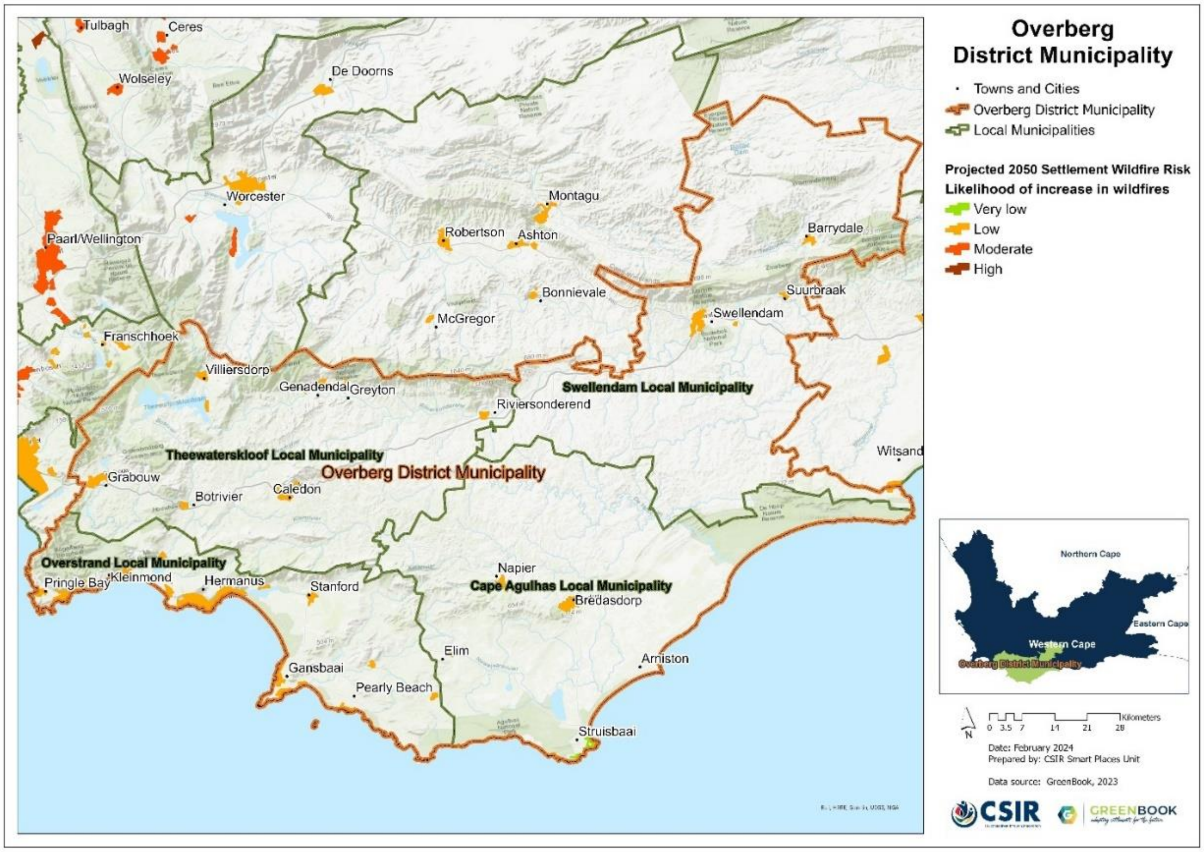

Figure 17: The likelihood of wildfires under projected future climatic conditions across settlements in the Overberg District Municipality

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

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.

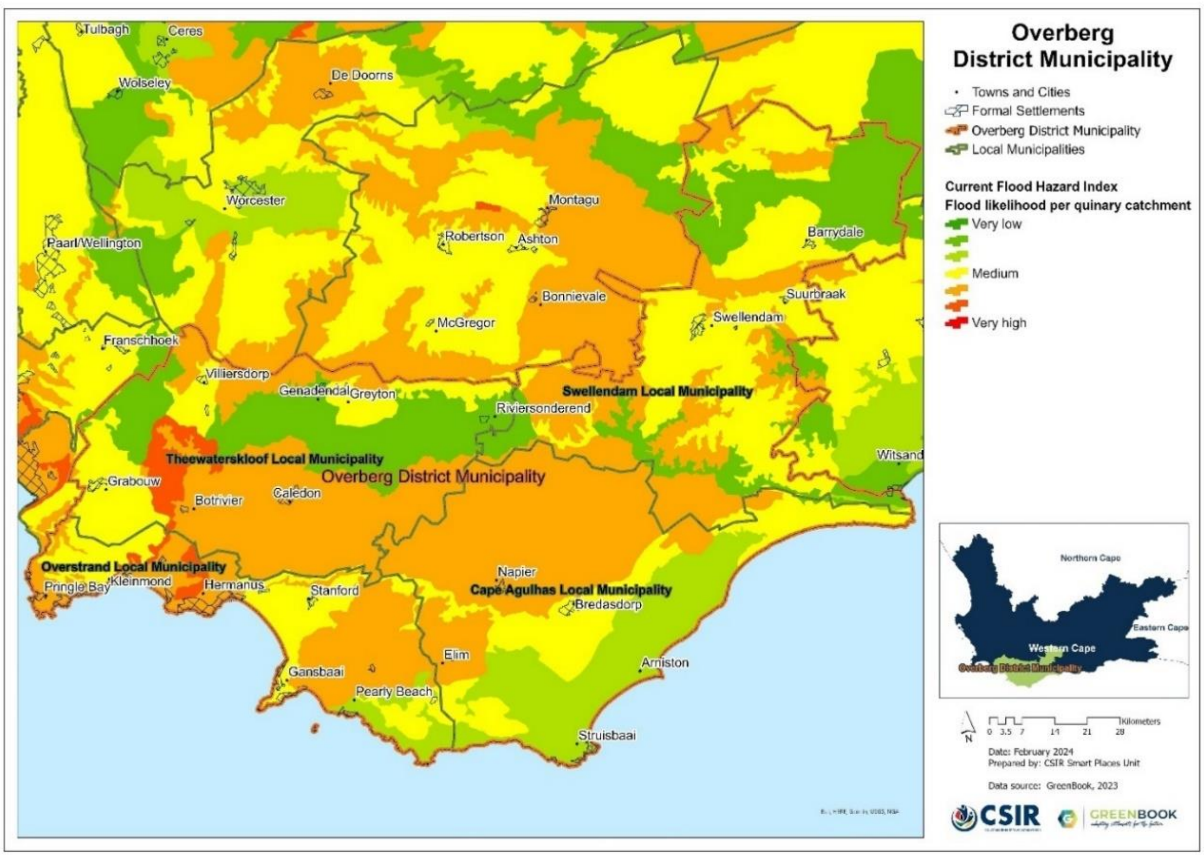

Figure 18: The current flood hazard index across the Overberg District Municipality under current (baseline) climatic conditions

Figure 18 depicts the flood hazard index of the individual Quinary catchments present or intersecting with the district. The flood hazard index is based on the catchment characteristics and design rainfall, averaged at the Quinary catchment level. Green indicates a low flooding hazard, while red indicates a high flood hazard. There is significant variation of the flood hazard index across the district, ranging from high over wide inland area to very low in some drier inland catchments and very high in some mountainous areas in the western Overstrand and Theewaterskloof LMs. Figure 19 depicts the projected change into the future in extreme rainfall days for an 8 x 8 km grid. This was calculated by assessing the degree of change when projected future rainfall extremes (e.g., 95th percentile of daily rainfall) are compared with those under the current rainfall extremes. A value of more than 1 indicates an increase in extreme daily rainfalls. Most of the Overberg DM will experience no significant change in the number of extreme rainfall days. Over Theewaterskloof and Overstrand, the trend is leaning towards slight decreases while over Swellendam and Cape Agulhas, the trend is leaning towards slight increase in the number of extreme rainfall days.

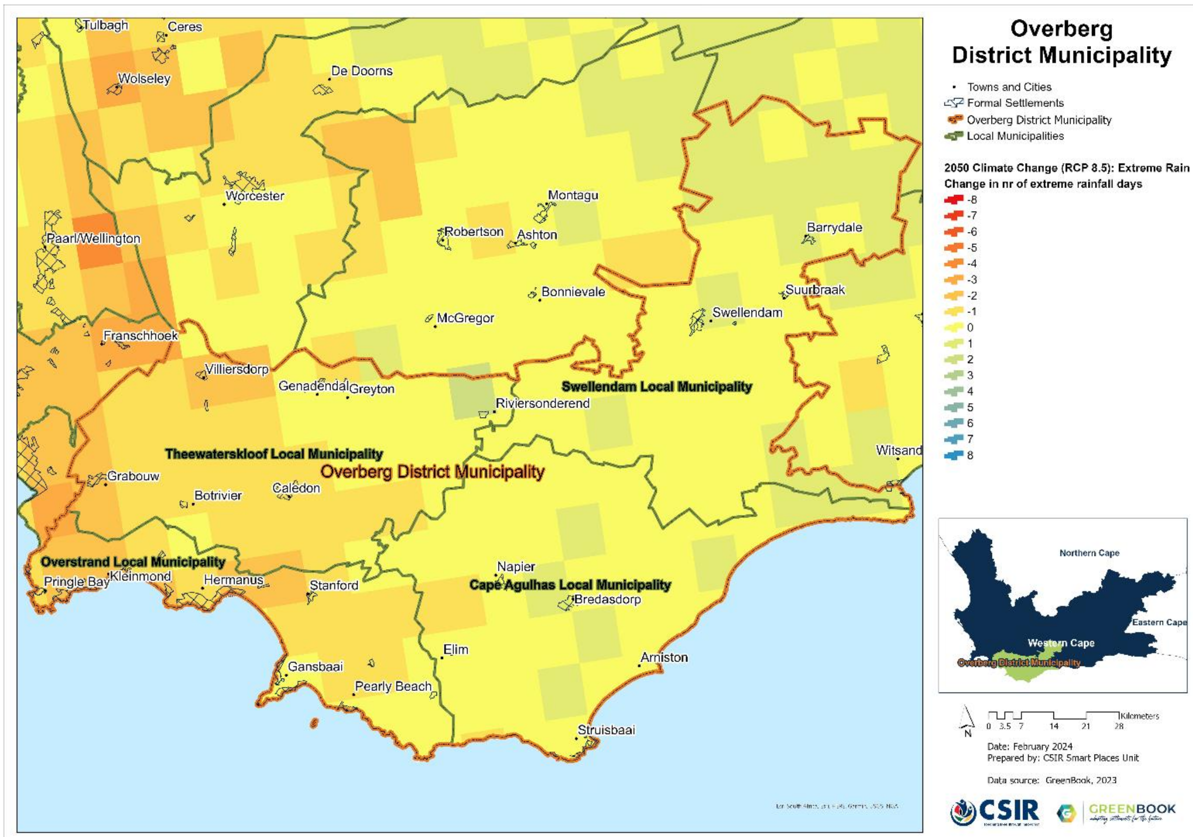

Figure 19: Projected changes into the future in extreme rainfall days across the Overberg District Municipality

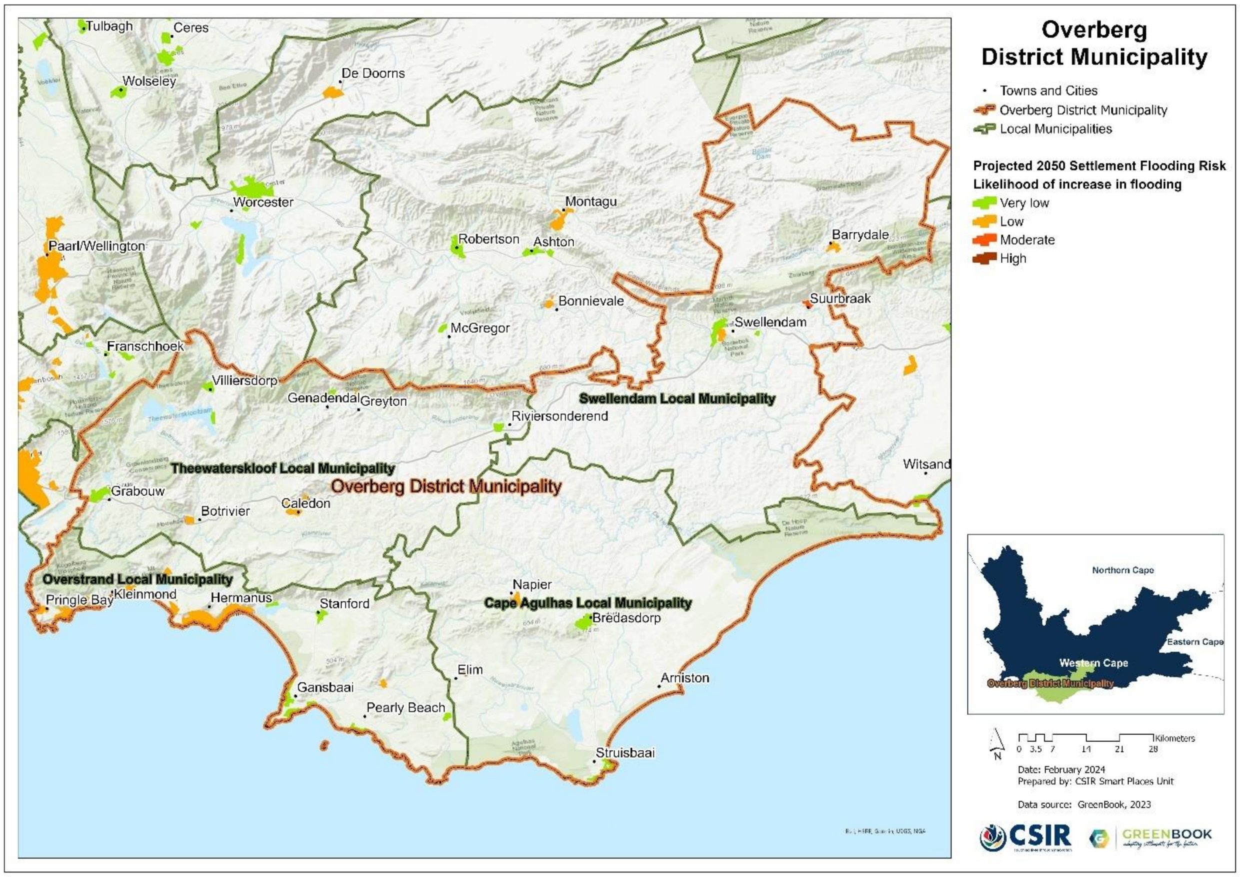

Figure 20: Flood risk into a climate change future at settlement level across the Overberg District Municipality.

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. The settlements of Suurbrak (Swellendam LM) and Elim (Cape Agulhas LM are expected to see a "moderate" increase in flooding, all other settlements in Overberg a very low to low increase in flood likelihood.

2.3.5. Coastal flooding and erosion

The coastal zone plays a major role in Overberg's economy. Most of the Overstrand's settlements are located on the coast and have a long history of damage caused by coastal flooding and erosion. Hence, assessment of coastal risk has been on the radar of the provincial and local authorities for about a decade already, resulting in the development and gazetting of Coastal Management Lines (CMLs) for the Province in 2021. The method used for the coastal risk assessment is described elsewhere (WC 2025).

Coastal management lines, as detailed in the ICM Act, are prescribed boundaries that indicate the limit of development along ecologically sensitive or vulnerable areas, or an area where dynamic natural processes pose a hazard or risk to humans. The purpose of CMLs is to demarcate areas where authorities can prohibit or restrict the building, alteration or extension of structures that are either wholly or partly seaward of the CML. The ultimate intention of CMLs is to:

- protect coastal public property, private property and public safety;
- determine features that should be protected under the coastal protection zone; and
- preserve the aesthetic values of the coastal zone.

This implies that CMLs can be based purely on coastal risk considerations but can also be positioned based on other land use and coastal management priorities.

Underlying the coastal risk assessment for the Overberg DM are the following storm and Sea Level Rise (SLR) scenarios (WC 2015):

- short term (1:20 years storm event and a 20cm prediction of sea level rise: "high risk"),
- medium term (1:50 years storm event and a 50cm prediction of sea level rise: "medium risk"), and
- long term (1:100 years storm event, a 100cm prediction of sea level rise and any additional littoral active zones: "low risk") projections

These scenarios were modelled using a high-resolution LIDAR based topographical map, bathymetric information, information on offshore and inshore wave heights and aerial photography. Figure 21 depicts the resulting risk lines for an area in Betty's Bay, Overstrand LM.

Future risks were considered in terms of natural coastal regression or accretion; littoral active zones (mobile sand); projected sea level rise; storm-driven coastal inundation; projections of storm-driven coastal erosion; and inundation levels in estuaries.

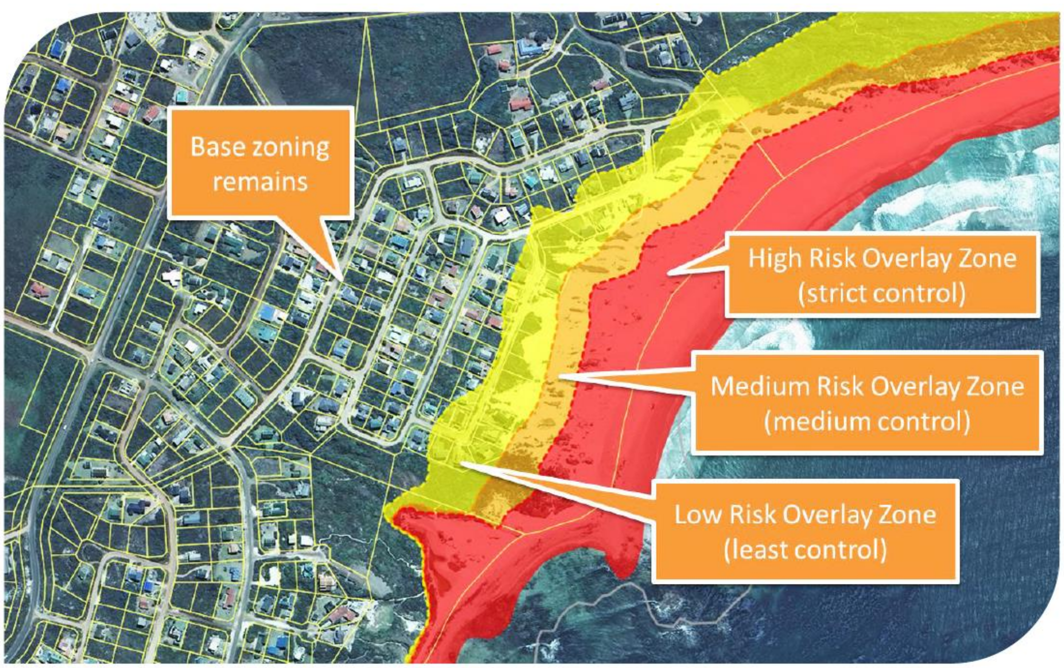

Figure 21: Example of the coastal risk lines underlying the district's CML lines for an area in Betty's Bay (Source: WC 2015).

For the GreenBook, a slightly different approach to model coastal flood and erosion risk, adopted from the National Coastal Climate Change Vulnerability Assessment (DEFF 2020) was used. Here, the assumption is that coastal flood and erosion risk depends on a variety of input factors, such as coastal topography, geology, land cover, presence of engineered protective structures (seawalls, breakwaters) as well as exposure to wave impact and sea level rise (SLR). In the National Coastal Climate Change Vulnerability Assessment (DEFF 2020), five coastal risk assessments were conducted, namely risk of coastal flooding as a result of storm impact, i.e. storm surge and wave run-up, and SLR, coastal short-term erosion caused by storms, coastal long-term erosion as a result of SLR. Further, estuarine flood and erosion were modelled as caused by inland storm events, i.e. due to rainfall. The open coast risk indices are more mature than the estuary risk indices, as their development was based on previous work. The resulting five coastal climate change vulnerability dataset and the technical report can be accessed through DFFE's Coastal Viewer (https://mapservice.environment.gov.za/Coastal%20Viewer/) can be downloaded here.

Coastal flood risk modelling approach is divided into two parts, first, hydrodynamic modelling determined the water-level height on the coastline, based on statistically determined offshore wave conditions for the 1:10, 1:30, 1:50 and 1:100 years storm events, in combination with a medium-future sea-level rise of 0.35 m and a long-term sea-level rise scenario of 1.0 m. The expected wave run-up heights for those scenarios were then extrapolated inland, using the enhanced BathTubModel in ArcGIS (Williams & Lück-Vogel, 2020). Figure 22 shows an example of the resulting risk lines for the coast between Pringle Bay and Betty's Bay, Overstrand LM. Areas classified as "very low" risk are, according to the models, only affected by 1:100 years storm runup in combination with 1.0m sea level rise (SLR), "low risk" areas will be affected by 1:50 years storms with 1.0 m SLR, "medium" risk areas by 1:30 years storms and 1.0 m SLR, "high risk" areas by 1:30 years storms with 0.35 cm SLR and "very high risk" areas by 1:10 years storms at 0.35 m SLR. Coastal erosion was modelled in two different approaches. Coastal long-term recession due to SLR was modelled separately from coastal erosion due to storm impact. Both resulting risk line datasets can be accessed through DFFE's Coastal Viewer (https://mapservice.environment.gov.za/Coastal%20Viewer/) and can be downloaded here.

The modelling of storm-related coastal short-term erosion extents followed a three-step approach as described in DEFF (2020). First, hydrodynamic modelling determined the water level height and wave energy on the coastline, based on statistically determined offshore wave conditions for 1:1, 1:10, 1:30, 1:50 and 1:100 years storm events. Engineering-based equations were used to determine the expected "erosion distance" i.e., the amount the coastline would move "inland", based on the erodibility of the local geology. This geologically possible erosion distance was then modulated with protective factors such as respective coastal vegetation, dune height and presence of seawalls and breakwaters. Soft engineered erosion protection structures were not considered. The resulting modulated erosion distance was then extrapolated inland in a GIS approach.

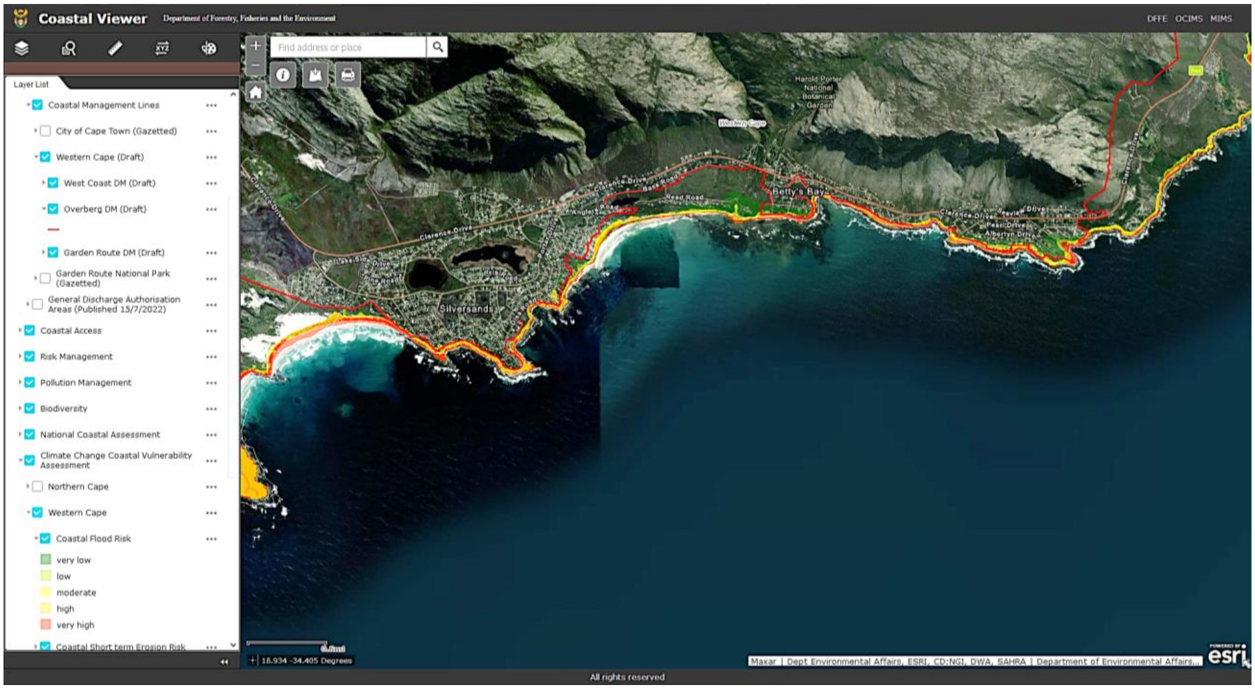

Figure 22: Coastal flood and erosion risk extent and coastal Management in the Betty's Bay area, Overstrand LM

Figure 22 overlays the DEFF (2020) coastal flood and erosion risk lines for the wider Betty's Bay area with the province's draft CML. The comparison shows that areas at risk of coastal flooding and/or erosion are largely falling on the seaward side of the CML. This means that, albeit coastal risk is an issue for the partly densely populated Overstrand coast, the risk is well contained and managed in the Overberg DM. In the Cape Agulhas and Struisbaai settlements in the Cape Agulhas LM, the situation is slightly different. Here the CML runs about 15 km inland of the coast, to include the extensive Seekoevlei area. There is however a risk of flooding and impact from SLR for structures in the immediate vicinity of the shore.

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 Overberg 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 23 indicates the catchment(s) related to the district. The entire district falls within the Breede-Gouritz Primary Catchment.

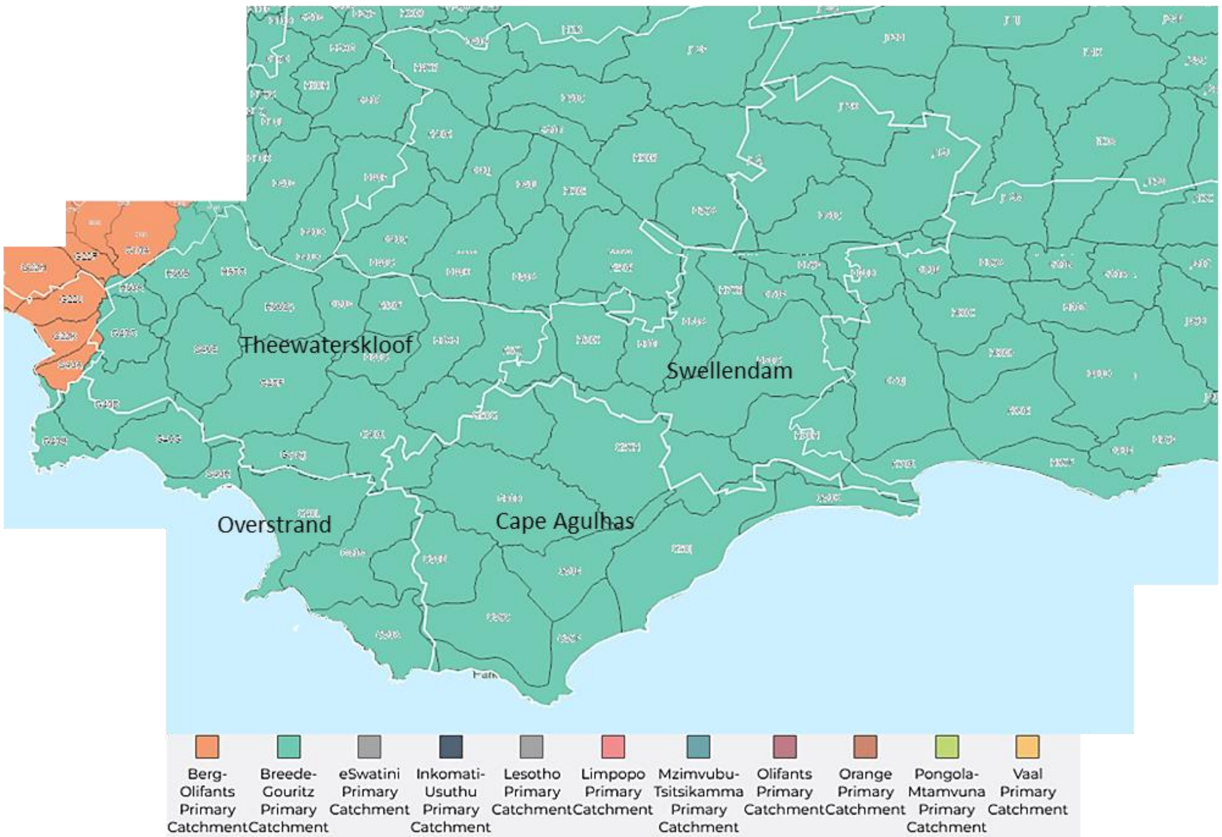

Figure 23: Quaternary catchments found in the Overberg District Municipality

Figure 24 indicates where settlements get their main water supply from, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed to be groundwater dependent. Settlements in the Swellendam LM are 100% surface water dependent, Overstrand and Cape Agulhas LMs are about 37% groundwater dependent, while in the Theewaterskloof, settlements derive 18.4% of their water from groundwater and the remainder from surface water (Table 3).

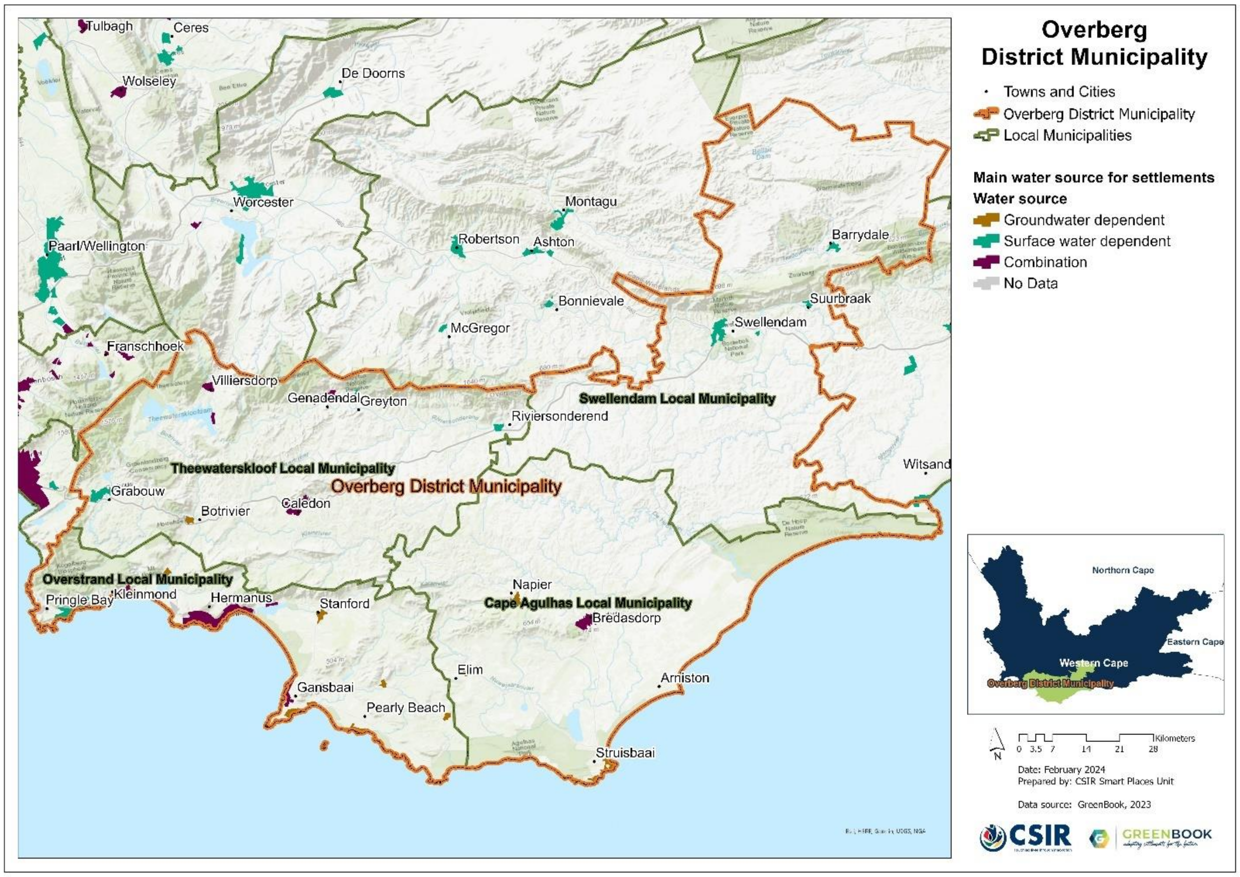

Figure 24: Main water source for settlements in the Overberg District Municipality

Figure 25 indicates the occurrence and distribution of groundwater resources across the District Municipality, with distinctive recharge potential zones, while Figure 26 indicates the projected change in groundwater potential. Comparison of Figure 25 and Figure 26 shows that over large areas of Theewaterskloof, Overstrand and Cape Agulhas the groundwater recharge potential is expected to increase in the future, only the northern ranges of the Swellendam LM might see a, partly significant, decrease in recharge potential.

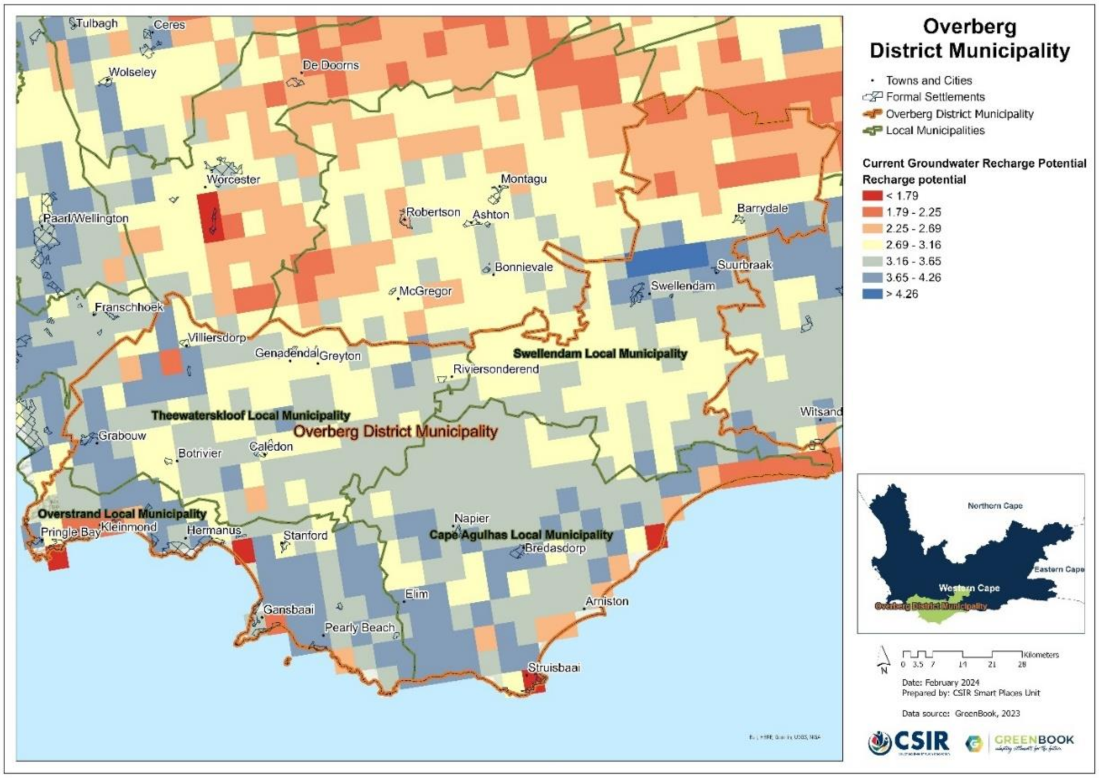

Figure 25: Groundwater recharge potential across the Overberg District Municipality under current (baseline) climatic conditions

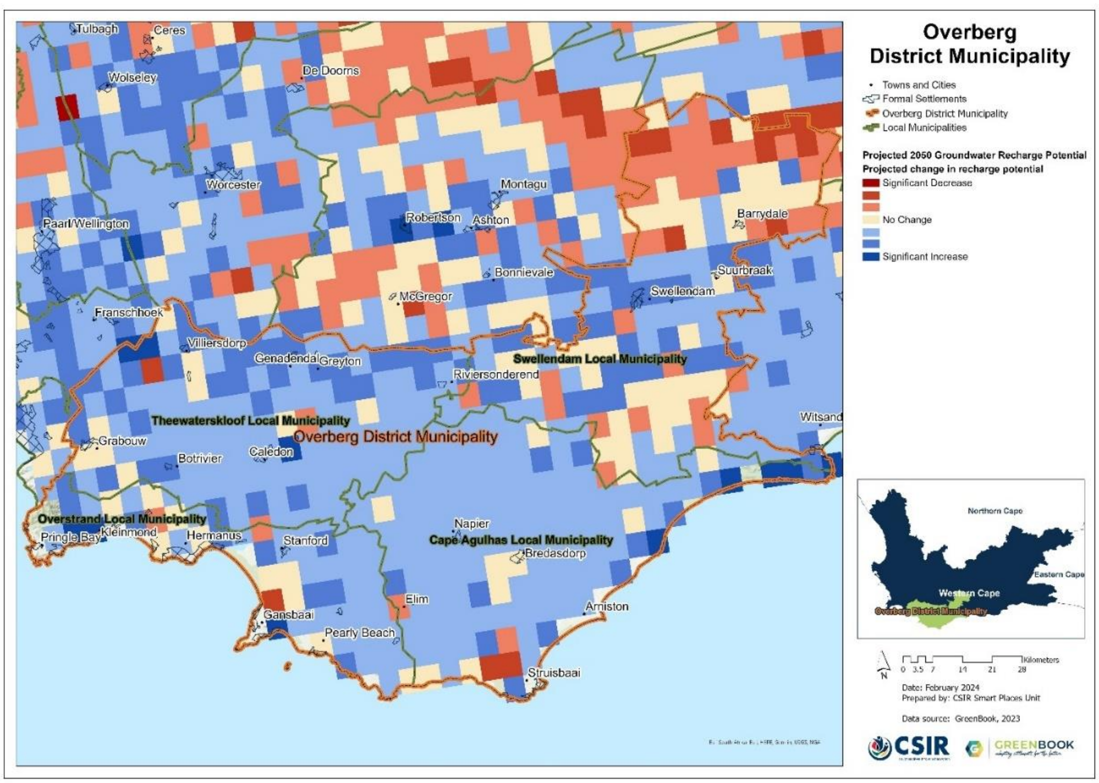

Figure 26: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across the Overberg District Municipality

Figure 27 indicates which groundwater dependent settlements that may be most at risk of groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure into the future. Given the high development pressure on the settlements in Overstrand, here the highest risk of groundwater depletion towards 2050 exists. However, on a national scale, the risk is still considered "moderate". The usage of other water sources, i.e. surface water, and the projected slight increase of rainfall might mitigate the pressure of the growing population on water resources. In the other LMs of the district, groundwater depletion risk is low to very low, or insignificant in Swellendam LM which is 100% surface water dependent.

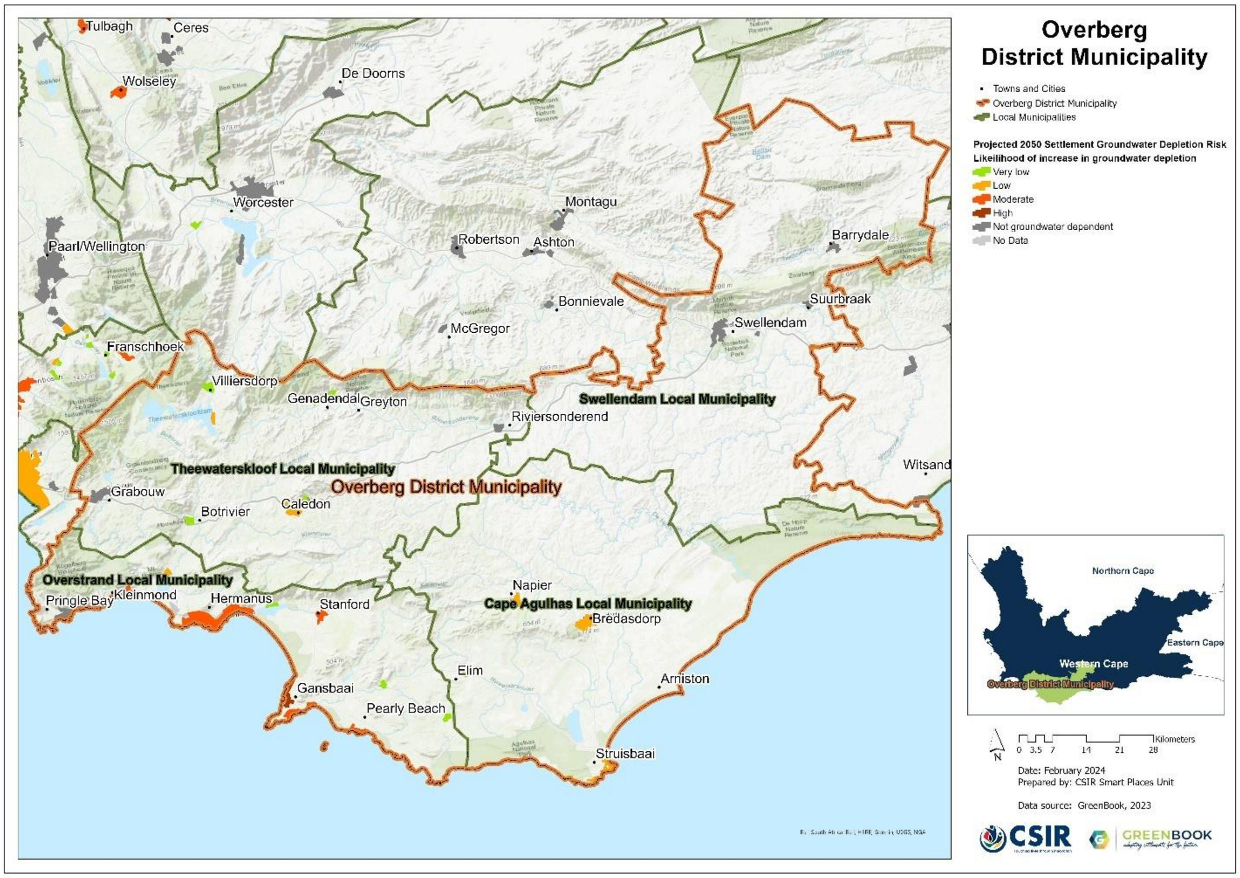

Figure 27: Groundwater depletion risk at settlement level across the Overberg District Municipality

Table 3 provides an overview of current water supply vulnerability (i.e., demand versus supply) for the Local Municipalities in the Overberg 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 groundwater dependency, water supply and vulnerability across the Overberg District Municipality

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability	Current Groundwater Dependency
Theewaterskloof	101.2	196.69	0.51	18.4%
Overstrand	279.72	427.57	0.65	36.6%
Cape Agulhas	176.4	273.55	0.64	36.5%
Swellendam	133.31	263.33	0.51	0%

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

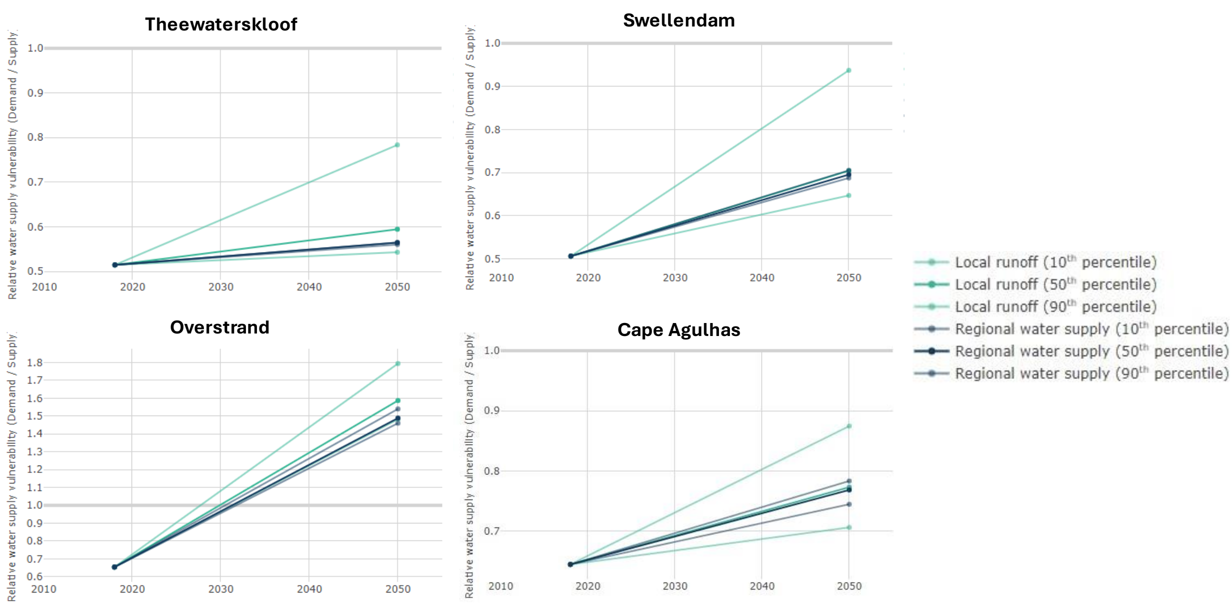

Figure 28: Projected water supply vulnerability for scenario 1 and 2, showing the 10th, 50th and 90th percentile.

In all four LMs of the Overberg DM, the water demand is lower than the current water supply. This leads to very low water supply vulnerability in all four LMs. Figure 28 shows that the Overstrand LM will see a continued, partly extreme, population increase in the future which could lead to an increase in water supply vulnerability, particular when combined with drying trends.

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.

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

Theewaterskloof

The Agriculture, Forestry and Fisheries sector contributes 16.92% to this LM’s GVA and 31.07% to its total employment. The total AFF GVA production of Theewaterskloof Municipality contributes

1.31% to the national AFF GVA, ranking them as the 17th biggest contributor. Main agricultural commodities are deciduous fruit, aquaculture (fish) and wheat.

Overstrand

Main AFF commodities in Overstrand are aquaculture (coastal and inland), wheat and deciduous fruit. AFF contributes 6.07% to Overstrand GVA production and 12.76% to the LM's total employment.

Cape Agulhas

The main agricultural commodity in this LM is wheat, followed by deciduous fruit and sheep. AFF contributes 7.49% to this LM's GVA and 13.89% to its employment. The total AFF GVA production of Cape Agulhas Municipality contributes 0.21% to the national AFF GVA, ranking them as the 130th biggest contributor.

Swellendam

In the Swellendam LM, the AFF sector contributes 11.33% to the local GVA and 22.75% to employments. The main agricultural commodities are deciduous fruit, wheat and milk and cream.

Table 4: Summary table of climate change impacts on agriculture for each agro-climatic zone in the Overberg District (Source: DoA & DEA&DP 2016).

Name	Main physical features	Main water resource features	Main climatic features	Climate change temperature projections	Main commodities	Socio-economic features	Future agricultural potential
Grabouw-Villiersdorp-Franschhoek	Plains with low elevation mountains	Western Cape Water Supply System large dams, farm dams, very large storage capacity	Unique climate, more cloudy, misty and wet than surrounding areas	Low range warming	Pome fruit, wine grapes, wheat, barley, stone fruit, berries	High income, seasonal labour	Remains high as long as dams fill up, but apples become unviable due to warming
Montagu-Barrydale	Mountainous with fertile valleys	Rivers, dams, low storage capacity	Winter rainfall, cold in winter with occasional heavy rain, hot in summer	Medium range warming	Stone fruit, wheat, barley, wine grapes, pome fruit, citrus, olives Sheep	Seasonal labour	Remains high as longs as dams fill up
Rûens-east[25]	Hilly coastal plain, bordered by mountains in north, coast in south, fertile soils	Farm dams, occasional river, low storage capacity	More variable rainfall than to the west, with recent droughts in Heidelberg-Albertinia area, mostly winter with some summer rainfall	Low range warming	Wheat, barley, canola Sheep, cattle, dairy, pigs ostrich		Currently becoming marginal for small grains but could improve given possible increases in rainfall
Rûens-west[26]	Hilly coastal plain, bordered by mountains in north, coast in south, fertile soils	Farm dams, occasional river, low storage capacity	More reliable dryland conditions than to the east, winter rainfall, warm dry summers	Low range warming	Wheat, barley, canola Dairy, sheep, cattle		Remains high for small grains but with increasing yield variability

The AFF sector contributes 10.4% 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. In all four LMs the production of deciduous fruit plays an important role in their AFF sector GVA. Deciduous fruit production requires some frost days in winter. Generally, increasing average annual temperatures, as predicted for Overberg DM, coincide with increased minimum temperatures, also in winter. This might negatively impact the flower and fruit production of apples and pears. Further, the predicted likely increase in temperatures with only a slight increase in rainfall might lead to an increase in evaporation which might put fruit yards and crops under stress, as will a potential increase in droughts. ODM (2017) summarises the impact of climate change per agro-climatic zones and main commodities (Table 4).

3. Recommendations

The main climate risks this district municipality will face in the future are an increase in temperatures, higher rainfall variability with potential increase of extreme events, e.g. inland and coastal flooding, as well as windstorms. These findings are in line with the models underlying the Overberg Climate Change Response Framework (ODM 2017) which predict "the likely increase in extreme weather events, such as intense rainfall, sea storm surges, increased wind speeds, drought and flood events."

Between 2003 and 2016, flooding events have occurred in the ODM almost every year. The total financial damage from floods in the Western Cape over this period was estimated to be R4.9 billion, and a significant proportion of this damage occurred in the Overberg (ODM 2017). However, coastal risks are now contained through the DMs implementation of coastal management lines, which will, in the long-term, contribute to the protection of coastal economic infrastructure and livelihoods. Increase in intensity of rainfall and inland flooding could lead to increased surface runoff, resulting in increased soil erosion, soil loss and degradation in rural and agricultural areas, as well as infrastructure damage especially in informal settlements.

The deciduous fruit production in the DM is flourishing in this region currently because of the specific climate conditions of frost in winter and mild summers. Increased minimum temperatures will decrease risk of damage to some crops but will increase risk to deciduous fruits that rely on cooling period in autumn and winter (ODM 2017).

Environmental vulnerability is relatively high across all LMs within the District, indicating pressure on biodiversity due to rapid urbanisation (especially in Overstrand), agricultural expansion and land-use change, thus increasing the vulnerability of the environment to extreme climate events.

Therefore, in response to these climate risks and impacts, adaptation goals are recommended, in support of the four objectives of the Western Cape Climate Change Strategy:

1. Responding to the climate emergency.
2. Transitioning in an equitable and inclusive manner to net zero emissions by 2050.
3. Reducing climate risks and increasing resilience.
4. Enabling a just transition through public sector, private sector, and civil society collaboration.

The adaptation goals set out for Overberg District Municipality are:

1. 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. 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.

2. 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).

3. To protect biodiversity and improve sustainable use of natural resources: As noted earlier, the district's natural environment a valuable asset to its economy. However, it 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.

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 the district’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 Overberg DM. 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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