Garden Route District Municipality Climate Change Response Implementation Plan

Abbreviated Version

2024/2025

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Executive Summary

Historically, the Western Cape Province has been the most disaster-prone province in the country (WC PDMC, 2021). The province frequently experiences drought, fire and flood events with significant adverse impacts (Pasquini, Cowling, and Ziervogel, 2013). Increased temperatures in the future are certain for the Western Cape (Western Cape Government, 2015), but rainfall projections are less certain, with some projections revealing increased rainfall, whilst others predict decreased rainfall in the future.

The following climate change impacts have already been observed in the Garden Route District: increased average temperatures; shifts in seasonality; increased frequency of veld fires; increased magnitude and frequency of storm events accompanied by strong winds; more frequent and severe storm surges and flood events; and increases in rainfall variability as well as the number of dry days.

In addition, sea level rise and associated hazards are a major concern for coastal areas within the district. Sea level rise impacts are likely to include inter alia coastal erosion, flooding, disturbance of estuarine systems, destruction of infrastructure and saltwater contamination of freshwater bodies (WC PDMC, 2021).

It is for this reason that the Garden Route District Municipality recognises climate change as a threat to the environment, its residents, and to future development. Therefore, measures should be implemented to reduce or eliminate carbon emissions or enhance greenhouse gas sinks (mitigation) (Böckmann, 2015). However, due to lag times in the climate and biophysical systems, the positive impacts of past and current mitigation will only be noticeable in the next 25 years (Jiri, 2016). In the meanwhile, adaptation is regarded as inevitable and a necessary response to the changes that are projected to take place in the district. The Garden Route District Municipality has therefore prioritised the development of a Climate Change Adaptation Plan developed in 2014. This Garden Route District Climate Change Strategy builds on the original Adaptation Plan by providing more detail at a sector level on key Climate Change Vulnerabilities and Responses.

The Climate Change Adaption Strategy was developed with the assistance of the Local Government Climate Change Support (LGCCS) Programme (http://www.letsrespondtoolkit.org/); in partnership with the Western Cape Climate Change Municipal Support Programme. The LGCCS is led by the Department of Environmental Affairs and is part of the International Climate Initiative (IKI) and is supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

Through the LGCCS Programme, a Climate Change Vulnerability Assessment Toolkit was developed to assist municipalities to identify and prioritise climate change indicators to facilitate the assessment of adaptive capacity. Indicators are a range of potential impacts which have been developed using the Long-Term Adaptation Scenario (LTAS) reports (Department of Environmental Affairs, 2013g).

The LGCCS Toolkit was applied to the Garden Route district to assist with the development of its Climate Change Response Plan. The Vulnerability Assessment methodology included a Garden Route District workshop, which was held with key environmental stakeholders of

the seven Category-B Municipalities in the district, where the focus was specifically on the identification and review of key climate change vulnerabilities for the area. The process included the identification of context specific climate change indicators, assessing exposure, sensitivity and adaptive capacity. Participants also developed priority climate change responses (please refer to Chapter 5 for the detailed Vulnerability Assessment methodology used). The vulnerability assessment outlined the key climate change vulnerabilities, as well as the responses to address these vulnerabilities for Garden Route District Municipality.

A summary of the key vulnerability indicators is provided in the Table 1 below (DEA, 2017b).

Table 1: Key Vulnerability indicators for Garden Route District Municipality

No	Sector	Name Indicator Title	Exposure Answer	Sensitivity Answer	Adaptive Capacity Answer
10	Agriculture	Increased risks to livestock	Yes	High	Low
13	Biodiversity and Environment	Increased impacts on threatened ecosystems	Yes	High	Low
14	Biodiversity and Environment	Increased impacts on environment due to land-use change	Yes	High	Low
15	Biodiversity and Environment	Loss of Priority Wetlands and River ecosystems	Yes	High	Low
19	Coastal and Marine	Loss of land due to sea level rise	Yes	High	Low
20	Coastal and Marine	Increased damage to property from sea level rise	Yes	High	Low
30	Human Settlements, Infrastructure and Disaster Management	Increased impacts on traditional and informal dwellings	Yes	High	Low
32	Human Settlements, Infrastructure and Disaster Management	Increased migration to urban and peri-urban areas	Yes	High	Low
33	Human Settlements, Infrastructure and Disaster Management	Increased risk of wildfires	Yes	High	Low
36	Water	Decreased water quality in ecosystem due to floods and droughts	Yes	High	Low
40	Air Quality	Increase in Air Pollution	Yes	High	Low
41	Air Quality	Increase in odour complaints	Yes	High	Low
42	Air Quality	Increase in Brown haze	Yes	High	Low

Based on the vulnerability assessment, the following indicators were identified as high priority climate change vulnerabilities for the municipality. These were shortlisted by answering “yes” to exposure, “high” to sensitivity and “low” to adaptive capacity. Indicators are grouped into the following themes:

- Agriculture
- Biodiversity and Environment
- Coastal and Marine
- Human Health
- Disaster Management, Infrastructure and Human Settlements
- Water

The major climatic hazards in the Garden Route district as identified by the Vulnerability Assessment include: droughts, floods and veld fires. Climate change is also expected to incrementally increase the frequency and severity of these hazards. Additionally, financial losses in the district, due to these climate hazards, has already been high, and will increase going into the future.

It is therefore crucial to conserve our water resources, wetlands, marine and coastal environment, and our rich biodiversity. Land-use and settlement plans should be updated to take disaster risk management criteria into account, and by increasing public awareness regarding water conservation, droughts, fires and floods. This is particularly pertinent given the recent devastating fires in and around the Garden Route as well as the severe ongoing drought in the Garden Route district.

As an outcome of the Vulnerability Assessment, various Sector Plans were also developed as part of this Strategy (please refer to Chapter 6 to view these Plans).

1 Climate Change Introduction

1.1 Document Outline

This document outlines key climate change vulnerabilities and responses to address these vulnerabilities for the Garden Route district. The main chapters within this document are as follows:

- Executive Summary
- Climate Change Introduction
- Provincial Climate Change Context
- Garden Route District Municipality
- Major Climate Change Impacts of Extreme Concern within the Garden Route District
- Garden Route District Climate Change Vulnerability Assessment
- Climate Change Implementation
- Sector Adaptation Response Plans
- Concluding Remarks
- References

1.2 Climate Change Defined

Climate change is a natural phenomenon that takes place over geological time. However, over the past few decades the rate of climate change has been more rapid, and the magnitude of global warming has increased dramatically (Warburton and Schulze, 2006; Warburton, 2012). This change has been attributed to increased anthropogenic greenhouse gas emissions (Koske and Ochieng, 2013). For example, the burning of coal to generate electricity, the burning of petrol in cars, some chemical processes in industries, and many farming activities all contribute to the increased concentration of greenhouse gasses in the atmosphere. Climate change adaptation can be defined as: "*The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation*" (IPCC TAR, 2001).

Moser and Ekstrom‟s (2010) definition of adaptation is also useful:
"*Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities*."

This definition recognizes that adaptation to climate change takes place in a complex context where climate variability and change is only one of many stressors that require response. It also acknowledges that some adaptive responses help deal with current variability and others may be more transformative and sustainable; yet there is no defined separation between the two and they can, and in fact in many circumstances should, be linked.

Climate change is not just an increase in average global temperatures but changes in regional climate characteristics such as rainfall, relative humidity and severe weather extremes (Davis, 2011). Climate change can manifest as a shock or a stress (Ziervogel and Calder, 2003). Shocks are defined as discrete, extreme events (rapid onset) such as floods, while gradual change (slow onset) such as long-term climate variability is classified as a stress (Ziervogel and Calder, 2003). The negative impacts of climate change "*are already felt in many areas, including in relation to, inter alia, agriculture, and food security; biodiversity and ecosystems; water resources; human health; human settlements and migration patterns; and energy, transport and industry*" (United Nations Women Watch, 2009:1).

1.3 Climate Change Legislative Context in South Africa

Climate change is a relatively new area of policy development in South Africa. As policies and structures are developed, it is necessary to ensure that they are evidence-based, coordinated and coherent.

1.3.1 Alignment with the New Draft South African Climate Change Act (Bill), 2022

The new Draft South African Climate Change Act (Bill), 2022 requires that all organs of state align their policies with the Act. They must also give effect to the objectives and principles of the Act. This new Act will be binding to all organs of state. The Garden Route District Municipality therefore took the opportunity to pre-empt the review of its current Garden Route Climate Change Strategy to be aligned with, and to ready, the document in anticipation of the date when the new Act comes into operation by proclamation in the Gazette.

The draft Climate Change Act (Bill), 2022 also requires the Mayor of a District Municipality to develop two documents which must both be reviewed every 5 years, and to be published in the Gazette:

1. A Climate Change Needs and Response Assessment, and;
2. A Climate Change Response Implementation Plan.

In order to prepare the current Garden Route District Climate Change Strategy document, and ready ourselves for the requirements of the new Act, the Garden Route District Municipality revised its Garden Route Climate Change Strategy to comply with the requirements of the new Act, resulting in the title change of the current document as follows:

- Garden Route District Municipality Climate Change Response Implementation Plan, 2024

The Climate Change Response Implementation Plan contains the response measures or programmes relating to both adaptation and mitigation, as per the requirements of the Act.

The GRDM also developed a second document which contains a Climate Change Vulnerability Assessment and other info as per the requirements of the new Act., and which

informs the content of the Climate Change Response Implementation Plan. The title of this second document is:

- Garden Route District Municipality Climate Change Needs and Response Assessment, 2024.

As per the draft Climate Change Act (Bill), 2022, the following climate change objects and principles is of importance in achieving, promoting and the protection of a sustainable environment:

1.3.1.1 Objects of the South African Climate Change Act (Bill), 2022

The objects of the Act are to—

(a) provide for a coordinated and integrated response by the economy and society to climate change and its impacts in accordance with the principles of cooperative governance;
(b) provide for the effective management of inevitable climate change impacts by enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to building social, economic and environmental resilience and an adequate national adaptation response in the context of the global climate change response;
(c) make a fair contribution to the global effort to stabilise greenhouse gas concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system;
(d) to ensure a just transition towards a low carbon economy and society considering national circumstances;
(e) give effect to the Republic's international commitments and obligations in relation to climate change; and
(f) protect and preserve the planet for the benefit of present and future generations of humankind.

1.3.1.2 Principles of the South African Climate Change Act (Bill), 2022

The interpretation and application of the Act must be guided by—

(a) the national environmental management principles set out in section 2 of the National Environmental Management Act where applicable in this Act;
(b) the principle that the climate system should be protected for the benefit of present and future generations of humankind;
(c) the principle that acknowledges international equity and each country's common but differentiated responsibilities and respective capabilities, in light of different national circumstances;
(d) a contribution to a just transition towards low-carbon, climate-resilient and ecologically sustainable economies and societies which contribute to the creation of decent work for all, social inclusion and the eradication of poverty;
(e) the need for integrated management, in the context of climate change, which requires climate change considerations to be integrated into the making of decisions which may have a significant effect on the Republic's ability to mitigate or which exacerbate its vulnerability to climate change;
(f) the need for decision-making to consider the special needs and circumstances of localities and people that are particularly vulnerable to the adverse effects of climate

change, including vulnerable workers and groups such as women, especially poor and rural women, children, especially infants and child-headed families, the aged, the poor, the sick and persons with disabilities;

(g) the need for a risk-averse and cautious approach to be adopted, which takes into account the limits of current knowledge about causes and effects of climate change and the consequences of decisions and actions in relation thereto;

(h) the need for climate change mitigation and adaptation responses to be informed by evolving climate change scientific knowledge and decisions which should be based on the best available science, evidence and information;

(i) an effective climate change response which requires preventative measures to mitigate the causes of climate change and to strengthen resilience through the adoption of adaptation measures;

(j) the costs of responding to the adverse impacts of climate change and of mitigation which must be paid for by those responsible for causing the adverse impacts;

(k) an integrated climate change response which requires the enhancement of public awareness of climate change causes and impacts and the promotion of participation and action at all levels; and

(l) a recognition that a robust and sustainable economy and a healthy society depend on the services that well-functioning ecosystems provide, and that enhancing the sustainability of the economic, social and ecological services is an integral component of an effective and efficient climate change response.

1.3.2 The National Environmental Management Act 107 of 1998

This Garden Route District Municipality Climate Change Response Implementation Plan is Guided by the principles in the National Environmental Management Act (NEMA), 107 of 1998 as set out in section 2 of the Act, which are as follows:

1.3.2.1 Principles of the National Environmental Management Act 107 of 1998

Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably. Development must be socially, environmentally and economically sustainable.

(a) Sustainable development requires the consideration of all relevant factors including the following:

- That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;
- that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;
- that the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided, or where it cannot be altogether avoided, is minimised and remedied;

- that waste is avoided, or where it cannot be altogether avoided, minimised and re-used or recycled where possible and otherwise disposed of in a responsible manner;
- that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource;
- that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;
- that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and
- that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied.

(b) Environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated, and it must take into account the effects of decisions on all aspects of the environment and all people in the environment by pursuing the selection of the best practicable environmental option. :

(c) Environmental justice must be pursued so that adverse environmental impacts shall not be distributed in such a manner as to unfairly discriminate against any person, particularly vulnerable and disadvantaged persons.

(d) Equitable access to environmental resources, benefits and services to meet basic human needs and ensure human well-being must be pursued and special measures may be taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination.

(e) Responsibility for the environmental health and safety consequences of a policy, programme, project, product, process, service or activity exists throughout its life cycle.

(f) The participation of all interested and affected parties in environmental governance must be promoted, and all people must have the opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation, and participation by vulnerable and disadvantaged persons must be ensured.

(g) Decisions must take into account the interests, needs and values of all interested and affected parties, and this includes recognising all forms of knowledge, including traditional and ordinary knowledge.

(h) Community wellbeing and empowerment must be promoted through environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means.

(i) The social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment.

(j) The right of workers to refuse work that is harmful to human health or the environment and to be informed of dangers must be respected and protected.

(k) Decisions must be taken in an open and transparent manner, and access to information must be provided in accordance with the law.
(l) There must be intergovernmental co-ordination and harmonisation of policies, legislation and actions relating to the environment.
(m) Actual or potential conflicts of interest between organs of state should be resolved through conflict resolution procedures.
(n) Global and international responsibilities relating to the environment must be discharged in the national interest.
(o) The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest, and the environment must be protected as the people's common heritage.
(p) The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment.
(q) The vital role of women and youth in environmental management and development must be recognised and their full participation therein must be promoted.
(r) Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

1.3.3 Other International and National Climate Change Policies and Structures

This section introduces international and national climate change policies and structures, which are listed below:

- The United Nations Framework Convention on Climate Change (UNFCCC). This international treaty provides guidance on setting agreements pertaining to the reduction of greenhouse gas emissions;
- The Paris Agreement came into effect on 4 November 2016. This is the first agreement all countries have committed to and stipulates that all countries must reduce carbon emissions to limit global temperature increase to 1.5 degrees Celsius above pre-industrial levels;
- South Africa’s Nationally Determined Contributions came into effect after the Paris Agreement was signed. South Africa is therefore required to report on mitigation and adaptation efforts. Concerning mitigation, South Africa is to reduce emissions by a range between 398 and 614 million metric tons of carbon equivalent by 2025 and 2030. There are several instruments to ensure reduction in carbon emissions including car tax and company carbon budgets among other instruments. With reference to adaptation a National Adaptation Plan is currently being developed, and climate change is to be incorporated in all policy frameworks, institutional capacity is to be enhanced, vulnerability and adaptation monitoring systems are to be in place, vulnerability assessment and adaptation needs framework are to be developed and there needs to be communication of past investments in adaptation for education and awareness;

- The National Climate Change Response White Paper (NCCRWP) was adopted in 2011 and presents the South African Government's vision for an effective climate change response in the long-term, to transition to a climate-resilient and lower-carbon economy and society;
- The National Development Plan, focuses on eliminating poverty and reducing inequality by 2030 and creating an environmentally sustainable country through mitigation and adaptation efforts;
- Long Term Mitigation Scenarios, outline different scenarios of mitigation action for South Africa;
- Long Term Adaptation Scenarios, consist of two phases. Phase one was the identification of climate change trends and projections as well as impacts and responses for the main sectors. Phase two focussed on integrating issues such as climate information and early warning systems, disaster risk reduction, human settlements and food security.

1.4 Climate Change Impacts in South Africa

South Africa's temperature is expected to increase to 1.2o C by 2020, 2.4o C by 2050 and 4.2o C by 2080 (Kruger and Shongwe, 2004). Contrary to the global increase in rainfall, South Africa's rainfall is expected to decrease by 5.4% by 2020, 6.3% by 2050 and 9.5% by 2080 (Kruger and Shongwe, 2004). The frequency and intensity of climate extremes, inter alia, droughts, floods, storms and wildfires will increase (Davis, 2011; Böckmann, 2015). Climate change evidence indicates the changes in frequency and intensity of flood and prolonged drought events at small scales (Meyiwa et al., 2014). Furthermore, the sea level will continue rising and ocean acidification will get worse (Böckmann, 2015). There are however uncertainties associated with climate projections because they are based on the potential rates of resource use in the future, and associated greenhouse gas emissions (Nicholson-Cole, 2005).

To assist with assessing the potential impacts from climate change, the country has been divided into six hydrological zones (Figure 1). These hydrological zones not only reflect water management areas but have been grouped according to common climatic and hydrological characteristics (Department of Environmental Affairs, 2013a). Based on a range of data and projections, four possible climate scenarios have been identified for South Africa:

- Warmer/wetter (with greater frequency in extreme rainfall events);
- Warmer/drier (with an increase in frequency of drought and somewhat increased frequency of extreme rainfall events);
- Hotter/wetter (with substantially greater frequency of extreme rainfall events), and;
- Hotter/drier (with a substantial increase in the frequency of drought events and greater frequency of extreme rainfall events).

Projections on rainfall have also been developed for each of the hydrological zones (Department of Environmental Affairs, 2013a). The following four climate change scenarios have been described for the Breede-Gouritz-Berg Hydrological Zone (the dominant zone in the Western Cape) in the Department of Environmental Affairs' Long Term Adaptation Scenarios Reports. These are:

- Warmer wetter scenario - Decreased rain in autumn & increased in winter & spring;
- Hotter drier scenario - Decreased rain in all seasons & strongly decreased in west;
- Hotter wetter scenario - Decreased rain in autumn & increased in winter & spring;
- Warmer drier scenario - Decreased rain in all seasons & strongly decreased in west.

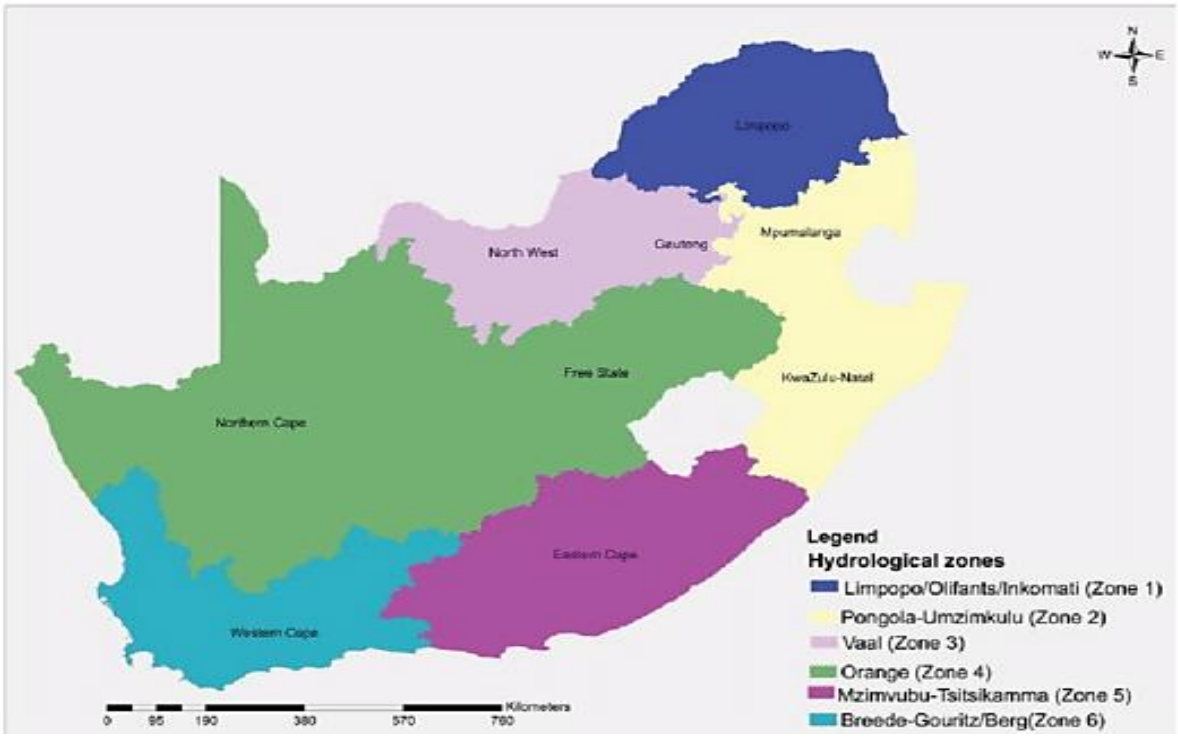

Figure 1: The hydrological zones of South Africa (Kephe et al., 2018).

According to Schulze (2016), globally, the effects of climate change resulting from steady increases in carbon dioxide (CO2) emissions into the atmosphere can no longer be denied or ignored, with 2015 having been the planet's warmest year on record (Figure 2). Since the 1860s, and up to the end of 2015, 14 of the 15 hottest years on record had been in this century.

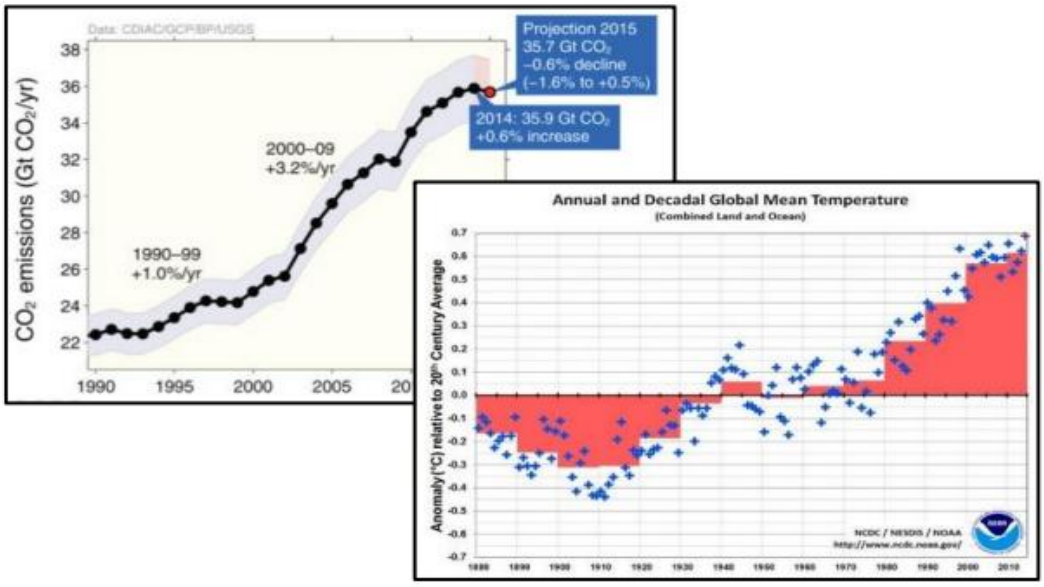

Figure 2: Annual CO2 emissions (in Gigatons) into the atmosphere (top) and annual (red pluses) as well as decadal (red bars) global temperature differences relative to the 20th century average (bottom), showing 2015 to be the hottest year on record (USGS, 2016; NOAA, 2016).

According to the National State of Water Report (2023), South Africa's temperature is also showing a warming trend of approximately 0.17 ºC per decade over the period 1951-2023, statistically significant at the 5% level (SAWS, 2024) (Figure 3).

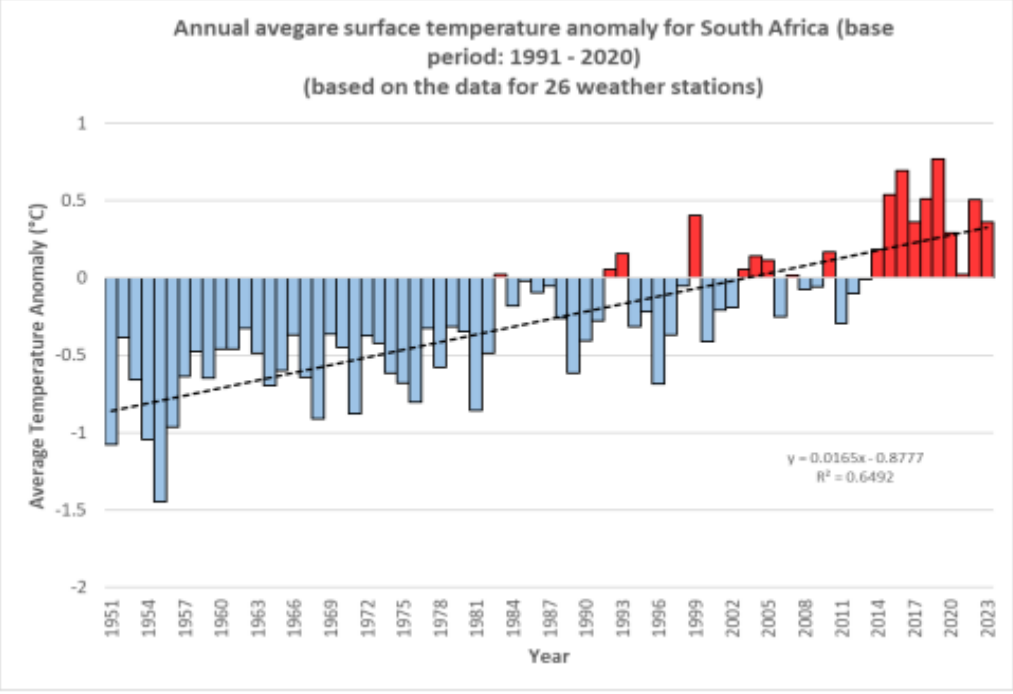

Figure 3: Average surface temperature deviation over South Africa based on 26 climate stations: 1951 - 2021 (base period: 1991 - 2020). The linear trend is indicated (SAWS, 2024).

An increase in Greenhouse Gas (GHG) emitting activities in South Africa have significantly

increased the atmosphere's absorption of the earth's outgoing infrared radiation, thereby enhancing the existing greenhouse effect, and then re-radiating part of it back to earth, resulting in the rising trend in global temperatures shown in Figure 4. Climate change thus refers to the changes of climate which are attributed directly or indirectly to human activities that alter the composition of the global atmosphere. This change in climate is superimposed onto natural climate variability, which is experienced world-wide, but which is particularly severe over South Africa (IPCC, 2001).

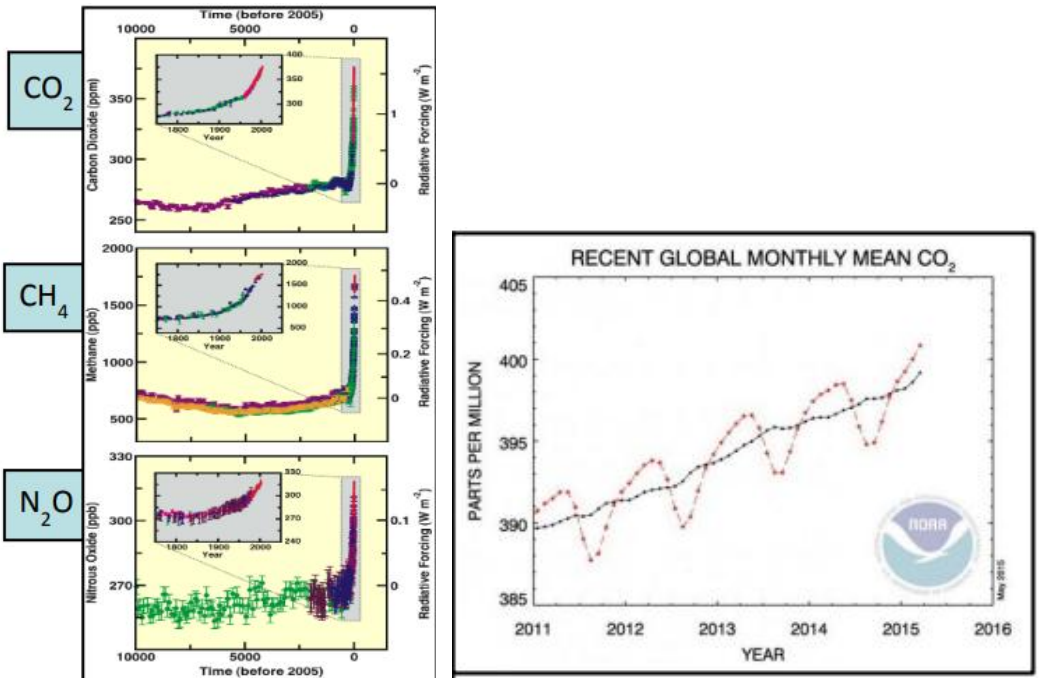

Figure 4: Increases in GHG emissions in the recent past (left), with more detail on recent global monthly mean CO2 concentrations in the atmosphere (IPCC, 2001).

2 Provincial Climate Change Context

The Western Cape Government has a well-developed climate change policy environment. In 2005, the Western Cape government carried out a study titled the “Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape” and in the same year, the Western Cape Government’s Department of Environmental Affairs and Development Planning (DEA&DP) signed the Montreal Accord to protect the Ozone layer (DEA&DP), 2008). The Western Cape Climate Change Response Strategy and Action Plan (2008) was then developed. The Climate Change Response Strategy and Action Plan placed a lot of emphasis on adaptation to allow for developmental prioritises (Coastal & Environmental Services, 2011). The Climate Change Strategy was then updated in 2014 to align with the National Climate Change Response Policy and is geared to strategically direct and mainstream climate change actions and related issues throughout relevant Provincial transversal agendas (DEA&DP, 2014).

DEA&DP also release the Western Cape Climate Change Response Strategy: Vision 2050: A vision for a resilient Western Cape (2023), which responds to the global climate change emergency amidst the dramatic global events since 2020-21. It incorporates the latest science and the overwhelming evidence supporting the need for a green and low-carbon economic recovery. Whilst recognising the progress made since the release of its predecessor in 2014, the updated strategy aims to address an urgent 2030 deadline, ultimately planning a trajectory for strategic outcomes in 2050.

The Western Cape Government also developed the Western Cape Climate Change Adaptation Pathways: Climate Change Adaptation Pathways for A Climate Resilient Province by 2050 (2025), which outlines a strategic approach to addressing the impacts of climate change by identifying and prioritizing adaptive measures over time. It provides flexible dynamic adaptation approaches that guides decision-makers and practitioners through various adaptation options for responding to future climate uncertainties.

The province experiences drought and flood events with significant adverse impacts (Pasquini, Cowling, and Ziervogel, 2013). Historically the province has been the most disaster prone in the country (Western Cape Government, 2015). Increased temperatures in the future are certain for the Western Cape (Western Cape Government, 2015). Rainfall projections are less certain, some projections reveal increased while others reveal decreased rainfall in the future, decreased rainfall has the most adverse impacts in comparison to increased rainfall (Western Cape Government, 2015).

Across most of the province, there is anticipation of reduced rainfall, albeit with variations in intensity across several regions. However, certain areas may face notably more pronounced declines than others. Even in regions where diminished rainfall isn't forecasted or observed, the escalation of temperatures poses formidable challenges to water balance (DEA&DP, 2025).

Concerning wildfire, the frequency and intensity is expected to increase with climate change (Pasquini, Cowling, and Ziervogel, 2013). The frequency and intensity of extreme events is expected to increase as well (Department of Environmental Affairs and Development Planning, Western Cape, 2008).

The Table 2 below is a summary of the key climate change impacts in the province as outlined in the Climate Change Response Strategy and Action Plan for the Western Cape (2014).

Table 2: Climate change impacts for the Western Cape Province (Climate Change Response Strategy and Action Plan for the Western Cape (DEA&DP, 2014).

Change to climate variable	Vulnerability Details
Higher mean temperatures	• Increased evaporation and decreased water balance; • Increase wild fire danger (frequency and intensity).
Higher maximum temperatures, more hot days and more heat waves	• Heat stress on humans and livestock; • Increased incidence of heat-related illnesses; • Increased incidence of death and serious illness, particularly in older age groups; • Increased heat stress in livestock and wildlife; • Decreased crop yields and rangeland productivity; • Extended range and activity of some pests and disease vectors; • Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. traffic lights, road surfaces, electrical equipment, etc.); • Increased electric cooling demand increasing pressure on already stretched energy supply reliability; • Exacerbation of urban heat island effect.
Higher minimum temperatures, fewer cold days and frost days	• Decreased risk of damage to some crops and increased risk to others such as deciduous fruits that rely on cooling period in autumn; • Reduced heating energy demand; • Extended range and activity of some pests and disease vectors; • Reduced risk of cold-related deaths and illnesses.
General drying trend in western part of the country	• Decreased average runoff, stream flow; • Decreased water resources and potential increases in cost of water resources; • Decreased water quality; • Decrease in shoulder season length threatening the • Western Cape fruit crops; • Increased fire danger (drying factor); • Impacts on rivers and wetland ecosystems.
Intensification of rainfall events	• Increased flooding; • Increased challenge to stormwater systems in urban settlements; • Increased soil erosion; • Increased river bank erosion and demands for protection structures; • Increased pressure of disaster relief systems; • Increased risk to human lives and health; • Negative impact on agriculture such as lower productivity levels and loss of harvest.
Increased mean sea level and associated storm surges	• Salt water intrusion into ground water and coastal wetlands; • Increased storm surges leading to coastal flooding, coastal erosion and damage to coastal infrastructure; • Increased impact on estuaries and associated impacts on fish and other marine species.

The provincial climate change strategy also lists a number of priority responses in each of the key sectors. These are summarised in Table 3 below:

Table 3: Priority Climate Change Adaptation Responses for the Western Cape Province.

Adaptation Category	Adaptation Responses
Water Security and Efficiency	• Invasive alien vegetation clearing; • Prioritisation, valuation, mapping, protection, and restoration of ecological infrastructure in catchments; • Effective utilisation of irrigation water; • Resource nexus decision support; • Develop ecosystem goods and services (EGS) investment opportunities.
Biodiversity and Ecosystem Goods and Services	• Prioritisation, valuation, mapping, protection, and restoration of ecological infrastructure; • Landscape initiatives/biodiversity corridors and identification of requirements for climate change adaptation corridors; • Biodiversity stewardship; • Mainstreaming of conservation planning into decision making.
Coastal and Estuary Management	• Establishment of coastal hazard overlay zones and setback lines; • Research best practice regarding responding to repeated coastal inundation in high risk areas; • Protecting and rehabilitating existing dune fields as coastal buffers / ecological infrastructure; • Monitor possible linkages between climate change and fisheries industry; • Ensure Estuary Management Plans take cognisance of climate change.
Food Security	• Farming practices that are in harmony with nature, i.e. 'conservation farming'; • Climate smart agriculture; • Agricultural water technologies that reduce consumption and increase efficiency; • Research on climate resilient and alternative crops and livestock applicable to the Western Cape; • Addressing climate vulnerability through the Municipal Support Programme; • Assessing food security in the context of the resource nexus.
Managing the effects of increased temperature on human lives	• Societal adaptation to human health impacts from temperature increases associated with climate change.
Healthy Communities	• Monitoring health trends in relation to climate trends; • Research linkages between human health and climate change in the WC context. These include: Air quality, Water quality, Food security, Heat stress, Disease vectors

2.1 Climate Change Projections for the Western Cape

Projections of future rainfall entail intricate complexities, contingent upon diverse models, scenarios, and temporal scopes. This complexity underscores the challenge of predicting future precipitation patterns accurately (DEA&DP, 2025). Figure 5 indicates that there are expectations of continued cycles alternating between wetter and drier years, persisting over the next 20-30 year period, further complicating long-term water resource management strategies (DEA&DP, 2025; Ziervogel *et al,* 2022).

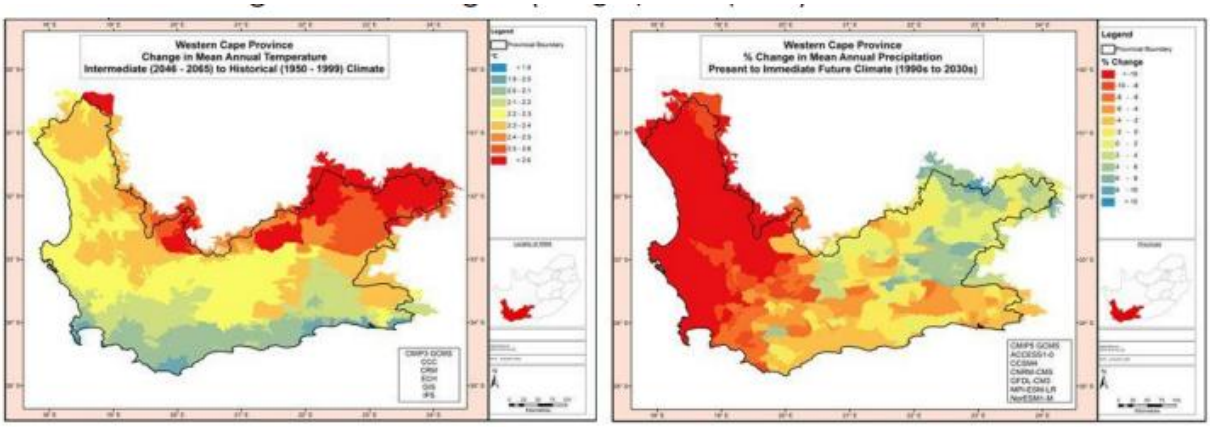

Figure 5: Projected changes in mean annual precipitation in the Western Cape expressed in mm (left) and as a percentage (right) between the period 1990s and the period 2030s (DEA&DP, 2025; Ziervogel et al, 2022).

Climate projections in the Western Cape indicate strong evidence of shifting temperature in the form of significant increases in temperature across all seasons. This is contributing to more frequent and intense droughts in parts of the province together with an increase in the number of hot days (Figure 6) (DEA&DP, 2025).

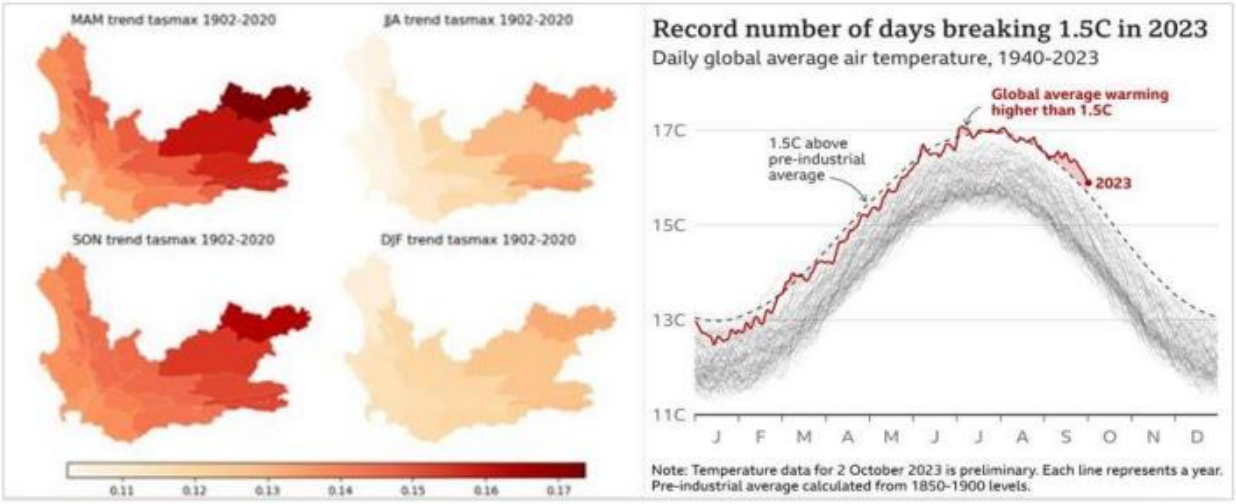

Figure 6: Left: Mean seasonal daily maximum temperature trends (°C/decade) across Western Cape SmartAgri zones based on the CRU TS4.05 dataset from 1902-2020 (Jack et al 2022); Right: Record number of days breaking 1.5 degrees. ERA5 (2023).

Future climate scenarios indicate an interplay between multifaceted climate-related events, which will contribute significantly to the prevalence of climate-related events and the need for behaviour change - lifestyle changes and alternatives to the business-as-usual. These will require proactive adaptation measures designed and implemented through partnerships between diverse stakeholders (DEA&DP, 2025).

3 The Garden Route District Municipality

Garden Route District Municipality is one of five district municipalities within the Western Cape Province. The district is situated on the south-western portion of the province and comprises of the following seven local municipalities: Bitou, George, Hessequa, Kannaland, Knysna, Mossel Bay, and Oudtshoorn Local Municipality. The district municipal area has a total population of 838 457, Statistics South Africa, 2022). Between 2023 and 2027, the population of the GRD is projected to grow by an average of 0.9 per cent annually, and the number of households in the district is set to increase at an average annual rate of 1.8 per cent, primarily because of declining household sizes during this period. The George local municipality is home to a great proportion of the district's population, and Kannaland local municipality is home to the least proportion of the district's population. The district is the largest and most rural district in the Western Cape Province (Garden Route District Municipality, 2017b).

The Garden Route district is a place of exceptional natural beauty which offers a range of environmental goods and services that, to a large extent, underpin the economic activity in the area. This "sense of place" has resulted in the district being collectively termed "The Garden Route" and is a major tourism draw card. However, the same things that form part of this tourism draw card, such as the lovely beaches, estuaries and rivers, pose a serious disaster risk to the area, particularly in the face of a changing climate. Over the past decade the district has been hit annually by climate related extreme events, resulting in a string of massive floods, coastal inundation, fires, and water crisis and drought.

3.1 Garden Route District Climate Overview

The climate of the Garden Route district is classed as Mediterranean, and as such is largely a winter rainfall region. Winter rainfall is the result of mid-latitude disturbances commonly known as cold fronts. While these frontal systems continually pass to the south of the country all year round, during winter their tracks move northwards and their influence on the regional climate is significant. Flood events are often associated with strong cold fronts or their closely related cousins, cut-off low pressure systems, which are more frequent during the transition seasons (i.e. spring and autumn).

The mean annual rainfall for the varies significantly, from as low as 170 mm in the drier Klein Karoo (Oudtshoorn) to over 1,200 mm in the Knysna forests, with mountain peaks receiving even more, showcasing a diverse climate influenced by mountains and coastlines. Lower coastal areas might see 250-650 mm annually, while higher mountain ranges can average 1,000 mm or more, with some peaks exceeding 2,500 mm. The following key rainfall variations occur within the district:

- Forests (e.g., Knysna): Around 1,200 mm annually;
- Coastal areas (e.g., Mossel Bay/Hartenbos): Lower, with Hartenbos receiving about 334 mm/year, distributed year-round;
- Mountain Ranges: Can average 1,000 mm or more, with peaks receiving significant rainfall;

- Klein Karoo (e.g., Oudtshoorn): Drier, with rainfall as low as 170 mm.

The Garden Route district also has moderately hot summers and mild winters, but temperatures vary significantly from the coast to the inland Klein Karoo, averaging summer highs around 25°C and winter lows around 8-10°C, with potential for extreme heat (40°C+) or near-freezing conditions inland.

The historical climate monthly averages for the Garden Route district area have been calculated by the University of Cape Town's Climate Systems Analysis Group using the nearest weather data station to the Municipality, which is the measuring station at George. The graph below (Figure 7), shows that average temperatures peak in January and February, while rainfall is fairly consistent throughout the year, indicating that the Garden Route district area is a year-round rainfall area (Climate System Analysis Group, 2017b). The lowest average monthly rainfall historically occurs in June, which averages less than 38 mm (Climate System Analysis Group, 2017b).

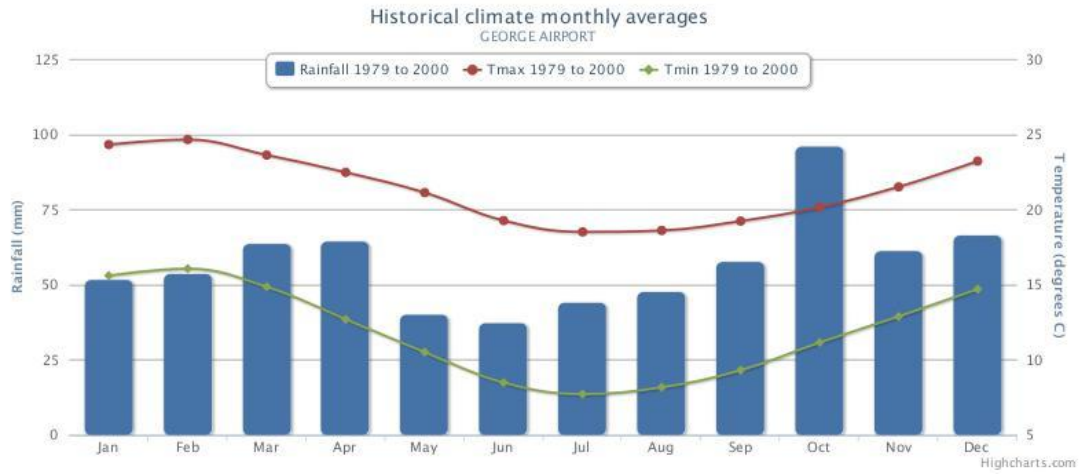

Figure 7: Historical Climate Monthly Averages for George (Climate System Analysis Group, 2017b).

3.2 Future Climate Change Projections for the Garden Route District

Climate change is predicted to have an impact on rainfall patterns in South Africa. Future rainfall projections for the Garden Route District Municipality (using the measuring station at George), for the period 2020 to 2040, are made using the Representative Concentration Pathways (RCP) greenhouse gas concentration trajectories (Climate System Analysis Group, 2017a). The bar chart (Figure 8) shows the potential change in rainfall, with the blue bars indicating a potential increase in average rainfall and the red bars indicate a potential decrease in average rainfall (Climate System Analysis Group, 2017a). The grey lines represent the various models used for this projection. It is therefore projected across most of the models that Garden Route district could experience an increase in rainfall in the months of January, February, March, April, July, September, October and December, and a decrease in rainfall during May, June, August and November (Climate System Analysis Group 2017a).

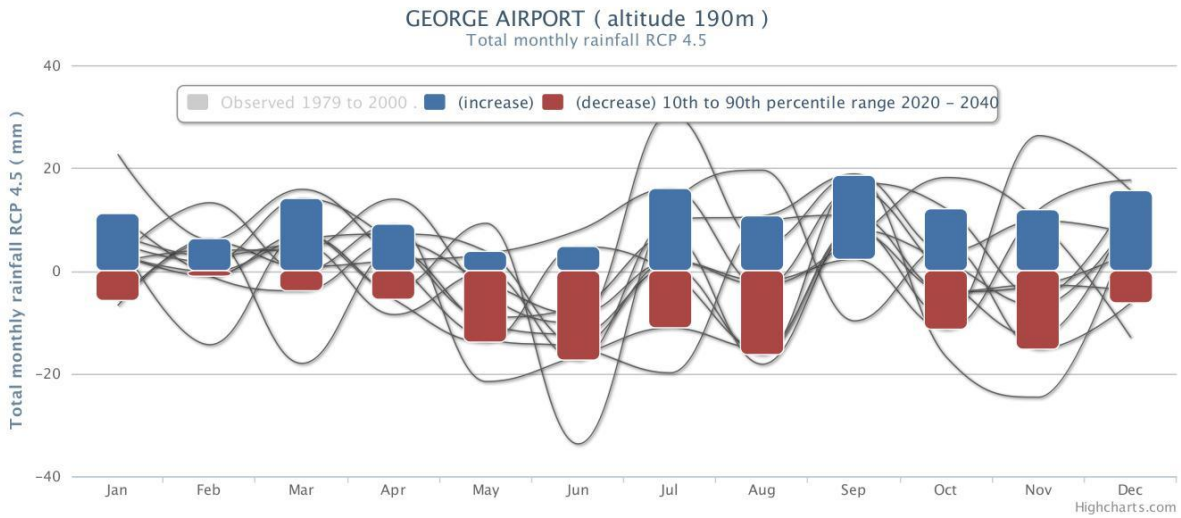

Figure 8: Rainfall Projections for George (Climate System Analysis Group, 2017a.).

Climate change impacts for the Western Cape carry a high degree of uncertainty due to the complexity of the frontal systems, and their interaction with the complex topography of the region. However, there is a fairly confident message present in two strong climate drivers, which adds weight to some of the changes projected. The first is the shift in the South Atlantic High Pressure systems further south. Many models produce a similar shift south in the future and the result is to push the winter cold fronts further south, away from the country, during winter.

However, a counterpoint to this is the increase in atmospheric moisture due to a warmer climate. Orographic (mountain) rainfall is a significant component of rainfall in the mountainous regions of the Western Cape, and the magnitude of such rainfall is often limited by the moisture content of the air flowing over the mountains. Increases in the moisture content could produce more orographic rainfall in mountain locations. The net result is a possible shift towards generally drier conditions but with wetter conditions in mountain locations (e.g. coastal region of the Garden Route district). Many river catchments include large portions of mountainous regions and hence the impact of climate change on river flows is likely to be complex and require a considerable modelling effort.

The Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) has forecast that climate change is predicted to increase temperatures and rainfall variability, while decreasing the total average rainfall in the west of South Africa (Department of Environmental Affairs, 2013c). The predicted increases in mean average temperature (Figure 9), shows that the inland parts of the Garden Route District Municipal area are projected to experience medium to high range warming, with the expectation of the Bo-Langkloof-Outeniqua SmartAgri Zone, which is projected to experience low to medium range warming (Western Cape Department of Agriculture, 2017). Meanwhile all the coastal parts of the district Municipal area are projected to experience a low range of warming (Western Cape Department of Agriculture, 2017).

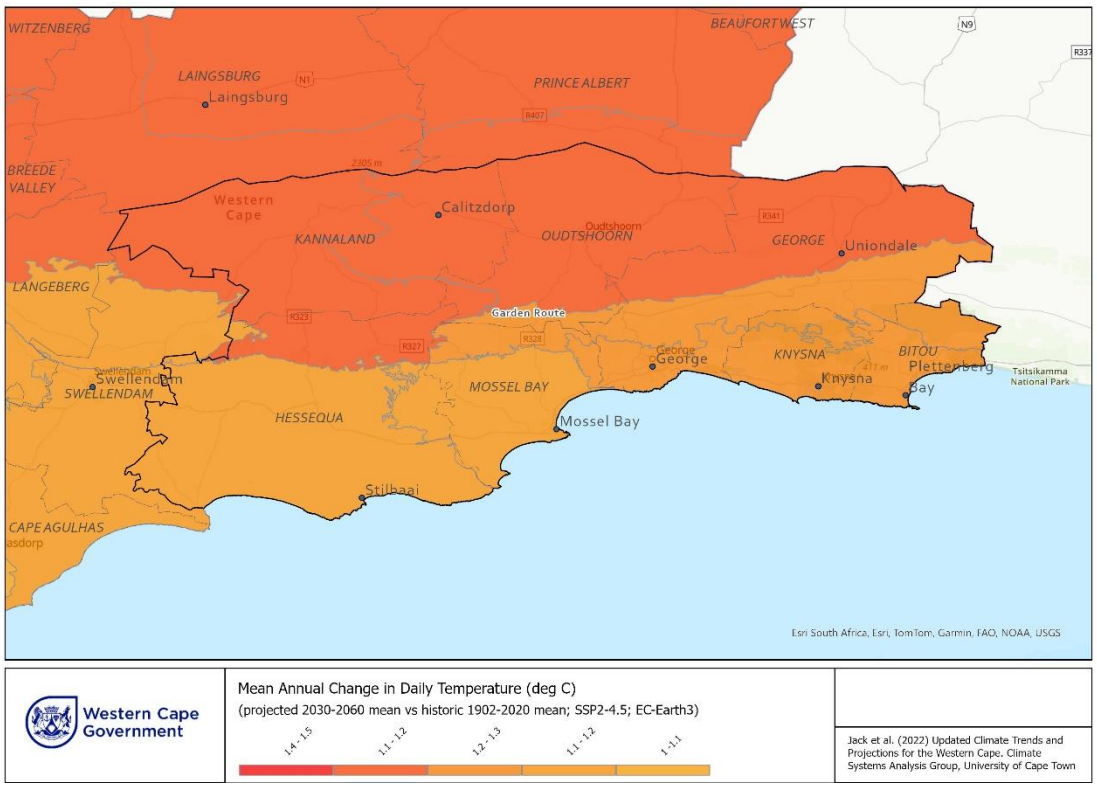

Figure 8: Temperature projections in the District Municipal area (DEA&DP, 2025; Jack et al., 2022).

Looking into the future, climate and natural land cover conditions within the Garden Route district are projected to continue to change. The capacity of our ecosystems to cope with anticipated changes in climate and fire thus need to be evaluated. A schematic representation of the main cascading impacts resulting from environmental changes caused by climate change is shown in Figure 10. In the Figure the direct flow of impacts is represented by large arrows. Important indirect impacts are shown as feedback. Climate change-fire-biodiversity effects operate throughout the complex cascade, as they are affected directly by environmental changes to disturbance regimes such as temperature, CO2 or rainfall (Box 1; Environment), interactive effects on species and ecosystems (Boxes 2 to 5; Individual biology to Ecosystems), and by the choices society makes about various landscape values (Box 6; Societal values). Fire regimes interact with all these processes.

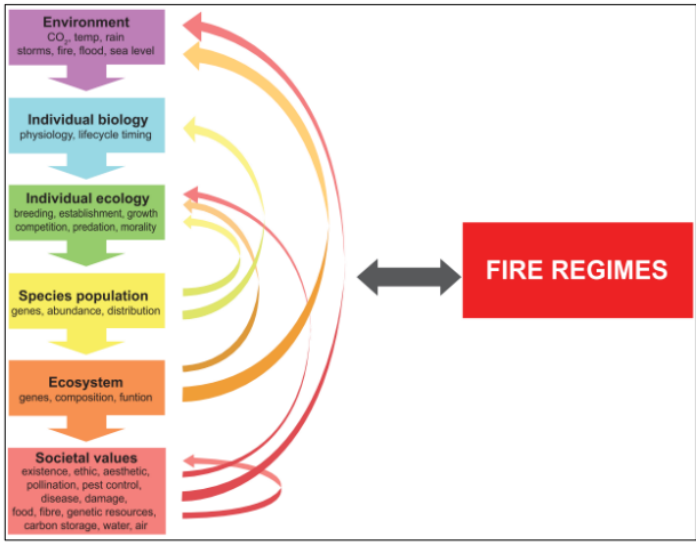

Figure 10: Schematic representation of cascading impacts resulting from environmental changes caused by climate change (Morena, 2014).

Going into the future, weather, as well as climate and fuel factors, are hypothesised to respond non-linearly to climate change, and specific responses, which are so critical for accurately predicting fire frequency, intensity and burned areas, will be highly locality dependent.

Finally, many projections suggest that changes in rainfall will occur through shifts in seasonality. Most distinctly, through decrease in peak winter rainfall but possible increases in the transition or “shoulder” seasons of autumn and winter. This shift agrees with the two large scale drivers discussed above as the shoulder season rainfall is often dominantly orographic while the core season rainfall is dominantly driven by strong cold frontal systems which, under climate change, could shift further from the continent.

There is some evidence that some of these changes are already being experienced, which adds further weight to the evidence for general drying, seasonal shifts, and increased mountainous rainfall. Climate change is predicted to increase the number and severity of droughts, fires and floods in the in the Garden Route district area (Garden Route District Municipality, 2014). To counter these risks, the Garden Route District Municipalities should conserve their water resources, wetlands and biodiversity, through updated land-use and settlement plans that take disaster risk management criteria into account, and by increasing public awareness regarding water conservation, droughts, fires and floods (Garden Route District Municipality, 2014, 2017a). This is particularly pertinent given the recent devastating fires in and around the Garden Route as well as the severe ongoing drought in the Western Cape (Garden Route District Municipality, 2014, 2017a).

4 Major Climate Change Impacts of Extreme Concern in Garden Route District

The district's vulnerability to climate change impacts is attributed to its physical location, topography and general climate conditions (Garden Route District Municipality, 2017a). In addition, increased vulnerability to climate change has been caused by rapid urbanisation and informal developments (Western Cape Government, 2013). Urbanisation has increased because of in migration of the youth from the Eastern Cape and the elderly to the coastal towns (Garden Route District Municipality, 2017b). However, housing delivery has not been able to keep up with the migration, hence the ongoing increase in informal dwellings in the district (Garden Route District Municipality, 2017b). Furthermore, the natural and scenic beauty of the district is a major tourist attraction that could be negatively affected by the impacts of climate change (Garden Route District Municipality, 2017a).

The following climate change impacts have already been observed in the district: increased average temperatures; shifts in seasonality; increased frequency of veld fires; increased magnitude and frequency of storm events accompanied by strong winds; more frequent and severe storm surges; and increases in rainfall variability and the number of dry days (Garden Route District Municipality, 2014). In addition, sea level rise and associated hazards are a major concern for coastal areas within the district (Garden Route District Municipality, 2012). Sea level rise impacts are likely to include inter alia coastal erosion, flooding, destruction of infrastructure and saltwater contamination of freshwater bodies (Western Cape Government, 2013).

Major climatic hazards in the district include: drought, floods and veld fires (Garden Route District Municipality 2014, 2017a). Climate change is expected to increase the frequency and severity of these hazards (Garden Route District Municipality, 2014). Additionally, financial losses in the district, due to these climate hazards, has already been high (Garden Route District Municipality, 2014) For example, it was estimated that the 2009/2010 drought cost the district R 300 million, while the cost of the 2011 floods was estimated to be R 350 million (Garden Route District Municipality, 2014). Furthermore, approximately 45% of the district's disaster relief budget is allocated to the repair and maintenance of road infrastructure after flood damage (Garden Route District Municipality 2014). Another 45% of the district's disaster relief budget is spent on fire-related disasters (Garden Route District Municipality, 2014).

4.1 Drought and Water Security

Water is a key resource for socio-economic development, food security and healthy functioning ecosystems in the province. Deteriorating water catchments, poor governance and inadequate infrastructure maintenance contribute to water availability and access challenges. At the same time, climate drivers such as seasonal shifts and rainfall variability (number of rain days and intensity) continue to pose threats to water security across the Western Cape (DEA&DP, 2025). It is anticipated that climate change will result in higher temperatures, lower rainfall and increased rainfall variability in the Garden Route district (Garden Route District Municipality, 2014, 2017b). Furthermore, impacts such as more frequent and intense droughts, fires and floods are predicted to not only result in agricultural

losses but also impact other sectors of the local economy as well (Garden Route District Municipality, 2014, 2017b, 2017a).

The Garden Route District Municipality falls mainly under the Breede-Gouritz/Berg Hydrological Zone, while small areas in the east fall within the Mzimvubu-Tsitsikama Hydrological Zone (Department of Environmental Affairs, 2013d). Under a warmer wetter scenario, the Breede-Gouritz/Berg Hydrological Zone is predicted to experience an increase in rainfall in winter and spring, and a decrease in autumn (Department of Environmental Affairs, 2013d). While under a hotter and drier scenario, the region will experience a decrease in rainfall in all seasons and a strong decrease in rainfall in the west of the Hydrological Zone (Department of Environmental Affairs, 2013d).

Most of the Garden Route district falls under the Breede-Gouritz Water Management area (Figure 11), while small parts in the east fall within the Mzimvubu-Tsitsikama water management area (Department of Environmental Affairs, 2013d).

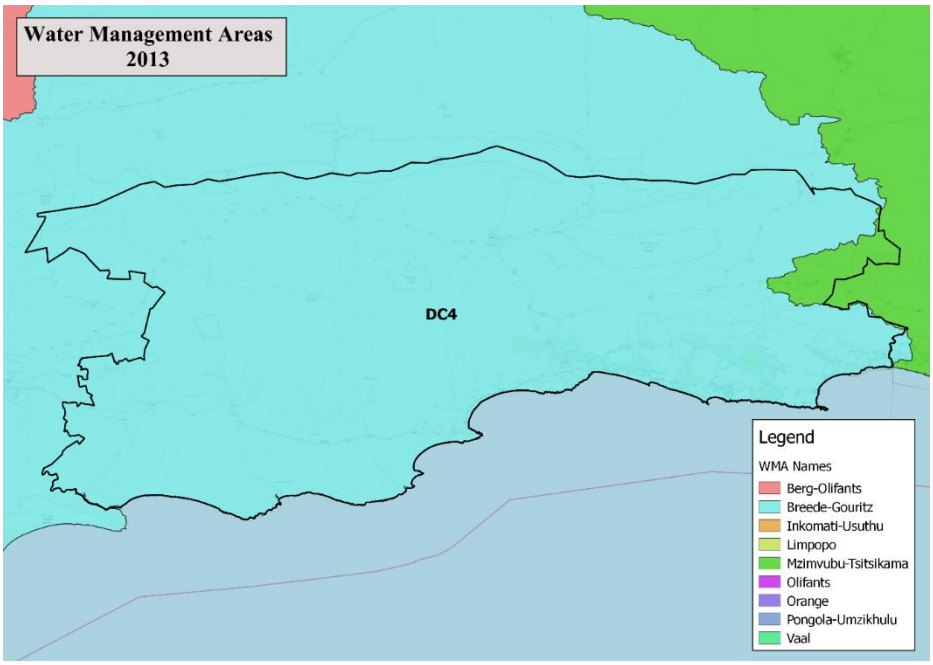

Figure 9: Water Management Area for the District Municipal Area (Department of Water Affairs, 2013).

Within the Garden Route District area there are 24 main water resources (such as dams, lakes and estuaries), some of which are the: Stompdrift, Garden Route, Wolwedans, Tierkloof and Prinsrivier Dams; Knysna and Sedgefield Lagoons; Groenvlei; Swartvlei; Rondevlei; and the Touws River Estuary (Department of Water and Sanitation, 2016b). While these resources are spread throughout the Garden Route district area (Figure 11), they are mostly found in the south of the district (Department of Water and Sanitation, 2016b).

4.1.1 Declining River States

The river quality within the Garden Route district area is mostly in a poor state, which means that many rivers are unable to contribute towards river ecosystem biodiversity targets (SANBI, 2011). The health of a river system is graded into one of several categories (SANBI, 2011). These categories are listed in Text Box 1.

Text Box 1: Freshwater Ecosystem Priority Areas (FEPAs) classification for river ecosystem conditions

River conditions in South Africa have been classified according to the Freshwater Ecosystem Priority Areas (FEPAs) for river ecosystems (SANBI, 2011). The different grades are provided below:

A = Unmodified, Natural
B = Largely Natural with Few Modifications
Ab = A or B Above
C = Moderately Modified
D = Largely Modified
E = Seriously Modified
F = Critically/Extremely Modified
Ef = E or F Above
Z = Tributary Condition Modelled as Not Intact, According to Natural Land Cover

Rivers that are unmodified or in their natural state are able to contribute towards river ecosystems biodiversity targets (SANBI 2011). In contrast, rivers that are categorised as 'largely modified' or worse are unable to contribute towards river ecosystems as they are not in a good state.

Several of the main rivers in the Garden Route district area, such as the Kammanassie, Olifants, Touws, and Wynands Rivers, as well as some sections of the Groot River, are classified as 'largely modified' (SANBI, 2011). Additionally, the Gourits River and sections of the Groot River are classified as 'moderately modified' (SANBI, 2011). Furthermore, most tributaries are classified as either 'largely natural with few modifications' or 'tributary conditions modelled as not intact, according to natural land cover' (SANBI, 2011).

4.1.2 Increased Aquifer Vulnerability

There are several aquifers in the Garden Route district area that are already highly vulnerable to contamination by pollution, however more of the aquifers in the Garden Route district municipal area have a medium vulnerability (Western Cape Department of Agriculture, 2017). Residents in some of the inland parts of the district already rely to varying degrees on groundwater and if these aquifers were to become polluted or over-utilised, water security in the district would diminish (Western Cape Government, 2016; Garden Route District Municipality, 2017a).

4.1.3 Decreased Groundwater Quality

The groundwater quality in the Garden Route district area has mostly lower categories of electrical connectivity, however, groundwater in some western parts of the district already have very high levels of electrical connectivity (Western Cape Department of Agriculture, 2017). These electrical connectivity categories represent how salty the groundwater is,

which is one way of measuring the water quality in the aquifers. The higher the level of salts in the water, the poorer the groundwater quality is.

4.1.4 Impact of Droughts on Agriculture

Observations of climate change impacts in the Western Cape's SmartAgri Zones indicate that significant climate change driven impacts will continue to negatively affect agricultural production and subsequent/ associated value chain (DEA&DP, 2025).The predicted changes in average rainfall and temperature in the district are forecasted to reduce the areas that are suitable for viticulture, or shift them to areas that are higher or cooler than current locations. The reduction in rainfall (and runoff) is predicted to reduce the yields of fruit and vegetables, notably deciduous fruit and rain-fed wheat production in the Western Cape (Department of Environmental Affairs, 2013c). Furthermore, the production of fruit (such as apples and pears) and sugar cane will be increasingly vulnerable to damage from a predicted expansion of the areas affected by agricultural pests (Department of Environmental Affairs, 2013c).

By decreasing agricultural yields, climate change could also impact the agriculture sector by reducing profitability and job opportunities in the sector, as well as increasing food security risks, especially amongst subsistence farmers and their dependents (Department of Environmental Affairs, 2013c; Garden Route District Municipality, 2014, 2017b). Indeed, the Garden Route District Municipality's 2025/26 Integrated Development Plan (IDP) has noted that climate change impacts could have dire consequences for the agriculture sector in the District Municipal area (Garden Route District Municipality, 2025).

4.1.5 Impact of Droughts on Water and Sanitation Services Provision

Linked to the rainfall and rivers in the Garden Route district area is its water and sanitation services. Specifically, a total of 2.3 % of households in the Garden Route district area do not receive their water from piped water schemes, which is lower than the national average of 0.6 % (Statistics South Africa, 2022). Furthermore, the percentage of the population with flush toilets in the Garden Route district area is 96.9 %, while the national average is 95.2 % (Statistics South Africa 2022). This indicates a good spread of sanitation access within the Garden Route district area.

Although the Garden Route district has high scores for the provision of water and sanitation services to households, there is still room for improvement. Accordingly, the Garden Route District Municipality, in its 2025/26 Integrated Development Plan, has identified the need for increased efficiency in the use of water and other natural resources, while enabling environmentally sustainable developments (Garden Route District Municipality, 2025). This is especially necessary given the ongoing drought in the Western Cape, and the water supply issues in Knysna and surrounding areas.

4.2 Increasingly Frequent and Intense Fire Events

Wildfires are a major hazard in the Garden Route district and are responsible for large areas burned every year. As climates become hotter and moisture regimes change, and as elevated CO2 levels change the rate of fuel accumulation, new and different fire regimes will come into play in the Garden Route district landscape. Burned areas result mainly from the interaction of flammable vegetation (fuel) that can support combustion and the prevalence of hot, dry spells or seasons which predispose these landscapes to burn whenever there is a source of ignition (Schulze and Schütte, 2016). Fires are thus driven by dry spells and other weather anomalies such as heat waves, by low humidity and strong winds, each of which can play a major role in determining fires. Extreme episodes, such as long dry spells, can be most relevant in determining fire season severity, and improvements in weather forecasting (daily, seasonal, annual) may allow for developments in fire danger and risk prediction.

Veld fires occur mainly between November and February, however, in Knysna they occur throughout the year (Western Cape Government, 2013). Increases in the frequency and intensity of veld fires have had negative impacts in the agricultural, forestry and tourism sectors. The risk of veld fires is high for most of the Garden Route district, however, there are areas of extremely high veld fire risk in the south, and low veld fire risk in many parts in the north and west of the district.

4.3 Impacts of Climate Change on Human Health

In the field of human health, climate change poses a major and largely unfamiliar challenge (WHO, 2005b). There is an increasing amount of information available to climate change scientists and the assessments of likely changes are no longer based on possible future scenarios and models, but rather on observations on global climate data. Thus, the picture of future changes is becoming clearer, but the impact on human health has not yet been determined in depth or with narrow margins of certainty. What is clear, however, is that the increasing understanding of climate change is transforming how we view the determinants of human health (WHO, 2003).

There are some fundamental factors that should be borne in mind in any discussion on climate change and the effects that its accompanying processes may have the environment and human health, such as (WHO, 2003):

- Climate change does not cause novel environmental exposures, but may exacerbate the burden of climate-sensitive diseases. The size of the impact will depend on the implementation and effectiveness of timely interventions.
- Climate change results from both natural and human-induced processes. Emissions of greenhouse gases affect human health at different scales. At the local scale, particulate matter emitted by vehicles has harmful effects. At the regional scale, transport of sulphur and nitrogen oxides causes acid deposition. At the global scale, the links between climate change and local environmental factors produce a range of hazards to human health.

Broadly, a change in climatic conditions can have three kinds of health impacts (WHO, 2003):

- Those that are relatively direct, usually caused by weather extremes. [DIRECT]
- The health consequences of various processes of environmental change and ecological disruption that occur in response to climate change. [INDIRECT]
- The diverse health consequences – traumatic, infectious, nutritional, psychological and other – that occur in demoralized and displaced populations in the wake of climate-induced economic dislocation, environmental decline, and conflict situations. [MULTI-STAGE]

Climate change has been deemed the "greatest global health opportunity of the 21st century" (Watts *et al*., 2015) and the impacts of climate change on human health are featuring more prominently in global discussion. Considerations of climate change and health at the regional level, particularly in Africa, are limited (Baker *et al*., 2012; Pasquini *et al*., 2013). Climate change is a cross-cutting concern of many sectors, especially health, and developing locally appropriate regional health strategies is often challenging for governments of low- and middle-income countries (LMICs), particularly as there is a plethora of information available from a global perspective, which may not be applicable to, or translated for, local conditions.

Climate change impacts affect the social and environmental determinants of health which include clean air, secure shelter, safe drinking water, and sufficient food (World Health Organization, 2017). Below are some general climate change manifestations and their associated impacts on human health (World Health Organization, 2017):

- Natural disasters - The frequency and severity of natural disasters has increased. Natural disasters destroy health facilities and homes. People may be forced to vacate their properties leading to increased risk to a wide range of health effects including communicable diseases and mental disorders;
- Increased storm events - These affect the supply of fresh water consequently increasing the risk of diarrhoeal diseases;
- Floods - The frequency and intensity of floods has increased. Floods pollute water supplies and increase the risk of water borne diseases. In addition, people lose their life's as a result of drowning or physical injuries, property is damaged and the supply of health services is disrupted;
- Climate change will also impact the distribution and causes of several communicable diseases including cold-influenza and dry-meningococcal meningitis among others (Singh and Kistnasamy, 2014).
- Changes in climate conditions also affect vector-borne diseases that are transported through organisms such as snails, insects and other cold-blooded animals. With climate change the transmission season will lengthen and the geographic range of some vector borne diseases will change;
- Increased temperatures and variable rainfall are likely to reduce agricultural yields consequently increasing the prevalence of malnutrition and hunger as a result of food insecurity;
- Increased heat stress leads to death which can be attributed to cardiovascular and respiratory diseases;
- Increased air pollution and increased occupational health problems.

The main climate change disaster risks that are likely to affect human health in the Garden Route district area are wildfires, drought, severe storms and floods (Garden Route District Municipality, 2014).

4.4 Invasive Alien Species and Climate Change

Over the past few decades globalisation has increased the movement of people and goods around the world, leading to a rise in the number of invasive alien species (IAS) introduced to areas outside their natural ranges. A 2017 study in the journal *Nature Communications* found that over one third of all introductions in the past 200 years occurred after 1970, and the rate of introductions is showing no sign of slowing down. Invasive alien species are an animal, plant or other organism that is introduced by humans, either intentionally or accidentally, into places outside its natural range. Some alien species – classed as "invasive" – become established and negatively impact native biodiversity, as well as ecosystem services on which humans depend.

IAS are compounded by climate change, which facilitates the spread and establishment of many alien species and creates new opportunities for them to become invasive. Extreme climatic events resulting from climate change, such as storms, floods and droughts can transport IAS to new areas and decrease the resistance of habitats to invasions. Alien invasive vegetation species' germination rates are also increased due to increasingly frequent fire events due to a drying climate. Climate change is also opening up new pathways of introduction of IAS. Climate change can cause IAS to have the ability to expand rapidly to higher latitudes and altitudes as the climate warms, out-pacing native species. Alien species that are regularly introduced by humans but have so far failed to establish may succeed in doing so thanks to climate change, creating new sets of invaders. Some habitats, such as temperate forests and freshwater systems that currently have thermal barriers limiting the establishment of IAS will become more suitable for alien species as the climate changes. The increase and geographic redistribution of IAS will have diverse societal and environmental impacts. Biological invasions are a major threat to food security and livelihoods, with developing countries being the most susceptible.

Invasive alien plant (IAP) infested natural habitats suffer reduced capacity to produce ecosystem services that help support a healthy and productive living environment for people. Availability of natural products, such as medicinal plants, fodder and building materials is decreased, and disease-carrying pests such as mosquitoes and rats may be more numerous due to a reduction in natural predators with declining ecosystem functioning (Terblanche *et al*., n.d.). The aesthetic, recreational and cultural values of the natural environment are also significantly decreased where IAP's take over. IAP's also threaten local and national water security. The notable reduction of South Africa's water resources from IAP infestations has far-reaching ecological, economic and social implications. In KwaZulu-Natal, IAP's have been estimated to use approximately 576 million m3 of water per annum. This is 5% of the province's Mean Annual Run-off (MAR), and is equivalent to 230mm of rain falling across KZN per year being used up by IAPs (Terblanche *et al*., n.d.). Every large invasive alien tree, such as Eucalyptus grandis, can use between 100 and 1,000 litres of water per day – which is significantly more than the average indigenous tree (Terblanche et al., n.d.). Considering that South Africa is a drought-prone country that already uses 98% of its available water

resources, the increasing loss of water through IAPs is a serious issue (Terblanche *et al*., n.d.).

Invasive alien plant species are especially negatively impacting on the Garden Route district's indigenous biodiversity, ecosystem services or human well-being. IAP's are reducing the district's resilience of natural habitats, making the area more vulnerable to the impacts of climate change. The high alien invasive plant infestations withing the Garden Route district is resulting in the occurrences of severe fire disasters within the district by significantly altering the natural fire regimes, especially in areas that are becoming warmer and drier. This increases the frequency and severity of wildfires and puts habitats, urban areas and human life at risk.

4.5 Climate Change Impacts on Coastal Environments

The coastal zone in South Africa includes the inshore, offshore and estuarine ecosystems. It is a continually changing area where land and ocean meet, and includes beaches, rocky shores, estuaries, wetlands and the ocean near the coast (Nelson 2013; Provincial Government of the Western Cape, 2005). A coastal zone extends seaward up to the boundary of the exclusive economic zone, which is 200 nautical miles (roughly 370 km) out to sea, and inland up to one kilometre after the high-water mark (Republic of South Africa, 2014).

Climate change is predicted to result in several changes to South Africa's coastal zone (Department of Environmental Affairs, 2013e, 2012). It is forecast that climate change will:

1. increase impacts on marine and benthic ecosystems;
2. increase impacts on estuary ecosystems;
3. increase impacts on coastal livelihoods, and;
4. increase impacts on infrastructure and property due to sea level rise.

With regards to impacts from sea level rise, the Long-Term Adaptation Scenarios specifically considers all land under 5.5 metres (m) above the current mean sea level to be part of the coastal zone (Department of Environmental Affairs, 2013f). The reason for this is that 5.5 m is the maximum estimated height of land that could be affected by the predicted increases in storm surges, sea level rise and tidal fluctuations by the year 2100 (Department of Environmental Affairs, 2013f).

Theoretical, observational and numerical studies all show that predicted changes in the next fifty years shows that the large-scale current systems around South Africa will change in their average physical properties and behaviour due to anthropogenically induced alterations to the earth's atmosphere. These predicted changes to the large-scale ocean currents will impact on the coastal zone and change the average properties and circulation patterns.

Lutjeharms and de Ruijter (1996) showed that the Agulhas Current will exhibit increased meandering, which will force the current (on average) further offshore from its contemporary mean position. In the present global climate regime, the Agulhas Current is located within 15 km from the shore along the east coast of South Africa 77% of the time. However, perturbations in the form of large intermittent meanders force the current's core up to 300 km offshore. The meander modes of the Agulhas Current impact between four to six times a year. Lutjeharms and de Ruijter (1996) suggest that the meander modes will increase in

frequency due to global warming and that the current will on average be located further from the coastline. This will impact on the socio-economics of the eastern and southern coastal zones.

The western coastal zone, which consists mainly of the Benguela Upwelling System, will exhibit more intense upwelling due to a predicted increase in wind stress over the southern Atlantic on account of global climate change (Lutjeharms *et al*., 2001). This will induce much cooler sea surface temperatures (SST) along the west coast of South Africa than at present. However, an intensification of the South Atlantic Sub-tropical gyre may also lead to increased atmospheric subsidence, fewer clouds, increased insolation and higher air temperature. The latter will result in warming of the surface water, which may negate the increased upwelling and offshore transport of cooler waters.

The increase in surface temperatures leads to an increase in sea levels through the interaction of various processes such as thermal expansion of the oceans and melting of glaciers. It is predicted that climate change may also bring greater storm intensities. This makes coastal settlements vulnerable, especially considering that coastal zones are densely populated and growing rapidly. Coastal resources are expected to be affected by a number of consequences of climate change, namely higher sea levels, higher sea temperatures, changes in precipitation patterns and sediment fluxes from rivers, altered oceanic conditions as well as changes in storm tracks, frequencies and intensities.

Climate change may also have a negative effect on coastal livelihoods (Department of Environmental Affairs, 2013e). Predicted increases in the severity and frequency of storms and sea level rise may reduce the number of feasible fishing days and cause damage to shore-based infrastructure (e.g. harbours and launch sites) and fishing boats (Department of Environmental Affairs, 2013e).

Climate change can cause extreme storm events which can result in coastal erosion and flooding disasters along the coast. Our oceans have absorbed about 90% of excess heat connected to rising greenhouse gas emissions from human activities in recent decades (Aster et al., 2023). That excess energy increases the ocean wave energy which can cause a higher frequency in damaging waves and more severe storm surge events along our coastline.

Climate change is expected to reduce the diversity and quantity of fishes and other biota in estuarine ecosystems (as well as inshore and offshore ecosystems) through changes to: land and sea surface temperatures; frequency and distribution of precipitation; water runoff patterns; increased coastal storm frequency and intensity; oxygen levels; and wind (Department of Environmental Affairs, 2013e). Sea level rise may also cause saltwater intrusions into estuarine and agricultural lands which can lead to a reduction in their ecosystem services (Atkinson and Clark, 2005).

4.6 Climate Change and Energy Provision

Tourism along the Garden Route district's results in, particularly, energy management and waste challenges, as infrastructure and supply have to cope with large tourism season-driven peaks. This would mean that distribution infrastructure has to be able to cope with a seasonal peak demand that is far higher than the yearly average demand.

The district has an average annual carbon emissions level of 7.3 tonnes per person; higher than the global average of 4 tonnes per capita, but on a close par with provincial average and the national average of 8.0 and 7.7 tonnes per capita respectively. This carbon footprint is substantially higher within industrial towns compared to non-industrialised towns. However, when looking at the of energy consumed per unit of economic output and as well greenhouse gas emissions per unit of economic value, then the area can be seen to be a relatively high user of energy and carbon emitter.

While the energy consumption in this district is small and it represents a very small part of the total provincial consumption (8% of the provincial total), important saving opportunities exist within the built environment as well as the industrial sector. The Garden Route district experiences the highest level of energy poverty of all the districts/metros. It's per capita energy and waste GHG emissions footprint is in line with the provincial average, but this masks a large range; from 3 tonnes per capita in Kannaland and Oudtshoorn, and 5 in George (the largest town after Cape Town), to 8 in Mossel Bay (a heavy industrial area). Garden Route has the second-highest vehicle ownership, which, combined with the high energy poverty, may indicate large wealth inequality. Liquid fuel represents the largest amount of energy consumed in the district, while electricity use is the cause of the most GHG emissions. Industry uses about half of the district's electricity, with the residential sector consuming a third.

4.7 Climate Change and Air Quality Management

The rise in the average global temperature is due, primarily, to the increased concentration of gases known as greenhouse gases (GHGs) in the atmosphere that are emitted by human activities. These gases intensify a natural phenomenon called the "greenhouse effect" by forming an insulating layer in the atmosphere that reduces the amount of the sun's heat that radiates back into space and therefore has the effect of making the earth warmer.

While weather changes on a daily basis, climate represents the statistical distribution of weather patterns over time, and on a global scale has changed only very slowly in the past – usually over periods of tens of thousands of years or even millions of years which allows time for the earth's bio-physical systems to adapt naturally to the changing climatic conditions. Currently, the global climate is changing much more rapidly as a result of global warming, leading to, among others, the melting of polar and glacier ice, sea-level rise, ocean acidification, changes in rainfall and snowfall patterns, more frequent floods and droughts and increased frequency and intensity of extreme weather events, such as tornadoes, hurricanes and cyclones.

Climate change can impact air quality and, conversely, air quality can impact climate change. Changes in climate can result in impacts to local air quality. Atmospheric warming associated with climate change has the potential to increase ground-level ozone in many regions, which may present challenges for compliance with the ozone standards in the future. The impact of climate change on other air pollutants, such as particulate matter, is less certain, but research is underway to address these uncertainties.

Emissions of pollutants into the air can result in changes to the climate. Ozone in the atmosphere warms the climate, while different components of particulate matter (PM) can have either warming or cooling effects on the climate. For example, black carbon, a particulate pollutant from combustion, contributes to the warming of the Earth, while particulate sulphates cool the earth's atmosphere.

According to a NASA study, an increase in ozone pollution, or smog, is causing warming in the Arctic regions. Ozone in the troposphere is a greenhouse gas and also a health hazard. Ozone pollution created in the Northern Hemisphere is transported towards the Arctic during winter and spring months, which leads to warming. Ozone pollution has the greatest impact on the region where it originates, which means some areas are warming more than others. The Arctic is currently warming faster than any other region on Earth, partly because of ozone pollution, but also because of positive feedback loops, where warming melts snow and ice, which changes the Earth's surface, and leads to more warming. The warming climate is causing drastic changes to Arctic ecosystems. Because of climate warming, the Earth experiences more extreme weather, such as heat waves and drought, which can negatively impact air quality. Heat waves cause an increase in ground-level ozone pollution because the chemical reactions that create ozone in the atmosphere occur more often in hot temperatures.

Higher pollen concentrations and longer pollen seasons are also influenced by the changing climate. Airborne allergens, like pollen, decrease air quality and cause health problems. During heat waves, areas of high pressure create stagnant air that concentrates air pollutants in one area. Prolonged high temperatures due to climate warming often lead to drought conditions where forest fires, which release carbon monoxide and particulates, are more common. Dry, dusty air during periods of hot weather also increases the amount of particulate pollution.

5. Garden Route Climate Change Vulnerability

Climate change has been identified as a key issue for the Garden Route District Municipality (Garden Route District Municipality 2017a, 2016, 2014). Following the publication of the Western Cape Climate Change Response Strategy in 2014, the Garden Route District Municipality developed the Garden Route District Climate Change Adaptation Plan in 2014 (Garden Route District Municipality 2016, 2014).

While the Garden Route District Climate Change Adaptation Plan of 2014 primarily focused on adapting to climate change, its reviewed version, namely the Garden Route District Climate Change Strategy 2019, also focused on the inclusion of climate change adaptation hazards, as well as a vulnerability assessment. Table 4 below indicates the key climate change hazards identified for the Garden Route district:

Table 4: List of Key Climate Change Hazards in the Garden Route district

Climate Change Hazard	Vulnerable areas
Temperature dependant vulnerability:	Water; Agriculture; Environment
Extended Dry Spell periods (longer periods between rainfall events and more intense rainfall events – this does vary between areas within EDM due to different landscapes and location)	i. Water ii. Agriculture iii. Communities/Society iv. Tourism
Fire Risks (there are fire regimes that are needed i.e. Fynbos, but this focussed on unwanted fires)	i. Community/Society ii. Human Settlements iii. Environment
Increased intensity of Storm Events	i. Infrastructure ii. Human settlements – Built environment, planning, location iii. Communities/Society – safety, emergency response
Coastal areas (Storm Surge and Sea-level rise)	i. Infrastructure ii. Coastal areas, Built environment, natural barriers, dunes, ecosystem services iii. Human settlements

5.1 Garden Route Climate Change Vulnerability Assessment

A Garden Route Climate Change Vulnerability Assessment was conducted through the Local Government Climate Change Support (LGCCS) program (http://www.letsrespondtoolkit.org/) in partnership with the Western Cape Climate Change Municipal Support Programme. The LGCCS is an initiative of the National Department of Environmental Affairs and the International Climate Initiative (IKI) and is supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The assessment outlines the key climate change vulnerabilities and responses to address these vulnerabilities for Garden Route District Municipality.

The three primary objectives of the LGCCSP are to:

- Perform a desktop analysis of the municipality to provide context on change vulnerabilities and responses;
- Undertake district municipal specific engagements to draft climate change vulnerabilities and responses;
- Facilitate capacity building and knowledge-transfer throughout the program to enhance implementation of prioritised climate change adaptation options.

Through the LGCCSP, a Climate Change Vulnerability Assessment Toolkit was developed to assist municipalities to identify and prioritise climate change indicators to facilitate the assessment of adaptive capacity. The LGCCS Toolkit was applied to the Garden Route District Municipality to assist with the development of its Climate Change Response Plan.

5.2 Vulnerability Assessment Results Summary

The Tables 5 and 6 below list the high and medium priority climate change indicators identified for the Garden Route District Municipality, based on the results of the Vulnerability Assessment in the Garden Route District Municipality's Climate Change Needs and Response Assessment document.

5.2.1 High Priority Climate Change Indicators

Based on the vulnerability assessment, the following indicators were identified as high priority climate change vulnerabilities for the municipality. These were shortlisted by answering "yes" to exposure, "high" to sensitivity and "low" to adaptive capacity.

Table 5: High Priority Indicators Garden Route District Municipality

No	Sector	Indicator Title	Exposure Answer	Sensitivity Answer	Adaptive Capacity Answer
10	Agriculture	Increased risks to livestock	Yes	High	Low
13	Biodiversity and Environment	Increased impacts on threatened ecosystems	Yes	High	Low
14	Biodiversity and Environment	Increased impacts on environment due to land-use change	Yes	High	Low
15	Biodiversity and Environment	Loss of Priority Wetlands and River ecosystems	Yes	High	Low
19	Coastal and Marine	Loss of land due to sea level rise	Yes	High	Low
20	Coastal and Marine	Increased damage to property from sea level rise	Yes	High	Low
26	Human Health		Yes	High	Low
30	Human Settlements, Infrastructure and Disaster Management	Increased impacts on traditional and informal dwellings	Yes	High	Low
32	Human Settlements, Infrastructure and Disaster Management	Increased migration to urban and peri-urban areas	Yes	High	Low
33	Human Settlements, Infrastructure and Disaster Management	Increased risk of wildfires	Yes	High	Low

No	Sector	Indicator Title	Exposure Answer	Sensitivity Answer	Adaptive Capacity Answer
36	Water	Decreased water quality in ecosystem due to floods and droughts	Yes	High	Low
40	Air Quality	Increase in Air Pollution	Yes	High	Low
41	Air Quality	Increase in odour complaints	Yes	High	Low
42	Air Quality	Increase in Brown haze	Yes	High	Low

5.2.2 Medium Priority Climate Change Indicators

Based on the above vulnerability assessment the following indicators were identified as medium priority climate change vulnerabilities for the municipality. These were shortlisted by answering “yes” to exposure, “medium” or “high” to sensitivity and “low” or “medium” to adaptive capacity.

Table 6: Medium Priority Indicators Garden Route District Municipality

No	Sector	Indicator Title	Exposure Answer	Sensitivity Answer	Adaptive Capacity Answer
1	Agriculture	Change in grain (maize, wheat & barley) production	Yes	Medium	Medium
4	Agriculture	Change in Sugarcane Production	Yes	Low	Low
5	Agriculture	Change in viticulture (grapes) production	Yes	High	Medium
6	Agriculture	Change in fruit production	Yes	High	Medium
7	Agriculture	Change in other crop production areas (e.g. vegetables, nuts, etc.)	Yes	High	Medium
8	Agriculture	Increased areas for commercial plantations	Yes	High	Medium
9	Agriculture	Increased exposure to pests such as eldana, chilo and codling moth	Yes	High	Medium

No	Sector	Indicator Title	Exposure Answer	Sensitivity Answer	Adaptive Capacity Answer
11	Agriculture	Reduced food security	Yes	Medium	Low
12	Biodiversity and Environment	Loss of High Priority Biomes	Yes	High	Medium
16	Coastal and Marine	Impacts on Marine and Benthic Ecosystems	Yes	High	Medium
17	Coastal and Marine	Impacts on estuary ecosystems	Yes	High	Medium
18	Coastal and Marine	Impacts on Coastal Livelihoods	Yes	Medium	Medium
21	Human Health	Health impacts from increased storm events	Yes	Low	High
22	Human Health	Increased heat stress	Yes	Medium	Medium
23	Human Health	Increased vector borne diseases from spread of mosquitoes, ticks, sandflies, and blackflies	Yes	Medium	Medium
24	Human Health	Increased water borne and communicable diseases (e.g. typhoid fever, cholera and hepatitis)	Yes	Medium	Medium
27	Human Health	Increased Occupational health problems	Yes	Medium	Medium
28	Human Settlements, Infrastructure and Disaster Management	Loss of industrial and labour productivity	Yes	Medium	High
29	Human Settlements, Infrastructure and Disaster Management	Increased impacts on strategic infrastructure	Yes	High	Medium
31	Human Settlements, Infrastructure and Disaster Management	Increased isolation of rural communities	Yes	High	Medium
34	Human Settlements, Infrastructure and Disaster Management	Decreased income from tourism	Yes	Medium	Low
35	Water	Decreased quality of drinking water	Yes	Medium	Medium
37	Water	Less water available for irrigation and drinking	Yes	Medium	Low
39	Water	Increased fish mortality	Yes	Low	Medium

6. Climate Change Implementation

6.1 Implementation of Climate Pathways

Within the document “Western Cape Government’s Western Cape Climate Change Adaptation Pathways: Climate Change Adaptation Pathways for A Climate Resilient Province by 2050 (2025)”, the following stakeholder recommendations and best-practice findings with regards to the implementation of the adaptation pathways, as identified within the document, were listed (DEA&DP, 2025):

- **Appropriate scale for implementation:** Determine the appropriate level and specificity and expected impact for the implementation of respective adaptation options.
- **Integrate equity considerations:** Explicitly incorporate equity considerations into the development and evaluation of pathways during implementation stages. Adaptation pathways should address and promote just and equitable outcomes for vulnerable communities, livelihoods, infrastructure etc.
- **Flexibility and adaptability:** Implementation of the respective pathways requires the identification of ideal situations where existing pathways will be revisited in the event that they are no longer appropriate or effective. This requires a proactive approach that anticipates and responds to changing circumstances.
- **Institutional arrangements:** Several adaptation options require collaboration of different stakeholders. There is therefore a need for integrating adaptation options and desired outcomes within existing institutional structures. The need for innovative approaches, such as reviving external and open forums, to facilitate collaboration will overcome institutional barriers.
- **Centralized adaptation platform:** There is a greater need for centralizing the pathway maps into a universal and interactive platform that will serve as a tool for engagement and collaboration among stakeholders.
- **Clarifying roles and responsibilities:** The pathways should clearly identify roles and responsibilities of different stakeholders at various levels (e.g., provincial, municipal, community) in implementing adaptation actions.
- **High Road Adaptation Options:** Adaptation options that will have maximum impact and are ready for implementation given the availability of financial resources, capacity, and buy-in from stakeholders should be identified and prioritised.
- **Low Road Adaptation Options:** Adaptation options that have minimal impact and are not ready for implementation due to a lack of financial resources, capacity, and broad societal support should be identified.

6.2 Sector Adaptation Response Plans

The section below summarises sector responses that have been identified to address the key vulnerabilities identified in the assessment under* Chapter 5 above.

6.2.1 Agricultural Sector

6.2.1.1 Introduction

	Program Name
	Agricultural Sector Adaptation to Climate Change
!	**Overview of Key Issues**
	The South African agricultural sector is highly diverse in terms of its activities and socio-economic context. This sector can be described as two-tiered (commercial vs. small-holder and subsistence farmers), with activities across a wide variety of climatic conditions (especially of rainfall). Roughly 90% of the country is sub-arid, semi-arid, or sub-humid, and about 10% is considered hyper-arid. Only 14% of the country is potentially arable, with one fifth of this land having high agricultural potential. Climate is important in determining potential agricultural activities and suitability across the country, especially in smallholding and homestead settings. Irrigation and conservation tillage practices can overcome rainfall constraints, especially in the high-value commercial agricultural sector. Irrigation currently consumes roughly 60% of the country's surface water resources, with important implications for agricultural exports, and food and water security in the context of climate change. In the Western Cape the current priority areas have been identified in the WCCCRS for the Agriculture sector 1. The promotion of climate smart agriculture; 2. Promoting food security at the municipal level; and 3. Research on climate resilient and alternative crops and livestock applicable to the Western Cape Furthermore, the following priority areas have been listed in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for addressing food security and an economically sustainable agricultural industry in the province. 1. Farming practices that are in harmony with nature, i.e. 'conservation farming';

	2. Climate smart agriculture; 3. Agricultural water technologies that reduce consumption and increase efficiency (see Water); 4. Research on climate resilient and alternative crops and livestock applicable to the Western Cape; 5. Addressing climate vulnerability through the Municipal Support Programme; and 6. Assessing food security in the context of the resource nexus.
	Objectives
10	The following objective has been identified through the LGCCSP as a priority area for the agriculture sector in the District Municipality. Manage increasing risks to livestock

6.2.1.2 Identified Adaptation Responses

The Garden Route District Municipality's agricultural sector will be adversely affected by climate change. Increased temperatures, drought, and the increase in frequency and severity of storm events will impact on the crops that can be grown and potentially result in a loss of livestock.

The following key agricultural sector adaptation responses for the identified objective were identified for the Garden Route district:

No	Objective	Adaptation Response
10	**Manage increasing risks to livestock**	Commission research and improve understanding of climate change impacts livestock and land availability
		Develop a framework that will assist and educate farmers with adjusting to reduced rainfall.
		Generate and share scientific, social and indigenous knowledge that will assist with adapting to the reduction in herbage yields.
		Improve collaboration and partnership on existing programs (e.g. LandCare Programme, EPWP and River Health Programmes)
		Strengthen management plans, to enable continuous monitoring of water and herbage availability for livestock.
		Investigate sustainability of dairy industry, as a high-water demand industry, in the district.

No	Objective	Adaptation Response
		Develop a map indicating the best areas to produce high water demand crops as well as areas where alternative crops should be considered

6.2.2 Biodiversity and Environmental Sector

6.2.2.1 Introduction

	Program Name
	Biodiversity and Environmental Sector Adaptation to Climate Change
	Overview of Key Issues
	Biodiversity is crucial to ecosystem health, and healthy ecosystems are central to human well-being. Healthy ecosystems interlinked with working landscapes and other open spaces form the ecological infrastructure of the country and are the foundation for clean air and water, fertile soil and food. All South Africans depend on healthy ecosystems for economic and livelihood activities, including agriculture, tourism and a number of income generating and subsistence level activities. These natural ecosystems are under pressure from land use change and related processes causing degradation, as well as invasive alien species. Accelerated climate change (resulting in increasing temperature, rising atmospheric CO_2 and changing rainfall patterns) is exacerbating these existing pressures. Well-functioning ecosystems provide natural solutions that build resilience and help society adapt to the adverse impacts of climate change. This includes, for example, buffering communities from extreme weather events such as floods and droughts, reducing erosion and trapping sediment, increasing natural resources for diversifying local livelihoods, providing food and fibre, and providing habitats for animals and plants which provide safety nets for communities during times of hardship. Sustainably managed and/or restored ecosystems help in adapting to climate change at local or landscape level. In the Western Cape the current priority areas have been identified in the WCCCRS for the biodiversity and ecosystem goods and services sector 1. Prioritisation, valuation, mapping, protection, and restoration of ecological infrastructure; 2. Landscape initiatives / biodiversity corridors and identification of requirements for climate change adaptation corridors; 3. Biodiversity stewardship; and 4. Mainstreaming of conservation planning into decision making. Furthermore, the following opportunities, gaps and recommendations have been identified in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the biodiversity and ecosystem goods and services sector:

	1. Better data sharing is needed between government entities 2. Finding comprehensive information on the numbers/hectares of aliens cleared is problematic 3. Informally protected areas are hard to track, as the data is often patchy or outdated. 4. Set fact-based climate change targets for this focus area. 5. There is a need to expand the conservation estate within these corridors. 6. Local community stewardship over corridors and unprotected areas should be promoted.
	Objectives
	The following objectives have been identified through the LGCCSP as priority areas for the Biodiversity and Environment sector in the district Municipality:
13	Manage Increased impacts on threatened ecosystems
14	Manage Increased impacts on environment due to land-use change
15	Manage Loss of Priority Wetlands and River ecosystems

6.2.2.2 Identified Adaptation Responses

Climate change predictions include the shifting of biomes across South Africa. In the Garden Route District Municipality, it is projected that, under a high-risk climate scenario, that the area currently covered by the Fynbos Biome will be substantially reduced by the Albany Thicket, Nama-Karoo, Succulent Karoo and Desert Biomes. Terrestrial, wetland, and river ecosystems and their associated species will be negatively impacted. Furthermore, development and changes in land use will impact negatively on the environment in the district.

The following key biodiversity and environmental sector adaptation responses for the identified objective were identified for the Garden Route district:

No	Objective	Adaptation Response
13	**Manage Increased impacts on threatened ecosystems**	Increase investment in ecological infrastructure that translates into financial revenue for the district such as ecosystem services bonds and market options that reduce flood risk within the region
		Completion of Invasive Species Control Plan (NEMBA) for all state-owned properties in local municipalities and district municipalities.
		Research Programme investigating potential risks associated with loss of fynbos biome through

		involving local universities (NMMU) stakeholders, SANParks, CapeNature, etc., involving scenario planning of loss of species. 0-50 years.
14	**Manage Increased impacts on environment due to land-use change**	Develop program to diversify community livelihoods strategies to earn income from other activities such as ecotourism and other non-farming activities.
14		Incentivize small scale farmers to practice sustainable and conservative agriculture
		Incorporate sustainable land use management and planning into other sectors plans.
		Research and improve understanding of land use change in the municipality.
		Strengthen institutional capacity to deal with pressure on land use change
15	**Manage Loss of Priority Wetlands and River ecosystems**	Adopt a local wetland protection by law that require vegetated buffers around all wetlands
		Control invasive wetland plants
		Encourage infrastructure and planning designs that minimize the number of wetland crossings
		Establish volunteer wetland monitoring and adoption programs
		Identify priority wetlands and River ecosystems to be conserved
		Restrict discharges of untreated wastewater and stormwater into natural wetlands
		Wetland restoration/rehabilitation programmes/projects
		Protect ecological infrastructure functioning/ecosystem services

6.2.3 Coastal and Marine Sector

6.2.3.1 Introduction

	Program Name
	Coastal and Marine Sector Adaptation to Climate Change
	Overview of Key Issues
	Climate change will affect the Coastal and Marine Environment, having various impacts on productivity and diversity of South Africa's coastal, marine and estuarine ecosystems. A changing climate is likely to result in changes in species availability and distribution impacting largely on fisheries. This could result in significant adverse impacts on subsistence fishing markets, community livelihoods as well as commercial industries. Changes in sea surface temperature, rising sea levels and increasing storm frequency will have adverse effects on coastal communities and infrastructure. To develop appropriate adaptation responses a more nuanced understanding of the challenges and options for the Coastal and Marine Sector is required, building on the insights of the existing coastal and marine plans. This understanding needs to consider the importance of associated ecological infrastructure in sustaining local economies and livelihoods as well and building resilient communities. In the Western Cape the current priority areas have been identified in the WCCCRS for the coastal sector 5. Establishment of coastal risk overlays and coastal management lines; 6. Research best practice regarding responding to repeated coastal inundation in high risk areas; 7. Protecting and rehabilitating existing dune fields as coastal buffers /ecological infrastructure; 8. Monitor possible linkages between climate change and fisheries industry; and 9. Ensure Estuary Management Plans take cognisance of climate change Furthermore, the following opportunities, gaps and recommendations have been identified in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the coastal sector: 1. Case studies and cost benefit analyses on optimal approaches to coastal protection should be developed for the Western Cape. 2. Fact-based climate change targets for this focus area need to be set out. 3. A better understanding of the fisheries sector and the impact of climate change on the sector in the Western Cape is required. 4. Monitoring standards need to be implemented for estuaries, possibly through the incorporation of a monitoring and evaluation component in all EMPs.

	Objectives
	The following objectives have been identified through the LGCCSP as priority areas for the Coastal and Marine sector in the District Municipality.
19	Manage loss of land due to sea level rise
20	Manage increased damage to property from sea level rise

6.2.3.2 Identified Adaptation Responses

In the Garden Route District Municipality, changes in precipitation and freshwater flow, sea-level rise, increased temperatures, and coastal storminess are predicted to negatively impact on coastal, marine and estuarine ecosystems. These ecosystem impacts are likely to result in changes in species availability and distribution impacting largely on fisheries. This could result in significant adverse impacts on subsistence fishing markets and community livelihoods in the district. Rising sea levels and increased coastal storms will pose potential risks to coastal infrastructure and communities in the district.

The following key coastal and marine sector adaptation responses for the identified objective were identified for the Garden Route district:

No	Objective	Adaptation Response
19	**Manage loss of land due to sea level rise**	Revise Spatial Development Frameworks to consider areas vulnerable to climate change impacts.
		Comment on Environmental Authorisation Applications to control unsustainable/risk coastal development
		Storm surge early warning and emergency breaching of estuaries guidelines
		Implementation of Coastal Management Lines for Garden Route district
		Education and awareness campaigns on the estuary management and mouth management plans of the Garden Route district
20	**Manage increased damage to property from sea level rise**	Protect biophysical barriers to coastal storm surges such as rehabilitation of dune systems and the establishment of coastal management zones that will restrict development within at-risk areas
		Incorporate climate-related disaster information into current property valuations and insurance schemes

		Collaborative Coastal and Estuary Management Agreements
		Community collaboration programmes
		Protection of three primary dune systems in Garden Route district: Stilbaai, Wilderness and Sedgefield. To be implemented by local authority to restore the dune system by June 2020.

6.2.4 Disaster Management, Infrastructure and Human Settlements Sector

6.2.4.1 Introduction

	Program Name
	Human Settlements, Infrastructure and Disaster Management Sector Adaptation to Climate Change
	Overview of Key Issues
	South Africa is a diverse country, not just in terms of populations and biodiversity, but also in terms of its human settlements. These settlements face severe challenges, even before climate change is taken into account. The implications of the compounding impacts of climate change will be profound, and human settlements therefore represent a crucial part of national adaptation strategies. The overarching strategic framework for the development of human settlements is described in the National Development Plan (NDP) and, more specifically in relation to the implications for climate change, in the National Climate Change Response White Paper (NCCRWP). However, to develop appropriate adaptation responses a more nuanced understanding of the challenges and options for human settlements is required, building on the insights of the NCCRWP. This understanding needs to take into account the unusually diverse urban forms of human settlement in the South African context, and the importance of ecological infrastructure in supporting service delivery and building resilient communities. In the Western Cape the current priority areas have been identified in the WCCCRS for the human settlements sector 1. Mainstreaming climate change into human settlement developments; 2. Implementation of energy efficiency interventions in low income houses and communities; and 3. Improving the resilience and adaptive capacity of informal settlements.

	Furthermore, the following recommendation has been identified in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the human settlements sector for the province: Clearer understanding of what resilience means for humans' settlements.
	Objectives
	The following objectives have been identified through the LGCCSP as priority areas for the Disaster Management, Infrastructure and Human Settlements sector in the District Municipality.
30	Manage increased impacts on traditional and informal dwellings
32	Manage potential increase migration to urban and peri-urban areas.
33	Manage potential increased risk of wildfires

6.2.4.2 Identified Possible Responses

Climate change impacts will affect Disaster Management, Infrastructure and Human Settlements in several ways in the Garden Route District Municipality. Increases in the severity of storm events and increase in flooding will damage infrastructure which may result in a loss of industrial productivity and service delivery disruptions. The impacts of storm events will particularly affect communities located in informal settlements, on flood plains and where there is poor drainage infrastructure. In addition, communities in rural areas that depend on subsistence farming may be unable to grow crops that they have grown in the past due to the changing climate. It is predicted that there will therefore be an increase in rates of rural-urban migration. Rural communities may also become more physically isolated due to extreme events impacting on key infrastructure.

The following key Disaster Management, Infrastructure and Human Settlements adaptation responses for the identified objectives were identified for the Garden Route district:

No	Objective	Adaptation Response
30	**Manage increased impacts on traditional and informal dwellings**	Commission a reliable early warning system (linked to radio stations, community leaders and social media) to alert communities and industries on the possible occurrences of storm events.

No	Objective	Adaptation Response
		Conduct a climate change risk assessment on informal dwellings.
		Conduct regular assessments of informal dwellings in order to identify priority areas for interventions to reduce climate change risk.
		In order to reduce flood and fire disaster risks, the placement of informal dwellings must receive special attention. Lessons learned must be incorporated into new housing projects.
		A district flood hazard master plan should be developed and included as part of the District SDF
		Implement informal settlement upgrades.
		Update community emergency evacuation plans that will assist with responding to climate change related impacts/risks.
32	**Manage potential increase migration to urban and peri-urban areas.**	Conduct public awareness on campaigns to save water by Disaster Management sector in collaboration with District Communications Department.
33	**Manage potential increased risk of wildfires**	Develop Integrated Veldfire management Plan for the Garden Route District.
		Strengthening of existing initiatives such as Working on Fire and the GEF climate change and fire project
		Fuel load management master plan
		Buy-in from private landowners and farmers through the construction of firebreaks.
		Improvement of fire safety through urban fringe management

No	Objective	Adaptation Response
		Fireproof alternative building/construction materials

6.2.5 Water Resources Sector

6.2.5.1 Introduction

	Program Name
	Water Sector Adaptation Responses to Climate Change
	Overview of Key Issues
	South Africa's climate is generally arid to semi-arid, with less than 9% of annual rainfall ending up in rivers, and only about 5% recharges groundwater in aquifers. In addition, rainfall and river flow are unpredictable in time and unevenly distributed in space, with only 12% of the land area generating 50% of stream flows. Decadal rainfall variability also results in extended dry and wet periods across the country. The main users of surface water resources are agricultural irrigation, domestic, industrial, mining and power generation, while plantation forestry intercepts and reduces runoff before it reaches the rivers and groundwater. Surface water resources were already over-allocated by the year 2000 in five of nineteen water management areas historically used for water planning and management purposes. The potential demand for water is expected to increase with economic growth, increased urbanisation, higher standards of living, and population growth. Because of the critical importance of water in the South African economy the country has a sophisticated water resources planning capacity, founded on a good understanding of the country's variable rainfall. This planning capacity will be a key capability for adaptation planning under ongoing and future climate change. In the Western Cape the following priority areas have been identified in the Western Cape Climate Change Response Strategy (WCCCRS) Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the water sector 1. Invasive alien vegetation clearing; 2. Prioritisation, valuation, mapping, protection, and restoration of ecological infrastructure in catchments; 3. Effective utilisation of irrigation water;

	4. Resource nexus decision support; and 5. Develop ecosystem goods and services (EGS) investment opportunities. Furthermore, the following recommendation has been identified in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the water sector for the province: 1. Review the Specifications of the Regional Bulk Infrastructure Grant (RBIG), Municipal Infrastructure Grant (MIG), Accelerated Community 2. Infrastructure Programmes (ACIP) and other similar funds and allocations to determine their climate responsive state (and link to any other ongoing such initiatives). 3. Protection of Strategic Water Source Areas (SWSAs) should be a strategic climate protection priority for the Western Cape. 4. Ground water monitoring needs to become a growing priority in the Western Cape. 5. Further cooperation between IAP clearing authorities and rehabilitation programmes for wetlands and rivers will be beneficial in a changing climate. 6. Continued focus on the way in which we manage our water systems, and increased emphasis on Water Sensitive Urban Design.
	Objectives
36	The following objective has been identified through the LGCCSP as a priority area for the Water sector in the District Municipality. Manage decreased water quality in ecosystem.

6.2.5.2 Identified Possible Responses

Water resources are the primary medium through which climate change impacts will be felt by South Africans (Schulze et al., 2014). Climate change will affect Garden Route District Municipality's water accessibility, quantity, and quality (Parikh, J 2007). Drought, reduced runoff, increased evaporation, and an increase in flood events will impact on both water quality and quantity.

The following key water resource adaptation responses for the identified objective were identified for the Garden Route district:

No	Objective	Adaptation Response
36	**Manage decreased water quality in ecosystem.**	Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.
		Conduct a climate change impact assessment on health risks to aquatic systems.
		Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

		Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
		Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
		Research and improve understanding of climate change impacts on water quality and availability.
		Strengthen wastewater treatment management plans, to enable the ability to respond to the declining water reserves.
		Investigate international best-practice as well as new technology, innovation and methodologies.
		Assessing wastewater plant infrastructure and condition/implement technology and infrastructure failure risk and upgrade plans.
		Implementation of alternative water resources
		Water Resource Management Collaboration Initiatives and Partnerships

6.2.6 Air Quality

6.2.6.1 Introduction

	Program Name
	Air Quality Adaptation Responses to Climate Change
	Overview of Key Issues
	Continued reduction in air pollution and GHG emissions are essential, as they pose serious threats to both people's health and the environment. Implementation of air quality and climate change policies can provide mutual benefits contributing to clean air and reduction in global warming. Furthermore, air pollution and climate change influence each other through complex interactions in the atmosphere. Increasing levels of GHGs alter the energy balance between the atmosphere and the earth's surface which, in turn, can lead to temperature changes that alter the chemical composition of the atmosphere. Direct emissions of air pollutants (e.g. black carbon) or those formed from emissions such as sulphate and ozone can also influence this energy balance. Thus, climate change and air quality management have consequences for each other. Linkages with air quality management was made with the energy focus area through GHG reductions as well as a contributor to healthy communities. Work is underway to align climate change

	priorities with goals and objectives of the Western Cape Air Quality Management Plan, which is currently being updated. Goal 4 of the Air Quality Management Plan is focussed on supporting climate change programmes that include the reduction of GHG emissions. In the Western Cape the following priority areas have been identified in the Western Cape Climate Change Response Strategy (WCCCRS) Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the air quality sector 1. Particulate matter (PM10) – below threshold but shows steady increase 2. Nitrogen oxides (NO, NOx) – acceptable but problems at certain locations 3. Sulphur dioxide (SO2) – below threshold 4. Green House Gases (GHG) – levels increasing Furthermore, the following recommendation has been identified in the Western Cape Climate Change Response Strategy Biennial Monitoring & Evaluation Report 2015/16 (Birch et al., n.d.) for the water sector for the province: 1 Review the Specifications of the Regional Bulk Infrastructure Grant (RBIG), Municipal Infrastructure Grant (MIG), Accelerated Community 2 Infrastructure Programmes (ACIP) and other similar funds and allocations to determine their climate responsive state (and link to any other ongoing such initiatives). 3 Protection of Strategic Water Source Areas (SWSAs) should be a strategic climate protection priority for the Western Cape. 4 Ground water monitoring needs to become a growing priority in the Western Cape. 5 Further cooperation between IAP clearing authorities and rehabilitation programmes for wetlands and rivers will be beneficial in a changing climate. 6 Continued focus on the way in which we manage our water systems, and increased emphasis on Water Sensitive Urban Design.
	Objectives
	The following objective has been identified through the LGCCSP as a priority area for the Water sector in the District Municipality:
40	Increase in air pollution
41	Increase in odour complaints
42	Increase in brown haze

6.2.6.2 Identified Possible Responses

The linkage between Air Quality and Climate change is well documented. Controlling the Air Quality environment is directly correlated to Climate Change mitigation. The District Air Quality section therefore play an important role in climate change mitigation.

The following key air quality sector adaptation responses for the identified objectives were identified for the Garden Route district:

No	Objective	Response
40 36	**Increase in air pollution**	Set up air quality goals that are linked to climate change mitigation and which talks to all the applicable legislation.
		Maintaining the current Garden Route Air Quality emissions inventory and the NAEIS system.
		Maintaining and expanding the Garden Route monitoring network.
41	**Increase in odour complaints**	Passive sampling programmes
		Diesel vehicle emission testing programmes with the B-authorities.
42	**Increase in brown haze**	Carrying out of regional dispersion modelling studies
		Define a strategy to disseminate ambient air quality data to the general public through various media, e.g. newspapers, EDM's web site, etc.
		Investigate international best-practice as well as new technology, innovation and methodologies.
		Carry out Risk assessments
		Link the Air Quality Climate change interventions and projects with the IDP in order to secure the necessary funding.

7. Concluding Remarks

The Garden Route district's vulnerability to climate change impacts is attributed to its physical location, topography and general climate conditions (Garden Route District Municipality, 2017a). In addition, increased vulnerability to climate change has been caused by rapid urbanisation and informal developments (Western Cape Government, 2013). Urbanisation has increased because of in migration of the youth from the Eastern Cape and the elderly to the coastal towns (Garden Route District Municipality, 2017b). However, housing delivery has not been able to keep up with the migration, hence the ongoing increase in informal dwellings in the district (Garden Route District Municipality, 2017b). Furthermore, the natural and scenic beauty of the district is a major tourist attraction that could be negatively affected by the impacts of climate change (Garden Route District Municipality, 2017a).

Climate change is predicted to shift the biomes in South Africa, resulting in a change to the ecosystems and vegetation found in the Garden Route District Municipal area. If the biodiversity and related ecosystem services in the Garden Route District Municipal area are badly reduced, it could have direct negative consequences for the economy and social structures in the Garden Route District Municipality. These consequences could have a detrimental effect on efforts to reduce poverty, inequity and unemployment in the Garden Route District Municipal area. Furthermore, it is predicted that climate change will exacerbate these challenges and their effects on the biodiversity and related ecosystem in South Africa.

Climate change is forecast to exacerbate the frequency and severity of extreme weather events. Major climatic hazards in the district include: drought, floods and veld fires. Additionally, financial losses in the district, due to these climate hazards, has already been high. The following climate change impacts have already been observed in the district: increased average temperatures; shifts in seasonality; increased frequency of veld fires; increased magnitude and frequency of storm events accompanied by strong winds; more frequent and severe storm surges; and increases in rainfall variability and the number of dry days.

Within the coastal zone, climate change projections indicate several possible changes to South Africa's coastal zone. In addition to the predicted effects of climate change, the coastal zone in South Africa is susceptible to anthropogenic impacts such as ecosystem overuse (e.g. overfishing) and degradation, increased pollution, and the increased nutrient runoff from coastal developments leading to eutrophication of wetlands, estuaries, etc. The anthropogenic and climate change impacts have already negatively affected biodiversity and ecosystems services in the coastal zone (and across South Africa) and are expected to worsen these issues unless climate change adaptation and mitigation responses are developed and implemented.

In addition, sea level rise and associated hazards are a major concern for coastal areas within the district (Garden Route District Municipality 2012). Sea level rise impacts are likely to include inter alia coastal erosion, flooding, destruction of infrastructure and saltwater contamination of freshwater bodies (Western Cape Government 2013).

Despite the potential for expanding agricultural production in the Garden Route District Municipal area, it is predicted that climate change will affect the agriculture sector negatively. Consequently, predicted impacts for households involved in agriculture include reduced agricultural yields and water security, as well as increased food insecurity. This is also one of the main disaster risks that are likely to affect human health in the Garden Route District Municipal area, together with the impacts of wildfires, drought, severe storms and floods. It is predicted that these disasters will be exacerbated by climate change.

The predicted changes in average rainfall and temperature are forecast to reduce the areas that are suitable for viticulture or shift them to areas that are higher or cooler than current locations. The reduction in rainfall (and runoff) is forecast to reduce the yields of fruit and vegetables, notably deciduous fruit and rain-fed wheat production in the Western Cape. Furthermore, the production of fruit (such as apples and pears) and sugar cane will be increasingly vulnerable to damage from a predicted expansion of the areas affected by agricultural pests.

To counter the above-mentioned risks, there is a need for climate change adaptation (and mitigation) projects to limit these negative impacts, and encourage any positive effects of climate change in the Garden Route District Municipal area. The Municipalities within the Garden Route district should implement various adaptation and mitigation actions to reduce the climate change impacts, such as conserving our water resources, wetlands and biodiversity through updated land-use and settlement plans that take disaster risk management criteria into account, and by increasing public awareness regarding water conservation, droughts, fires and floods, amongst others. This is particularly pertinent given the recent devastating fires in and around the Garden Route district, as well as the severe ongoing drought in the Western Cape. Hence, more ambition, co-created projects and programmes are therefore urgently required to build resilience by 2050 within the district.

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