GREENBOOK
adapting settlements for the future

Thabo Mofutsanyana District Municipality

Climate Change Adaptation Plan: Draft 1

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THABO MOFUTSANYANA District Municipality

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Abbreviations

Abbreviation	Explanation
°C	Degree Celsius
AR5	Fifth Assessment Report
CCA	Climate Change Adaptation
CCAM	Conformal-Cubic Atmospheric model
CDRF	Climate and Disaster Resilience Fund
CMIP5	Coupled Model Intercomparison Project 5
CoGTA	Department of Cooperative Governance and Traditional Affairs
CRVA	Climate Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DM	District Municipality
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EcVI	Economic Vulnerability Index
EnVI	Environmental Vulnerability Index
GCM	General Circulation Model
GVA	Gross Value Added
GDP	Gross Domestic Product
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
km	Kilometre
l/p/d	Litres Per Person Per Day
LM	Local Municipality
MAR	Mean Annual Runoff
mm	Millimetre
NCCRP	National Climate Change Response Policy
NDMC	National Disaster Management Centre
PVI	Physical Vulnerability Index
RCP	Representative Concentration Pathways
SCIMAP	Sensitive Catchment Integrated Modelling and Prediction
SDF	Spatial Development Framework
SEVI	Socio-Economic Vulnerability Index
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No.16 of 2013)
TMDM	Thabo Mofutsanyana District Municipality
THI	Temperature Humidity Index

Definitions

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

	results from the interaction of vulnerability, exposure, and hazard (DFFE, 2020, p. 11).
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (DFFE, 2020, p. 11)..
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (DFFE, 2020, p. 11).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (DFFE, 2020, p. 11).
Sensitivity	Factors that directly affect the consequences of a hazard. Sensitivity may include physical attributes of a system (e.g. building material of houses, type of soil on agriculture fields), social, economic and cultural attributes (e.g. age structure, income structure) (DFFE, 2020, p. 11).
Coping Capacity	The ability of people, institutions, organisations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term (e.g., early warning systems in place) (DFFE, 2020, p. 11).

1. Introduction

This draft Climate Change Adaptation Plan, as well as the accompanying Climate Risk Profile report, was developed specifically for Thabo Mofutsanyana District Municipality (TMDM), to support its strategic climate change response agenda. Both reviews are primarily informed by the GreenBook, which is an open-access online planning support system that provides a scientific evidence base to support local governments in the planning and design of climate-resilient, hazard-resistant settlements. The GreenBook is an information-dense resource and planning support system offered to South African local governments to better understand their risks and vulnerabilities in relation to population growth, climate change, exposure to hazards, and critical resources. In addition to this, the GreenBook also provides guidance on appropriate adaptation measures that can be implemented on a city or settlement scale, providing technical assistance to support South African settlements in reducing the impact of climate hazards on communities and infrastructure, while also contributing to national, provincial and local developmental goals (See Green Book | Adapting settlements for the future).

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

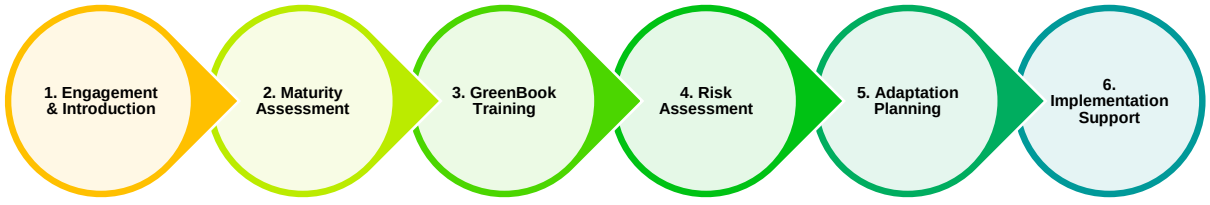

Figure 1: The value-chain towards the implementation of climate change response and adaptation in municipalities.

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

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

1.1. Municipal Context

The Thabo Mofutsanyana District Municipality (TMDM), as the second-largest district municipality in the Free State, spanning 32,722 km², encapsulates the rich environmental fabric of South Africa. This district, comprising six local municipalities – Mantsopa, Setsoto, Dihlabeng, Maluti a Phofung, Nketoana, and Phumelela – is strategically positioned in the eastern Free State. It shares borders with KwaZulu-Natal and Mpumalanga provinces to the east and northeast, while the majestic Kingdom of Lesotho graces its south-eastern frontier. This unique positioning brings with it varied terrains, from the towering peaks of the Maluti and Drakensberg mountains on its eastern periphery to the verdant rolling grasslands. Key water arteries, the Vaal river to the north and the Orange river to the south, course through the district, with numerous smaller tributaries feeding into them. These vital waterways not only support the communities living within TMDM but also serve as the linchpin for the region's unique biodiversity. Amidst this diverse ecological tableau, the district faces the continuous challenge of striking a balance between development and conservation, emphasizing the need for sustainable environmental management practices.

According to their IDP, Thabo Mofutsanyana District has around twenty-six urban centres, which include the following in each local municipality:

Table 1: Local municipalities and urban centres.

Local Municipalities	Urban Centres
Mantsopa Local Municipality:	• Hobhouse; Ladybrand; Excelsior; Thaba Patchoa; Tweespruit.
Setsoto Local Municipality:	• Clocolan; Ficksburg; Marquard; Senekal.
Dihlabeng Local Municipality:	• Rosendal; Paul Roux; Fouriesburg; Clarens; Bethlehem.
Maluti a Phofung Local Municipality:	• Kestel; Harismith; Qwa-Qwa; Tshiame.

Nketoana Local Municipality:	• Lindley; Arlington; Petrus Steyn; Reitz.
Phumelela Local Municipality:	• Vrede; Warden; Memel.

Encompassing a diverse populace, the Thabo Mofutsanyana District Municipality witnessed its population rise from 736,238 in 2011 to approximately 779,600 by 2016, marking a growth trajectory that's projected to surge by 7.60% between 2011 and 2030. This burgeoning population is primarily sustained by key sectors such as community services, which encompass governmental roles, along with the finance, insurance, and business sectors. Additionally, the trade sector, inclusive of wholesale, retail, and tourism, plays a pivotal role in the district's economic fabric. However, beneath this economic veneer lie stark vulnerabilities. As of 2011, the district grappled with an alarming unemployment rate of 35.10%, which disproportionately affected its female populace: while 28.50% of males were unemployed, the figure soared to 42% for females. This gender disparity underscores deeper social vulnerabilities that the district needs to address in its path to holistic development.

1.1.1. Key Risks

The greatest risks faced across the Thabo Mofutsanyana DM include the following:

- Drought: Drought risk is paramount in TMDM, especially in the northwest part of the district which exhibits the highest drought tendencies. Extended periods of reduced rainfall are recurrent, detrimentally impacting the agricultural sector, a cornerstone of the local economy. This leads to decreased crop yields and increased food insecurity. Some areas are also grappling with significant water shortages, intensifying the daily challenges of inhabitants. Given the current patterns, drought tendencies in this part of the district are predicted to rise in the future.
- Heat: The central regions of TMDM, especially encompassing Dihlabeng, Nketoana, and Maluti a Phofung Local Municipalities, are likely to experience more frequent and severe heatwave events. As the temperature rises, it exacerbates the vulnerability of infrastructure in this largely rural district. Roads, bridges, and other key facilities, particularly in areas with limited urban planning or informal settlements, might not be robust enough to withstand such extreme weather events. Flash floods resulting from intense rainfall can further damage this infrastructure, potentially isolating communities and endangering lives.
- Wildfire: The risk of wildfires is notable, especially along the wildland-urban interface encompassing the eastern, western, and southern settlements of TMDM. As socio-economic factors play a significant role, many communities, especially those reliant on subsistence farming, become even more vulnerable. These unpredictable patterns, be it from droughts, floods, or temperature fluctuations, can severely affect farming practices. Furthermore,

limited access to healthcare, education, and early warning systems due to poverty and unemployment can compound these challenges. Most settlements are expected to have a moderate wildfire risk increase, with only a few central ones expected to experience a low rise.

- Flooding: Despite drought risks, certain parts of TMDM, notably Phumelela and Maluti a Phofung Local Municipalities, have high flood hazards. The majority of the district faces a medium flood hazard, but there are pockets of low flood hazard regions in the southwest. Extreme rainfall days, especially in the eastern and south-western fringes of the district, are expected to rise, thereby augmenting flood risks.

1.1.2. Adaptation Goals

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

1. Water resource management: Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. This includes investing in efficient water infrastructure, prioritising infrastructure maintenance, promoting water conservation practices, implementing rainwater harvesting systems, and exploring alternative water sources such as groundwater and wastewater reuse.
2. Ecosystem conservation: Protecting and restoring natural ecosystems, such as high-priority biomes, wetlands, river ecosystems and riparian areas, to perform critical ecosystem services, enhance biodiversity, support water resource management, and provide natural buffers against climate-related hazards such as wildfires.
3. Social equity and vulnerable populations: Ensuring that adaptation efforts prioritise the needs of vulnerable populations, such as low-income communities and informal settlements. This could involve providing access to basic services, improving housing conditions, and implementing early-warning systems tailored to these communities.
4. Fire management: Targeting fire prevention and strategies to mitigate the risks associated with wildfires. This could involve identifying areas for designated firebreaks, ensuring water reserves for fire-fighting, and developing advanced early-warning systems for fires to protect vulnerable communities and infrastructure.
5. Agriculture and food security: Given that food security is a potentially significant future climate change-related impact, developing a food security and agricultural policy that takes climate change impacts into consideration is crucial. This includes increasing the resilience of the agricultural sector by supporting commercial and small-scale farmers across industries, promoting solutions to drought such as highly efficient irrigation systems, exploring alternative crop types, assessing livestock carrying capacity and implementing grazing management and fire management.
6. Flood management: Developing effective flood management strategies to mitigate the risks associated with heavy rainfall events. This could involve improving stormwater drainage systems, restoring damaged and degraded ecosystems, creating floodplains

and retention basins, and implementing advanced early-warning systems for flooding to protect vulnerable communities and infrastructure.

1.2. Outline of the Climate Change Adaptation Plan

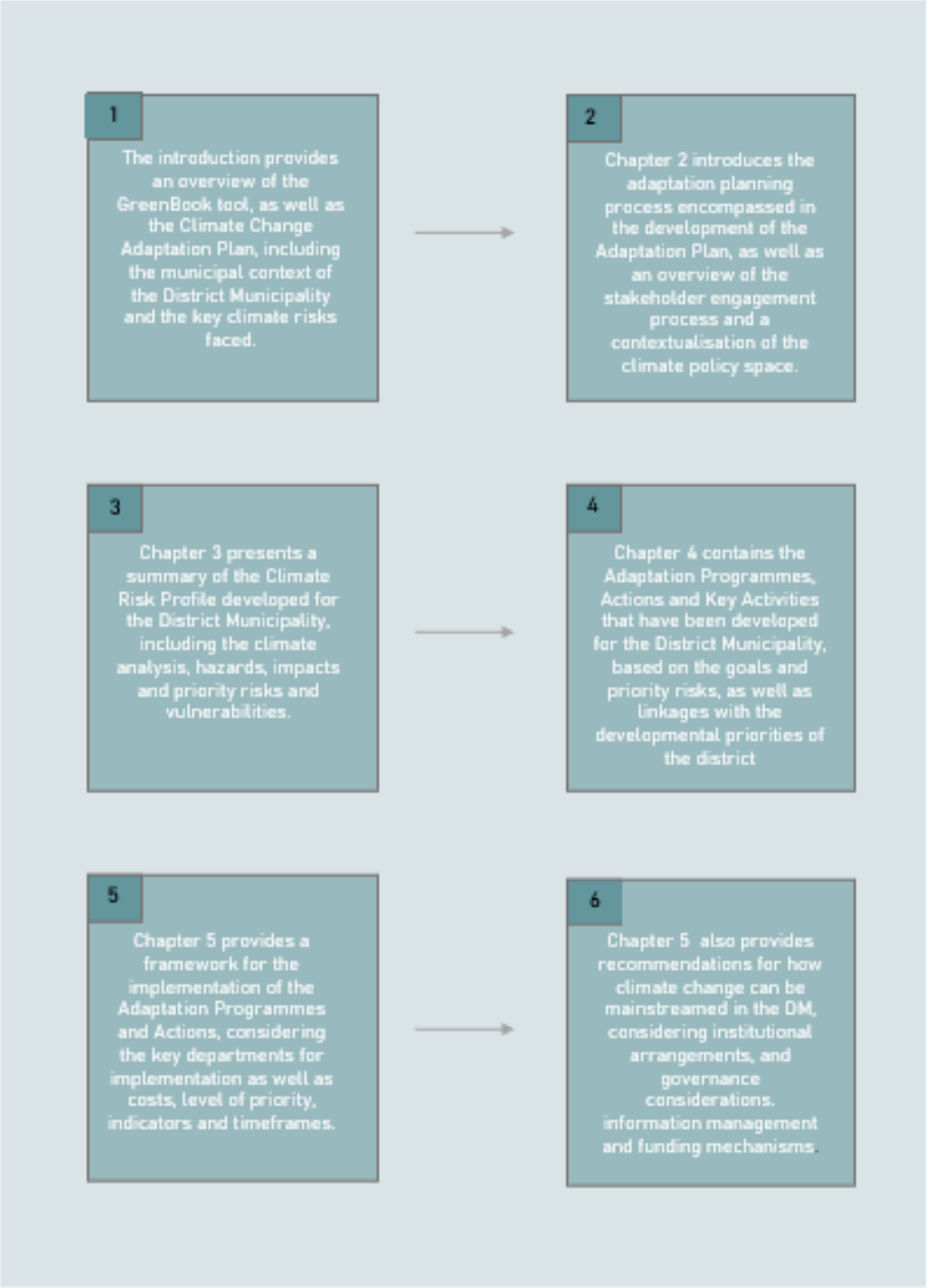

Figure 2: Outline of the climate change adaptation plan.

2. Climate Change Response

Climate change response encapsulates a two-pronged approach, as identified by the United Nations Framework Convention on Climate Change (UNFCCC) (IPCC, 2018), consisting of:

- Mitigation: A human intervention to reduce emissions or enhance the sinks of greenhouse gases.
- Adaptation: The process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.

Climate change actions can either fall into one of these two broad categories, or they can encompass co-benefits of both adaptation and mitigation and fall into both categories. Adaptation and mitigation go hand-in-hand in terms of responding to the climate crisis. Mitigation encompasses the reduction of greenhouse gas emissions to curb global warming to 1.5 compared to pre-industrial levels, a target set by the Paris Agreement. Mitigating the causes of climate change is imperative as the rise in temperatures will worsen climate hazards, impacting health, livelihoods, food security, water supply, human security, and economic growth. Climate change adaptation entails altering our behaviour, systems, and ways of life to protect communities, economies, and the environment in which we live from the impacts of climate change. Climate change has resulted in changes in average temperatures, shifts in seasonality as well as increased frequency of extreme weather events. Climate change adaptation and mitigation are both equally important and time-sensitive and we need to do both. The more we reduce emissions right now, the easier it will be to adapt to the changes we can no longer avoid.

Generally, the distinction is made between adaptation approaches, namely anticipatory or reactive adaptation. Anticipatory adaptation refers to acting in preparation for climate change. Reactive adaptation refers to acting when climate change effects are experienced. Future climate trends remain uncertain, highlighting the need for a flexible response and the development of adaptation strategies for the medium and long term. It also follows that adaptation will require greater consideration of local context compared to mitigation strategies.

2.1. Integrated Climate Change Response

Climate change response entails both adaptation and mitigation and is a complex, cross-sectoral, multi-disciplinary process which requires a suitable and accepted approach to ensure success and to maintain consistency and continuity.

Supported by the GreenBook evidence base, the climate change response process is proposed as a point of reference for establishing an overarching approach to climate change response in the TMDM and mainstreaming climate resilience into all municipal planning processes to:

- Facilitate the implementation of climate change response measures within existing sector plans and budgets; and
- Balance the incremental costs with the municipal development objectives and the economic, environmental, and social benefits produced through integrated climate change response.

TMDM's approach to the climate change response process is conceptualized in the figure below:

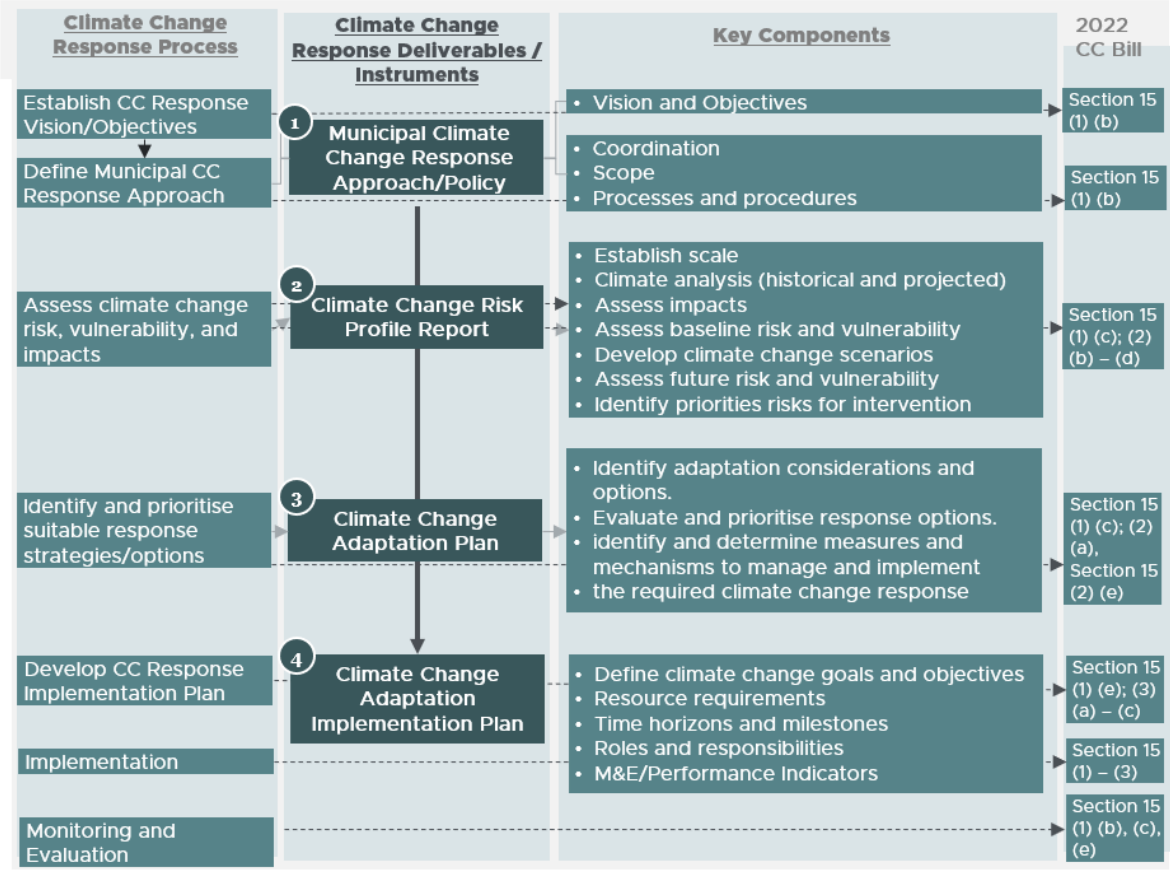

Figure 3: The municipal climate change response process (Brink and Modack, 2022).

Figure 3 illustrates the climate change response process proposed for the TMDM in accordance with the Climate Change Bill (B9-2022) requirements for local government. The development of the Adaptation Plan is a key component of the process outlined above. The specific Adaptation Approach applied in the development of the TMDM Adaptation Plan is outlined below.

2.2. Adaptation Approach

The approach framing climate change adaptation in the GreenBook and in this plan is centred around reducing climate-related risk. Climate-related risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and the occurrence of a

climate hazard (Figure 4). "*Relevant adverse consequences include impacts on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services, ecosystems and species*" (Chen, et al., 2021, p. 64).

Climate change adaptation aims to reduce climate-related risks by adjusting a system to the actual or anticipated climate and seeking "*to moderate or avoid harm [and] exploit beneficial opportunities*" (IPCC, 2022a, p. 2898) that may derive from unavoidable impacts of climate change such as extreme hazards. Through climate change adaptation, the components that makeup risk can be reduced, including exposure and vulnerability. Climate change adaptation consists of measures that range from providing social protection after disasters, to retrofitting habitats or settlements with more resilient infrastructure, protecting coastlines from flooding, securing water resources to rely on during periods of drought, and improving crop production for dryland farming, among others. Although disaster risk reduction and climate change mitigation, form part of the overall climate change response agenda, the focus of this plan is on adaptation.

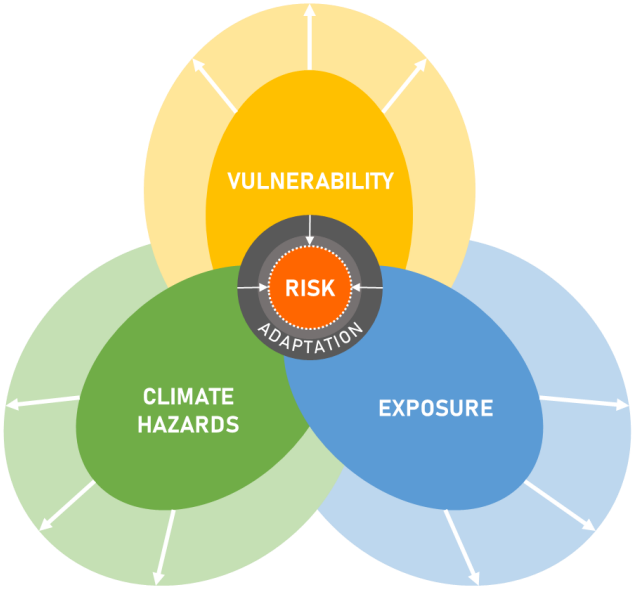

Figure 4: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

Adaptation planning uses the basis of spatial planning and climate change adaptation to shape built-up and natural areas to be resilient to the impacts of climate change and to realise co-benefits for long-term sustainable development to address root causes of vulnerability and exposure to risk. The process of climate change adaptation and planning is set out in Error! Reference source not found. below.

The development of this Adaptation Plan follows this adaptation logic and adaptation planning process to ensure that the plan is aligned with local policy, current and future anticipated risks

and vulnerabilities and that it is able to facilitate implementation and mainstreaming of climate change adaptation and resilience priorities into other planning processes and instruments.

Table 2: The adaptation planning process.

1. Understand your context	The Climate Risk Profile that unpacks climate hazards and vulnerability in your District Municipality. To be able to develop an appropriate adaptation plan, it is important to understand what contributes to risk and vulnerability.
2. Identify priority climate-related risks	Identify the climate hazards and impacts that pose the greatest risk within the District Municipality. Draw from both the Climate Risk Profile and local expert knowledge.
3. Identify adaptation goals	Identify adaptation goals to address priority risks that speak to policy goals within the District Municipality.
4. Develop adaptation programmes and actions	Develop adaptation programmes that speak to the identified adaptation goals and identify appropriate adaptation actions under each of the programmes that are mutually supportive. Adaptation actions should: • Be specific to a climate risk and/or vulnerability. • Suggest a target or an indicator to measure progress. • Be assignable to a primary implementer. • Be realistic and achievable given available resources. • Consider co-benefits and other possible implications. • Include mitigation as far as it builds resilience or reduces exposure and vulnerability.
5. Mainstream adaptation actions in planning	Integrate adaptation goals, programmes, and actions into existing instruments and processes, particularly those related to development and planning. The aim is to ensure that climate change adaptation and resilience are an integral part of all planning.

2.2.1. Stakeholder Engagement Process

To construct a Climate Change Adaptation Plan resonating with the specific requirements of the District Municipality and appropriately addressing its significant risks, a stakeholder engagement component was factored into the adaptation planning process. The inaugural phase of stakeholder engagement integrated a Risk Profile Engagement, succeeded by an Implementation Engagement designed to shape the Adaptation Plan. Moreover, District Municipalities (DMs) participated in a capacity development workshop intended to facilitate their use of the GreenBook tool. Engagement invitations were disseminated to pertinent DM departments including, but not limited to, Environmental Management, Disaster Management, Spatial Planning, and Water and Sanitation.

The initial interaction between the DMs and the CSIR took the form of the Risk Profile engagement. This virtual meeting, spanning two hours, aimed to validate the primary risks and vulnerabilities identified for the DM through the GreenBook Municipal Risk Tool and encapsulated within the Risk Profile Report. The central outcome of this engagement was the delineation of climate change adaptation goals, tailored to address the significant risks confronted by the DM, serving to inform the development of the preliminary Climate Change Adaptation Plan.

The subsequent DM engagement, the Implementation Engagement, was carried out virtually over a three-hour workshop. This engagement aimed to showcase the draft Climate Change Adaptation Plan, inclusive of the Adaptation Programmes and Actions, thereby allowing the DM to contribute comments. Additionally, the session incorporated a presentation on the Implementation Framework, established for the Adaptation Plan, along with a discourse on the integration of climate change adaptation within the district.

Collectively, the stakeholder engagement process offered a platform to interact with District stakeholders, promoting a more profound comprehension of the DM's context. Feedback gleaned from these engagement procedures has been deliberated upon and woven into the draft Climate Change Adaptation Plan.

2.3. Policy Context

2.3.1. National Policy Context

South Africa's institutional policy and legislative framework make provision for climate change adaptation at all levels of government, with local governments increasingly identified as the primary drivers of climate change adaptation. For instance, there exists various national policy and legislative mechanisms that promote, necessitate, guide and/or regulate climate change adaptation at the local level. These include the Disaster Management Amendment Act of 2015, the Spatial Planning and Land Use Management Act (SPLUMA) of 2013, the Climate Change Bill (B9 of 2022), the 2011 National Climate Change Response White Paper, as well as the 2019 National Climate Change Adaptation Strategy.

While the Disaster Management Amendment Act requires each organ of state, as well as provincial and local government to identify measures for, as well as indicate plans to invest in, disaster risk reduction (DRR) and climate change adaptation; SPLUMA identifies the principles of (1) spatial resilience – which "*accommodates flexibility in spatial plans, policies and land use management systems, to ensure sustainable livelihoods in communities most likely to suffer the impacts of economic and environmental shocks*" (Republic of South Africa., 2013, p. 20) – some of which may be induced by the impacts of climate change, and (2) spatial sustainability, which sets out requirements for municipal planning functions such as spatial planning and land

use management to be carried out in ways that consider protecting vital ecosystem features such as agricultural land, i.e., from both anthropogenic and natural threats, including the impacts of climate change, as well as in ways that consider current and future costs of providing infrastructure and social services in certain areas (e.g., uninformed municipal investments may lead to an increase in the exposure of people and valuable assets to extreme climate hazards) as one of the key principles intended to guide municipal planning and development. The Climate Change Bill sets out requirements for every district intergovernmental forum to serve as a Municipal Forum on climate change that coordinates climate response actions and activities in its respective municipality, while also requiring every municipality to report on their climate change response needs and draft resultant climate change response assessments and implementation plans.

Furthermore, the National Climate Change Response White Paper identifies local governments as critical role players that can contribute towards effective climate change adaptation through their various functions, including human settlement planning; urban development; municipal infrastructure and services provision; water and energy demand management; and local disaster response, amongst others. The National Climate Change Adaptation Strategy outlines several actions that are targeted at municipalities, including the development and implementation of adaptation strategies and vulnerability reduction programmes for communities and individuals that are most at risk of the impacts of climate change; the development of municipal early warning systems; as well as the integration of climate change adaptation into municipal development plans and relevant sector plans.

The table that follows presents a summary of both international and national policy instruments relevant to climate change mitigation and adaptation. These policy instruments range from the United Nations Framework Convention on Climate Change (UNFCCC), which governs global action against climate change, to the South African National Climate Change Adaptation Strategy (NCCAS), aimed at enhancing the country's ability to meet its obligations under the Paris Agreement on Climate Change. Other key international instruments include the International Carbon Action Partnership (ICAP), the Sustainable Development Goals (SDGs), and the Convention on Biological Diversity. On the national front, the instruments such as the Climate Change Bill, the National Development Plan (NDP), the National Climate Change Response Policy (NCCRP), the National Environmental Management Act (NEMA), and the Amended Disaster Management Act are discussed. Each of these policy instruments plays a crucial role in shaping climate change response strategies, establishing frameworks for low-carbon, climate-resilient economies, and ensuring environmental sustainability while promoting socio-economic development.

Table 3: International and national policy context.

International	
United Nations Framework Convention on Climate Change (UNFCCC)	The UNFCCC is the primary multilateral global treaty governing actions to combat climate change through adaptation and mitigation efforts.
International Carbon Action Partnership (ICAP)	The ICAP is an international forum for governments and public authorities that have implemented or are planning to implement carbon trading systems (ETS).
United Nations Sustainable Development Goals (SDGs)	The SDGs are a universal call to action consisting of 17 goals to end poverty, protect the planet and improve the lives and prospects of everyone globally.
Sendai Framework for Disaster Risk Reduction	This framework aims to substantially reduce disaster risk and losses in lives, livelihoods and health in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years.
Nationally Determined Contribution (NDC)	The Paris Agreement requests each Country to outline and communicate their post-2020 climate actions, known as their NDCs. NDCs embody efforts by each Country to reduce national emissions and adapt to the impacts of climate change.
Convention on Biological Diversity	The Convention on Biological Diversity is an international treaty designed to promote biodiversity conservation and ensure the equitable sharing of genetic resources.
National	
Climate Change Bill (2022)	The Climate Change Bill aims to enable the development of an effective climate change response and a long-term, just transition to a low-carbon and climate-resilient economy and society for South Africa in the context of sustainable development and to provide for matters connected in addition to that.
South Africa Low Emission Development Strategy 2050 (2020)	The South Africa Low Emissions Development Strategy (SA LEDS) aims to succinctly build upon this foundation and articulate the path going forward in order to place the country on a low carbon trajectory, while at the same time ensuring broader socio-economic development.
National Development Plan Chapter 5: "Transition to	The NDP aims to eliminate poverty and reduce inequality by 2030. According to the Plan, South Africa can realise these goals by drawing on the energies of its people, growing an inclusive economy, building capabilities, enhancing the state's capacity, and promoting leadership and partnerships throughout society. Chapter 5 of the NDP outlines'

Low-Carbon Economy"	ensuring environmental sustainability and an equitable transition to a low-carbon economy.
National Climate Change Adaptation Strategy (2020)	South Africa's National Climate Change Adaptation Strategy (NCCAS) supports the Country's ability to meet its obligation in terms of the Paris Agreement on Climate Change.
National Climate Change Response Policy	The NCCRP supports the national vision for a successful climate change response and long-term shift towards a lower-carbon and climate-resilient economy and society. It aims to manage efficiently climate change impacts through strategies that build and sustain South Africa's social, economic and environmental resilience, and the second is to stabilise greenhouse gas concentrations in the atmosphere.
National Environmental Management Act (NEMA)	The NEMA Act 107 of 1998 intends to provide for cooperative environmental governance by establishing principles for decision-making on matters affecting the environment. In addition, these institutions will promote cooperative governance and procedures for coordinating environmental functions by organs of state.
Just Transition Framework	This framework is a planning tool for achieving a just transition in South Africa, setting out the actions that the government and its social partners will take to achieve a just transition and the outcomes to be realised in the short, medium, and long term.
Disaster Management Act (2002)	The Disaster Management Act of 2002 provides for an integrated and coordinated disaster management policy that focuses on preventing or reducing the risk of disasters, mitigating the severity of disasters, emergency preparedness, rapid and effective response to disasters and post-disaster recovery, including climate-related disasters.
National Veld and Forest Fire Act (1998)	The purpose of this Act is to prevent and combat veld, forest and mountain fires throughout the Republic and to provide for a variety of institutions, methods and practices for achieving this purpose.

2.3.2. Desired Adaptation Outcomes

The development of Desired Adaptation Outcomes (DAOs) is a crucial objective that informs and directs the monitoring and evaluation of South Africa's progress towards a climate-resilient society. These DAOs are derived from sector-specific adaptation priorities, as outlined in Chapter 5 of the National Climate Change Response White Paper (NCCRWP). To establish these outcomes, consultative sessions have been held with various departments including the Department of Environmental Affairs (Biodiversity branch), Department of Water and Sanitation (DWS), Department of Health (DOH), Department of Human Settlements (DHS), and the National Disaster Management Centre. During these consultations, the proposed DAOs were widely accepted. It is recommended that the TMDM engages with the Desired Adaptation Objectives outlined below, in the implementation and mainstreaming of the Climate Change Adaptation Plan

The Desired Adaptation Outcomes encompass various key aspects to monitor and evaluate climate resilience. These include:

1. Robust policies, programmes and actions for climate change adaptation.
2. Appropriate processes and mechanisms for coordinating climate change adaptation.
3. Accurate weather forecasting, reliable seasonal predictions, climate projections and effective early warning systems for extreme weather and other climate-related events.
4. Capacity development, education, and awareness programmes for climate change adaptation.
5. Resources and capacity to deliver climate change adaptation.
6. Climate change adaptation is fully integrated into development planning.
7. New technologies/knowledge developed for use in climate change adaptation and other cost-effective opportunities optimized.
8. Systems, resources, communities, and sectors are less vulnerable to climate change impacts.
9. Reduction in non-climate pressures and threats to human and natural systems.
10. Secure food, water, and energy supplies are available for all.

These DAOs form a holistic framework aimed at guiding the country's adaptation strategies. They ensure a robust response to climate change impacts while integrating adaptation into broader developmental planning, emphasizing capacity building, education, and the development of new adaptation technologies. Ultimately, the goal is to create a society that is resilient to climate change impacts, ensuring secure food, water, and energy supplies for everyone.

2.3.3. Local Policy Context

At the local level, Thabo Mofutsanyana DM's climate change policy space is framed by a Climate Change Vulnerability Assessment and Response Plan that was developed in 2016 through the Department of Environmental Affairs, Local Government Climate Change Support Programme (LGCCSP).

The Climate Change Vulnerability Assessment and Response Plan (2016) highlights the key sectors that will be impacted by climate change, which include:

- Agriculture: Climate change is predicted to negatively impact the agricultural sector in TMDM. Increased temperatures, drought, and the increase in frequency and severity of storm events will impact the crops that can be grown and potentially result in a loss of livestock. Furthermore, it is expected that there will be an increase in exposure to pests that will impact crops grown.

- Biodiversity and Environment: Changes in climate are predicted to result in the shifting of bioregions across South Africa. In the TMDM, it is projected that with the warmer temperatures that there will be a replacement of the grassland biome with savanna. A large amount of grassland and grassland-related species will be lost.
- Water: TMDM is currently experiencing issues of water scarcity and quality. Climate change is expected to exacerbate this problem. Drought, reduced runoff, increased evaporation, and an increase in flood events will impact both water quality and quantity.

The themes that are discussed in the Response Plan include:

- Agriculture;
- Biodiversity and Environment;
- Human Health;
- Human Settlements; and
- Water.

Additionally, it should be noted that the TMDM does not currently have a Disaster Management Plan in place. In the IDP it is explained that municipalities do not receive funds for disaster management from the provincial government and therefore they do not have funds in their own budget to make provision for it. However, it is recommended that a Disaster Management Plan be formulated as soon as possible as this is prescribed by legislation.

2.4. District Municipality Responsibilities

In South Africa, district municipalities play a significant role in climate change adaptation. While the specific powers and functions related to climate change may vary slightly between municipalities, there are a number of established responsibilities typically associated with district municipalities in South Africa which can be linked to climate change adaptation:

1. Climate Change Planning: District municipalities are responsible for developing and implementing climate change adaptation plans at the local level. These plans are required to assess the vulnerability of the district to climate change impacts and outline strategies and actions to minimize risks and enhance resilience.
2. Infrastructure Development: District municipalities are tasked with planning and coordinating the development of infrastructure. Infrastructure should be developed to be resilient to climate hazards as well as support resilience objectives as part of an integrated climate change adaptation approach. This includes the construction of climate-resilient roads, bridges, and drainage systems that can withstand extreme weather events and reduces risk to vulnerable assets and communities.
3. Natural Resource Management: District municipalities are responsible for managing natural resources within their jurisdiction to support climate change adaptation. This involves conserving and protecting ecosystems, such as wetlands and forests, that provide a natural defense against climate impacts like flooding and erosion.

4. Disaster Risk Reduction: District municipalities have key responsibilities in disaster risk reduction, including preparedness, response, and recovery. They should play a role in establishing early warning systems, and emergency response plans, and coordinate efforts with other local government entities, provincial authorities, and national disaster management agencies.
5. Stakeholder Engagement: District municipalities facilitate stakeholder engagement processes to raise awareness about climate change adaptation and involve local communities, NGOs, businesses, and other relevant actors in decision-making processes. They often collaborate with local organizations to implement climate change adaptation projects and programs.
6. Capacity Building and Training: District municipalities are responsible for building capacity and providing training to local government officials, communities, and relevant stakeholders on climate change adaptation. This helps enhance their knowledge and skills in implementing climate-resilient practices and technologies.
7. Monitoring and Evaluation: District municipalities monitor the progress of climate change adaptation initiatives and evaluate their effectiveness. They collect data, measure key performance indicators, and assess the success of implemented strategies to ensure that adaptation measures are delivering the desired outcomes.

It is important to note that while district municipalities have a range of powers and functions related to climate change adaptation, collaboration with other levels of government, such as provincial and national authorities, is also crucial for effective climate action and coordination of resources and policies.

2.4.1. Power and Functions of the District Municipality

This section entails a high-level overview of the relevant power and functions of District Municipalities in South Africa that can be referenced to assign and assume responsibilities related to climate action. Due to the time- and resource-limited nature of this study, this is by no means an exhaustive review.

According to South Africa's Local Government: Municipal Structures Act, the District Municipality has the following functions and powers:

a) Integrated development planning for the district municipality as a whole, including a framework for integrated development plans of all municipalities in the area of the district municipality.
b) Potable water supply systems.
c) Bulk supply of electricity, which includes for the purposes of such supply, the transmission, distribution and, where applicable, the generation of electricity.
d) Domestic waste-water and sewage disposal systems.
e) Solid waste disposal sites, in so far as it relates to—

i. the determination of a waste disposal strategy;
ii. the regulation of waste disposal;
iii. the establishment, operation and control of waste disposal sites, bulk waste transfer facilities and waste disposal facilities for more than one local municipality in the district.

f) Municipal roads which form an integral part of a road transport system for the area of the district municipality as a whole.
g) Regulation of passenger transport services.
h) Municipal airports serving the area of the district municipality as a whole.
i) Municipal health services.
j) Fire-fighting services serving the area of the district municipality as a whole, which includes—
   i. planning, co-ordination and regulation of fire services;
   ii. specialised fire-fighting services such as mountain, veld and chemical fire services;
   iii. co-ordination of the standardisation of infrastructure, vehicles, equipment and procedures;
   iv. training of fire officers.
k) The establishment, conduct and control of fresh produce markets and abattoirs serving the area of a major proportion of the municipalities in the district.
l) The establishment, conduct and control of cemeteries and crematoria serving the [district as a whole] area of a major proportion of municipalities in the district.
m) Promotion of local tourism for the area of the district municipality.
n) Municipal public works relating to any of the above functions or any other functions assigned to the district municipality.
o) The receipt, allocation and, if applicable, the distribution of grants made to the district municipality.
p) The imposition and collection of taxes, levies and duties as related to the above functions or as may be assigned to the district municipality in terms of national legislation.

3. Summary of Climate Risk Profile

In line with global trends, TMDM is being confronted by the consequences of climate change, which are projected to result in the escalated intensity and frequency of climate hazards in the future. Recognizing the scale of this challenge, the DM has acknowledged the importance of enhancing resilience and safeguarding its populace, natural resources, economic endeavours, and livelihoods against climate change impacts.

The sections below provide a summarised overview of climate vulnerability in the TMDM, and the priority risks and climate impacts which provide the basis for the identification of suitable climate change adaptation actions.

3.1. Overview of Baseline and Future Climate Risk.

Thabo Mofutsanyana DM's baseline climate risk refers to the current level of risk posed by climate change and its impacts, and future climate risk refers to the projected level of risk that is expected to occur. An ensemble of 6 CMIP5 GCMs was used in the development of baseline and future climate change scenarios, for both the RCP 4.5 and 8.5 scenarios. The regional climate model (CCAM) was utilised in the downscaling from 50km resolution to 8km resolution. The periods that will be covered in the climate analysis are the baseline (1961 – 1990) and the future (2021 – 2050) periods.

3.1.1. Climate Analysis

3.1.1.1 Average temperatures

The District experiences current average annual temperatures of between 12 and 16 °C, with the highest temperatures found along the northeast of the District. The average annual temperature is projected to increase between 2 °C and 3 °C across the District by into the future, under a low mitigation, high emissions (RCP8.5), scenario. Mantsopa Local Municipality is projected to overall see the highest increase in average temperatures.

3.1.1.2. Rainfall

The District Municipality experiences a current average annual rainfall of between 1200 and 2400 mm, with the southeast part of the District having the highest average rainfall. The District is projected to see a slight increase in average annual rainfall of between 100 and 200 mm by 2050, under a low mitigation (i.e. a "business as usual" greenhouse gas emissions) scenario (RCP8.5).

3.1.2. Climate Hazards

A summary of the climate hazards is included below:

3.1.2.1. Drought

The north-west part of the District has the highest drought tendency within the District and is also projected to see the highest increase in drought tendencies into the future, under a low mitigation, high emission scenario (RCP8.5). Most of the settlements in the District are projected to have a very low to low risk of increasing drought tendencies into the future, with only Vrede and Memel projected to have a moderate risk of increase in drought tendencies.

3.1.2.2. Heat

The annual average number of very hot days, which is defined as a number of days when the maximum temperature exceeds 35°C GCM grid point for the baseline (current) period of 1961–1990, and the projected change for the period 2021–2050. Under baseline conditions, there are between 11 and 20 very hot days experienced within the District annually. While heatwave events are more likely to take place towards the central part of the District, affecting Dihlabeng, Nketoana, and Maluti a Phofung Local Municipalities the most. The areas that currently experience hot days are likely to experience an increase in the future. With the changing climate, it is expected that the impacts of heat will only increase in the future and most of the settlements are expected to have a low risk of increase in extreme heat by 2050.

3.1.2.3. Wildfire

Fire risk is determined by combining the typical fire hazard for a fire ecotype (i.e., likelihood, fire severity) and the social and economic consequences (i.e., the potential for economic and social losses). Many of the settlements are likely to experience wildfires on their wildland-urban interface, including most of the eastern, western and southern settlements. Most of the settlements within the district are also expected to have a moderate risk of an increase in wildfires, with only a few of the more central settlements having a low risk of an increase in wildfires in the future.

3.1.2.4. Flooding

The flood hazard assessment combines information on the climate, observed floods, and the characteristics of water catchments that make them more or less likely to produce a flood. There is a significant variation in the flood hazard index across the District. Most parts of the District have a medium flood hazard, with pockets of low flood hazard in the southwest and pockets of high flood hazard in Phumelela and Maluti a Phofung Local Municipalities. There is a slight

increase in extreme rainfall days expected for a large part of the District, with significant increases on the eastern and south-western borders of the District. Settlements that are at high risk of increase in the likelihood of flooding in their catchments include most of the settlements in Nketoana and the northern settlements in Phumelela. There are also quite a few settlements throughout the District that have a moderate risk of increase in flood likelihood in the future.

3.1.3. Climate Impacts

3.1.3.1. Water Resources

In South Africa, groundwater plays a key strategic role in supporting economic development and sustaining water security in several rural and urban settlements that are either entirely or partially dependent on groundwater supply. Groundwater is, however, a natural resource whose availability and distribution are highly influenced by climate variability and change. In the Thabo Mofutsanyana District, there is a mix of surface-water and groundwater-dependent towns, but most of the settlements are surface-water dependent. The groundwater recharge potential is higher along the eastern side of the District, but overall, there is a moderate recharge potential over most of the District.

The groundwater-dependent settlements in Dihlabeng, Nketoana, and Mantsopa have a very low to low risk of groundwater depletion, considering the projected groundwater recharge potential combined with population growth.

Table 4: Current Water Supply and Vulnerability Across the TMDM

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
Dihlabeng	196.05	340.66	0.58
Maluti a Phofung	141.52	252.6	0.56
Mantsopa	161.96	459.7	0.35
Nketoana	141.1	49.96	2.82
Phumelela	86.19	202.73	0.43
Setsoto	261.25	356.24	0.73

Key: A water supply vulnerability score above 1 indicates that demand is more than supply, while a score below 1 indicates that supply is meeting demand.

In a detailed examination of water supply metrics across selected local municipalities, distinct patterns emerge. Starting with Dihlabeng, the water demand per capita stands at 196.05 litres per person per day (l/p/d), while the supply per capita is significantly higher at 340.66 l/p/d, resulting in a current water supply vulnerability score of 0.58. Maluti a Phofung sees a water demand of 141.52 l/p/d and a water supply of 252.6 l/p/d, with a vulnerability score of 0.56. Mantsopa's demand is 161.96 l/p/d, but they boast a higher supply rate of 459.7 l/p/d, reflecting a relatively lower vulnerability at 0.35. A stark contrast is evident in Nketoana, which has a

demand of 141.1 l/p/d but a concerning supply of just 49.96 l/p/d, leading to the highest vulnerability score of 2.82 among the municipalities listed. Phumelela's figures present a demand of 86.19 l/p/d and a supply of 202.73 l/p/d, with a vulnerability rating of 0.43. Lastly, Setsoto has a relatively high water demand of 261.25 l/p/d, and a supply rate of 356.24 l/p/d, with a vulnerability score of 0.73. The vulnerability scores, in essence, reflect the stress levels on the water supply system, with higher values indicating greater vulnerability and potential challenges in meeting the water demands of the population.

3.1.3.2. Sectors

The Agricultural, Forestry and Fisheries sector contributes 10% to the local GVA of the District Municipality and employs approximately 21% of the District Municipalities' labour force. Phumalela Local Municipality has the highest amount of employment in the AFF sector, with around 35 % of the working population being employed in this sector. The main commodities produced by the District Municipality are maize, wheat, potatoes and beef cattle.

Climate projections show a generally hotter and wetter climate, which could result in:

- Increased crop yields in the short term.
- Increased heat stress could reduce the quantity and quality of crops produced in the area.
- Increased heat stress on livestock can lead to reduced growth & reproductive efficiency.
- Hotter and wetter conditions generally improve the conditions necessary for the growth and spread of parasites and diseases.

3.1.4. Priority Risks and Vulnerabilities

3.1.4.1. Municipal

Municipal vulnerability is unpacked in terms of four vulnerability indices (Socio-Economic Vulnerability Index [SEVI], Economic Vulnerability Index [EcVI], Physical Vulnerability Index [PVI] and Environmental Vulnerability Index [EnVI]).

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

Table 5: Vulnerability Indicators Across TMDM.

LOCAL MUNICIPALITY	SEVI 1996	SEV 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
Dihlabeng	5.40	4.30	↘	4.63	5.36	↗	5.19	N/A	3.69	N/A
Maluti a Phofung	6.28	5.58	↘	6.00	7.45	↗	4.88	N/A	4.26	N/A
Mantsopa	5.91	5.00	↘	4.36	4.30	↘	5.54	N/A	3.88	N/A
Nketoana	6.39	5.66	↘	5.67	6.67	↗	5.69	N/A	4.27	N/A
Phumelela	7.26	6.05	↘	7.40	8.00	↗	6.06	N/A	4.11	N/A
Setsoto	6.59	5.77	↘	4.68	7.04	↗	6.42	N/A	3.39	N/A

The socio-economic vulnerability has improved (decreased vulnerability) across all local municipalities in the District between 1996 and 2011. In comparison five of the six Local Municipalities saw a deterioration (increased vulnerability) in economic vulnerability, with only Mantsopa Local Municipality seeing an improvement in economic vulnerability. A big contributor to the increase in economic vulnerability for many of the Local Municipalities was an increase in unemployment, as well as an increase in inequality. The physical vulnerability for most of the Local Municipalities is on par with the average vulnerability for the country, with Phumelela and Setsoto Local Municipalities being a little below average and more vulnerable than the other four municipalities. All six of the Local Municipalities have a low environmental vulnerability.

3.1.4.2. Settlement

The unique set of six (6) indicators listed below highlights the multi-dimensional vulnerabilities of the settlements within the TMDM and its LMs.

- Socio-Economic Vulnerability Index
- Economic Vulnerability Index
- Environmental Vulnerability Index
- Growth-Pressure Vulnerability Index
- Regional Economic Connectivity Vulnerability Index
- Service Access Vulnerability Index

Table 6: Anticipated Settlement Vulnerability

Local municipality	Anticipated settlement vulnerability
Dihlabeng Local Municipality	• The major settlements Local Municipality are Bethlehem, Clarens, Fouriesburg, Mashaeng, Paul Roux, and Rosendal. • Bethlehem has seen the greatest growth pressure. • Rosendal has a high service access vulnerability as well as a high socio-economic, economic and regional connectivity vulnerability. • Mashaeng also have high socio-economic, economic, and regional connectivity vulnerability and also has the highest environmental vulnerability.

Maluti a Phofung Local Municipality	• The major settlements in this Local Municipality are Thaba Tshweu, Lejwaneng, Thab Bosiu, Monontsha, Phuthaditjhaba, Tshiame, Kestell, Wilgepark, Indistriaqwa, Harrismith and 42nd Hill. • Monontsha faced the highest growth pressure in past and also has the highest socio-economic vulnerability in the municipality. • Wilgepark has the highest regional connectivity and environmental vulnerability. • 42nd Hill has the highest economic vulnerability as well as a high regional connectivity and socio-economic vulnerability.
Mantsopa Local Municipality	• The major settlements in this Local Municipality are Dipelaneng, Excelsior, Hobhouse, Ladybrand, Manyatseng, Thaba Phatswa, and Tweespruit. • Dipelaneng experienced the highest growth pressure and also has the highest socio-economic vulnerability. • Excelsior has a high regional connectivity, socio-economic, economic, and environmental vulnerability. • Hobhouse has the highest service access vulnerability.
Nketoana Local Municipality	• The major settlements in this Local Municipality are Arlington, Lindley, Mamafubedu, Petrus Steyn and Reitz. • Mamafubedu has the highest socio-economic vulnerability and along with Petrus Steyn have very high growth pressure, regional connectivity and environmental vulnerability. • Arlington has the highest economic vulnerability. • Reitz has the highest service access vulnerability.
Phumelela Local Municipality	• The major settlements in this Local Municipality are Memel, Vrede, Warden, and Zenzeleni. • Zenzeleni overall have the highest vulnerability in all the vulnerability categories, except for service access vulnerability. • Warden has a very high regional connectivity vulnerability. • Memel has the highest service access vulnerability.
Setsoto Local Municipality	• The major settlements in this Local Municipality are Clocolan, Ficksburg, Marquard, Moemaneng and Senekal. • Ficksburg has a high environmental, growth pressure and service access vulnerability. • Clocolan has a high regional connectivity, economic, and service access vulnerability. • Moemaneng has the highest socio-economic and economic vulnerability.

4. Climate Change Adaptation Plan

4.1. Thabo Mofutsanyana's Vision and Mission Strategic and the Linkage to Climate Change Adaptation

TMDM identified a vision statement and mission statement to guide the district municipality's development process, as outlined in the IDP. Mainstreaming climate action should be considered a key success factor in achieving these objectives as it can help promote sustainable socio-economic development by protecting the investments being made by the TMDM and supporting livelihood resilience.

- Vision: Integrated, economically viable and developmental local government.
- Mission: Continuously develop and improve the living conditions of our communities by providing efficient and effective bulk services and creating a conducive environment for economic opportunities and job creation.

TMDM's mission statement aims to promote efficient and effective bulk services as well as to create a conducive environment for economic opportunities and job creation. This links to climate change adaptation as the provision of bulk services can increase resilience to climate change, as improved sanitation services and increased access to clean water can improve living conditions and reduce the occurrence of disease. Furthermore, creating a conducive environment for economic opportunities and job creation can further enhance resilience to climate change as individuals and communities will have increased access to financial resources needed to invest in climate change adaptation measures, as well as the opportunity to diversify income streams and reduce reliance on climate-sensitive sectors.

4.2. Climate Change Adaptation Vision

For the TMDM climate change resilience and mainstreaming would mean integrating the relevant climate change response principles into all aspects of municipal planning, development, and operations.

In the context of TMDM, there are several practices that could be considered as part of a shift towards a climate-resilient district:

- Climate-Resilient Communities and Settlements: TMDM could adopt design standards and practices that consider future climate change impacts, ensuring that infrastructure and settlements are resilient to these changes. This practice aligns with the goal of reducing the vulnerability and exposure of human and natural systems to climate change and extreme events.
- Climate-resilient Natural Resources and Ecosystems: This includes enhancing conservation efforts in protected areas, promoting sustainable farming and fishing practices, and raising public awareness about the importance of biodiversity.

- Water Conservation and Efficiency: Such measures can involve improving water infrastructure, encouraging water conservation practices, and exploring alternative water sources like rainwater harvesting, groundwater, and wastewater reuse.
- Sustainable Agricultural Communities: To enhance the resilience of the agricultural sector, TMDM could consider practices that promote climate-smart agriculture. This may include investing in research and development to identify and promote crops that are resilient to climate change, implementing water-efficient irrigation techniques, and providing training and support to farmers to adopt sustainable farming practices.

These best practices are not exhaustive and could be complemented by other strategies tailored to the specific context and needs of the TMDM. The key to success is integrating these principles into all aspects of municipal decision-making and operations and engaging the community in these efforts.

The proposed climate change response vision for the TMDM reads as follows:

"To become a municipality that protects natural resources, promotes climate change mitigation and adaptation, and works with communities and stakeholders to ensure a prosperous and equitable future for everyone."

This vision is focused on creating a municipality that is sustainable and can adapt to the challenges posed by climate change. The aim is to ensure that the communities are safe, prosperous, and able to protect and preserve natural resources for future generations. The response to climate change will be driven by innovative and cost-effective solutions that promote sustainable development and economic growth. The key to achieving this vision is through collaboration with stakeholders to ensure that climate change considerations are integrated into the planning and decision-making processes. It is important that all actions are informed by the latest scientific knowledge and best practices to build a resilient and sustainable future for the municipality.

To achieve this vision, we need to develop a comprehensive list of climate actions for TMDM that address climate risks, sustainability, adaptation, community safety and prosperity, natural resource preservation, innovation, collaboration, and resilience. The climate actions also offer co-benefits, promoting equity, a just -transition, and ensuring the health and resilience of people, natural resources, and the economy.

4.3. Climate Change Goals and Programmes

The identification of adaptation actions followed a sequenced approach initiated by the outcomes of the TMDM Climate Change Risk profile which informed the development of specific Adaptation

Goals have been developed to guide a contextually relevant approach to adaptation planning. The Adaptation Goals informed the development of Strategic Adaptation Priorities to support the identification and categorisation of Adaptation Programmes. Each Programme was then unpacked to provide a detailed breakdown of the key climate actions and support activities.

The Adaptation Goals include:

1. Water resource management: Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. This includes investing in efficient water infrastructure, prioritising infrastructure maintenance, promoting water conservation practices, implementing rainwater harvesting systems, and exploring alternative water sources such as groundwater and wastewater reuse.
2. Ecosystem conservation: Protecting and restoring natural ecosystems, such as high priority biomes, wetlands, river ecosystems and riparian areas, to perform critical ecosystem services, enhance biodiversity, support water resource management, and provide natural buffers against climate-related hazards such as wildfires.
3. Social equity and vulnerable populations: Ensuring that adaptation efforts prioritise the needs of vulnerable populations, such as low-income communities and informal settlements. This could involve providing access to basic services, improving housing conditions, and implementing early-warning systems tailored to these communities.
4. Fire management: Targeting fire prevention and strategies to mitigate the risks associated with wildfires. This could involve identifying areas for designated firebreaks, ensuring water reserves for fire-fighting, and developing advanced early-warning systems for fires to protect vulnerable communities and infrastructure.
5. Agriculture and food security: Given that food security is a potentially significant future climate change-related impact, developing a food security and agricultural policy that takes climate change impacts into consideration is crucial. This includes increasing the resilience of the agricultural sector by supporting commercial and small-scale farmers across industries, promoting solutions to drought such as highly efficient irrigation systems, exploring alternative crop types, assessing livestock carrying capacity and implementing grazing management and fire management.
6. Flood management: Developing effective flood management strategies to mitigate the risks associated with heavy rainfall events. This could involve improving stormwater drainage systems, restoring damaged and regraded ecosystems, creating floodplains and retention basins, and implementing advanced early-warning systems for flooding to protect vulnerable communities and infrastructure.

The TMDM Climate Change Programmes that have been developed from the Adaptation Goals and Strategic Priorities include:

1. Programme 1: Adopt an integrated approach to water augmentation, water use and water management.
2. Programme 2: Protect and conserve water through monitoring mechanisms and water conservation through Water Conservation and Water Demand Management (WCWDM).
3. Programme 3: Assessing the feasibility and sustainability of alternative water sources.
4. Programme 4: Implementing Sustainable Groundwater Use and Development Strategy.
5. Programme 5: Conserve, protect and restore natural open spaces, ecosystems and natural resources.
6. Programme 6: Enhanced natural resource management.
7. Programme 7: Integration of ecological support areas, ecological corridors and ecosystem services into municipal spatial plans.
8. Programme 8: Identify and prioritise climate change risks and develop response measures for settlements.
9. Programme 9: Community-based adaptation in communities most at risk of climate-related hazards.
10. Programme 10: Climate-resilient spatial planning.
11. Programme 11: Sustainable development of a resilient tourism industry.
12. Programme 12: Wind resilience initiative.
13. Programme 13: Climate-smart transport strategy for resilience and efficiency.
14. Programme 14: Energy efficiency initiative for climate change adaptation.
15. Programme 15: Integrated fire management for climate resilience.
16. Programme 16: Enhanced resilience of agricultural production and distribution systems from climate change.
17. Programme 17: Climate resilient agricultural communities.
18. Programme 18: Comprehensive stormwater and flood management programme.

4.4. Climate Change Goal 1: Water Resource Management

Goal:	To implement measures to secure water availability for all users and uses, while reducing water demand, use, pollution and waste, in response to the impacts of climate change on the water cycle
Outcome:	A secure and efficient water supply for all, with reduced demand, waste, and pollution.

4.4.1. Rationale/Context:

The Free State's geography, marked by its rivers – the Vaal to the north, the Orange/Gariep to the south, and the Caledon/Mohokare to the east – serves as the lifeline for its communities and ecosystems. These rivers, coupled with their tributaries, catchments, wetlands, and dams, form the backbone of surface water supply in the province. However, despite the province's efforts to maximize water access through dams and transfer schemes, the delicate balance is continually tested. Recent experiences, such as the severe drought that led to the province being declared a disaster area in late 2015, demonstrate the vulnerability of the region's water resources, affecting both drinking water supply and agricultural needs.

Furthermore, the quality of water in the Free State is under threat due to diverse activities, notably mining, agriculture, and challenges related to sewage management. The aftermath of these activities has resulted in degraded water quality, high salinity, and nutrient pollution, which, in turn, deteriorates river health, impacting both the ecosystem services they provide and the biodiversity they support. On top of these existing challenges, climate change further compounds the problem. Projections indicate that by 2035, the costs associated with meeting water demand could triple compared to the standard climatic scenarios. This potential financial strain underscores the critical nature of water security in the province, especially as the most vulnerable sections of society, lacking the means to take preventive or adaptive measures, will be hit the hardest.

In light of this, the Thabo Mofutsanyana District Municipality's emphasis on water security emerges as a paramount adaptation priority. As the municipality grapples with the realities of fluctuating temperatures, inconsistent rainfall, and increased drought risk, there is a pressing need to rethink the current water management strategies. This includes exploring sustainable alternatives, bolstering existing infrastructure, and implementing demand management to ensure the resilience of its water resources in the face of an unpredictable climate. Several programmes have been identified through which it will aim to achieve the goal and targets of this outcome:

4.4.2. Programme 1: Adopt an Integrated Approach to Water Augmentation, Water Use and Water Management.

This programme seeks to address the water resource limitations in TMDM. The programme aims to create a comprehensive strategy to manage these resources efficiently, improve water use, and ensure long-term sustainability amid climate change.

- The first component of the programme is water-sensitive urban design (WSUD). This strategy integrates the water cycle into urban landscapes to increase water availability and improve its quality.
- Addressing human resources constraints for effective water management is another critical step. This action involves identifying workforce gaps, training existing staff, and recruiting additional personnel as necessary.
- Reviewing the bulk water master plan is also integral to the programme. Regularly updating this strategic document is critical, especially given the dynamic nature of water resources within the district, the changing climate, and shifts in water demand projections.
- Finally, the development of a water safety plan (WSP) is necessary to ensure safe drinking water from the source to the tap and implementing a comprehensive WSP can safeguard public health, meet regulatory requirements, and boost consumer confidence in the water supply.

In summary, the proposed programme aspires to cultivate a holistic approach to water management, considering all aspects of the water cycle, from supply to disposal. It focuses on enhancing the resilience and sustainability of the district's water resources amidst changing climate conditions, a growing population, and an ageing infrastructure.

Table 7: Programme 1: Integrated approach to water augmentation, use and management.

Programme 1: Integrated Approach to Water Augmentation, Use, and Management.	
ACTIONS	KEY ACTIVITIES
Water-sensitive urban design (WSUD).	• Implementing green infrastructure. Maintain water services efficiently, the municipality can introduce green infrastructure to capture, store, and treat stormwater while improving air quality and biodiversity within the community. • Promoting water reuse. Identify and implement opportunities for using treated wastewater for non-potable purposes such as irrigation, industrial processes, and toilet flushing. This will ensure the sustainable use of water resources. • Encouraging water-efficient design: Ensure equitable water services, buildings and infrastructure could be designed to minimise water use through the use of low-flow fixtures, water-efficient landscaping, and water recycling systems.

	• Managing urban runoff: Assess the feasibility of capturing and re-using stormwater. • Educating and engaging stakeholders: Promote awareness of the benefits of WSUD and encourage participation in the design and implementation of WSUD projects. This will ensure that the community is well-informed and actively involved in sustainable water usage initiatives.
Addressing human resources constraints for effective water management	• Advocate for and secure funding for a dedicated water resources manager position: Highlighting the crucial role of a water resources manager in addressing drought and other water-related challenges in the municipality. This would help to ensure the efficient provision of water services. • Recruit and train a qualified water resources manager: By implementing a transparent recruitment process to select a skilled and experienced water resources manager, the municipality can ensure they have the necessary skills and knowledge to effectively manage water resources. • Strengthen collaboration and communication between the water resources manager and other relevant water management departments: Establishing a cross-functional working group to facilitate communication, collaboration, and information sharing between the water resources manager and other departments responsible for water management.
Review bulk water master plan	• Understanding the current water landscape: The initial stage will involve mapping out the current water resources and needs, which includes municipal, industrial, and agricultural sectors. It is crucial to integrate climate change projections into this analysis to anticipate future shifts in water supply and demand. • Exploring new water sources: The updated plan should investigate potential new sources of water, such as surface water, groundwater. This evaluation will take into account factors like cost, feasibility, and environmental impact for each potential source. • Evaluating Infrastructure requirements: The plan should conduct an in-depth review of the existing water-related infrastructure, including water treatment facilities, pipelines, and storage units. The aim is to pinpoint areas that may need additional infrastructure to cater to future demands. • Setting goals and formulating strategies: The plan will clear water usage goals and devise strategies to curb water consumption and augment efficiency. These strategies may involve initiatives like water metering, leak detection, and public education drives. • Execution of the plan: The final stage will involve the roll-out of the plan. Regular monitoring and evaluation will be integral to ensure that the set targets are being met and necessary

	adjustments are made to the plan as needed. This stage may also necessitate funding for new infrastructure, fostering partnerships with relevant organisations, and ensuring stakeholder alignment with the plan's objectives.
Developing a Water Safety Plan (WSP).	• Conducting a risk assessment: Assess the risks that can affect the quality and safety of the water supply, including natural hazards and man-made threats. • Determining control measures: Identify control measures that can be implemented to reduce risks and enhance the safety of the water supply, such as disinfection, filtration, and monitoring. • Developing an emergency response plan: Develop a plan for responding to incidents that could affect the water supply, such as natural disasters or system failures. • Implementing monitoring and reporting: Establish a monitoring programme to ensure that the water supply remains safe and of good quality. The results of monitoring should be reported to relevant authorities and stakeholders. • Training and educating staff: Ensure that all staff involved in the water supply system are trained on WSP development and implementation, including risk assessment, control measures, and emergency response. • Reviewing and updating the plan regularly: The WSP should be reviewed and updated periodically to ensure that it remains relevant and effective in addressing emerging risks and challenges.

4.4.3. Programme 2: Water Conservation and Demand Management

This Programme aspires to curtail water consumption and wastage, while also safeguarding the water quality within the TMDM. This is fundamental to ensuring the long-term sustainability of water resources, especially considering climate change, where intensifying water scarcity and pollution are anticipated. The specific actions under this programme are designed to tackle the significant pressures on TMDM's water resources, as described in the district's environmental profile.

- Implementing monitoring mechanisms and reducing pollution: Given the water pollution challenges, the mechanisms proposed will deliver consistent and reliable data on water quality, enabling timely interventions. Additionally, this activity aims to reduce pollution at its source, be it nutrient loading, bacterial and pathogenic contamination from sewage and animal waste, or poor wastewater management. Clean water is a critical component in ensuring water security, particularly under shifting climatic conditions.
- Implementing water conservation measures: As climate change could intensify drought conditions and increase the occurrence of very hot days, water conservation becomes crucial. Water conservation measures can vary from promoting water-efficient technologies

and practices, enhancing public awareness about the importance of water conservation, to implementing strict regulations on water use during drought periods.

- Alien invasive species clearing initiatives in catchment areas: Alien invasive species, particularly those infiltrating wetland habitats and river systems, often consume more water than native species, thereby jeopardising water security. Their presence can lead to the degradation of water catchment areas and wetlands. Enhancing water security, therefore, involves implementing strategic clearing of these invasive species from catchment areas, protecting these critical water sources. This initiative not only bolsters the health and resilience of these areas but also improves their capacity to provide clean, usable water.
- Enforce 'green' approaches in residential areas and developments: The green approach in residential areas and developments encourages the sustainable use of resources, including water. This can span from advocating for rainwater harvesting and greywater recycling to implementing green infrastructure such as permeable pavements and green roofs that help manage stormwater and reduce runoff.

The rationale for this programme stems from the urgent need to conserve water and manage demand amidst climate change, as well as the significant internal and external pressures that endanger UMDM's water resources. By focusing on these activities, the programme aspires to ensure that UMDM's water resources are managed sustainably, enabling the district to adapt effectively to the projected impacts of climate change.

Table 8: Programme 2: Protect and conserve water through monitoring mechanisms and water conservation through Water Conservation and Water Demand Management (WCWDM).

Programme 2: Protect and Conserve Water Through Monitoring Mechanisms and Water Conservation through Water Conservation and Water Demand Management (WCWDM).	
ACTIONS	KEY ACTIVITIES
Implementing monitoring mechanisms and protecting water sources by reducing pollution.	• Water quality monitoring: Implement a regular testing schedule to monitor the health of water sources and identify potential pollution sources. This will support the mandate of providing and maintaining efficient and sustainable water services. • Buffer zone establishment: Create and manage buffer zones around water sources, such as rivers and wetlands, to protect them from pollution. The design of these zones should prevent runoff from agricultural and urban areas from entering the water sources, supporting the district government's role in coordinating and integrating water management efforts. • Sustainable agricultural practices promotion: Facilitate awareness campaigns, training, and capacity-building programmes to encourage farmers to use environmentally friendly fertilizers and pesticides. This contributes to the provincial government's mandate of developing and implementing plans and programmes for the sustainable use of water resources.

	• Effluent discharge regulation: Develop by-laws and regulations to control the discharge of industrial and domestic effluent municipal sewer system. Regular monitoring of industries will ensure compliance, supporting the mandate of ensuring activities do not negatively impact water resources. • Responsible waste disposal advocacy: Further provide facilities for the disposal of hazardous waste and improve on public awareness campaigns on the importance of responsible waste disposal. This will help reduce the risk of water source pollution and aligns with the broader mandate of protecting water resources.
Implementing water conservation measures.	• Increase public awareness campaigns: Engagement with the public through campaigns, workshops, and educational programmes that promote water conservation practices. • Improve leak detection and repairs: Enhance efforts to identify and repair leaks in water supply systems and infrastructure to prevent water loss. • Continue water metering and billing: Persist with the installation of water meters and implement billing systems that charge consumers based on the amount of water used, as a means to encourage water conservation. Water-efficient infrastructure: The municipality can install water-efficient fixtures and appliances, such as low-flow showerheads, faucets, and toilets andin municipal buildings. • Greywater recycling: Promote the use of greywater for irrigation and other non-potable uses to reduce demand on the municipal water supply. • Water restrictions: Implement water restrictions during times of drought or water scarcity to limit water use and prevent wastage. • Reclaimed water systems: Install and operate reclaimed water systems that treat wastewater for non-potable uses like irrigation, industrial processes, or firefighting. • Rainwater harvesting: Encourage the installation of rainwater harvesting systems in households and municipal buildings to capture and store rainwater for non-potable uses like irrigation, cleaning, or flushing toilets.
Alien invasive species clearing initiatives in catchment areas.	• Stakeholder collaboration and equitable contribution: Recognising that catchment areas fall outside TMDM boundaries and that various water users utilise the it is essential to collaborate with all stakeholders to determine an equitable contribution from all parties to manage catchments. • Identifying and mapping invasive species: A comprehensive survey of invasive species within the catchment areas can be conducted in partnership with relevant stakeholders to identify and map the areas affected by invasive species.

	• Removal and control of invasive species: This involves the collaborative removal and control of invasive species using various techniques such as mechanical, chemical, and biological control methods, with contributions from all stakeholders. • Rehabilitation of cleared areas: After the removal of invasive species, the cleared areas need to be rehabilitated. This can be done through the restoration of indigenous vegetation and the implementation of erosion control measures, with support from all involved stakeholders. • Education and awareness: Education and awareness campaigns can be implemented in coordination with stakeholders to increase the understanding of the negative impacts of invasive species on catchment areas, and to promote responsible behaviour in preventing the spread of invasive species. • Monitoring and evaluation: The effectiveness of invasive species control measures can be monitored and evaluated in partnership with stakeholders to ensure the long-term sustainability of the project, and to assess the contributions and impact of each stakeholder.
Enforce 'green' approaches in residential areas and developments.	• Developing and implementing guidelines and standards for sustainable residential and commercial development. • Enforcing compliance with building codes and regulations that promote sustainable water use practices, such as the installation of low-flow fixtures and rainwater harvesting systems. • Providing incentives for property owners to invest in green infrastructure and technologies that reduce water consumption and improve water efficiency. • Conducting public awareness campaigns to educate residents on the importance of water conservation and the benefits of green infrastructure. • Implementing water-efficient landscaping practices, such as xeriscaping, in public spaces and parks to reduce water use and promote sustainable development.

4.4.4. Programme 3: Assessing Alternative Water Sources

This programme recognises that ensuring water security in the face of climate change and growing demand will require a diversification of water sources.

- Firstly, water resource management planning is a fundamental action that involves understanding the existing water resources, their usage, challenges, and potential for augmentation. This will entail a thorough review of surface and groundwater availability, projected demands, potential impacts of climate change, and infrastructure capacity. The

plan will provide a comprehensive understanding of the current state of water resources in the district and will serve as a foundation for the rest of the activities in the programme.

- The second activity, investigating alternative water sources, acknowledges the risks of over-reliance on any single water source, particularly groundwater. In the face of changing climate and potential reduction in groundwater recharge potential, alternative water sources such as new groundwater sources, and wastewater reuse need to be investigated. Each of these options has its own set of advantages and challenges, and their feasibility will depend on a variety of factors including cost, environmental impacts, and technological requirements.
- Once potential alternative sources have been identified and assessed, the next step is investing in these alternative water sources. This involves not just financial investment, but also planning and building the necessary infrastructure and implementing the technology needed to extract, treat, and distribute these alternative sources. This might include drilling new boreholes or upgrading wastewater treatment facilities.
- Finally, an essential part of this programme is to develop and implement a treated effluent reuse strategy for sustainable water management. Wastewater reuse involves treating wastewater to a standard where it can be safely used again, which can significantly contribute to water conservation efforts. The development and implementation of a strategy for reusing treated effluent will involve identifying potential uses, developing treatment and distribution systems, and ensuring compliance with health and safety standards.

Essentially, the programme "*assessing alternative water sources*" is a proactive and forward-thinking response to the complex water security challenges in the DM. It recognises the need to diversify water sources, invest in alternative options, and promote sustainable practices such as wastewater reuse, and it plays a crucial role in the district's strategy to ensure water security under a changing climate.

Table 9: Programme 3: Assessing the feasibility and sustainability of alternative water sources for climate change adaptation.

Programme 3: Assessing the Feasibility and Sustainability of Alternative Water Sources for Climate Change Adaptation	
ACTIONS	POSSIBLE KEY ACTIVITIES
Water resource management planning .	• Conducting a water resource assessment: A comprehensive assessment of the existing water resources should be conducted to determine the available water sources, water quality, and quantity. • Identifying water demands: Understanding the current and future water demands of the municipality, including domestic, industrial, and agricultural water use, is crucial for developing a water resource management plan. • Developing a drought management plan: Droughts can have a significant impact on water resources, so developing a drought

	management plan can help to prepare for and mitigate the impacts of drought. • Developing water conservation strategies: Water conservation strategies can help to reduce water demand and optimize the use of available water resources. • Engaging stakeholders: Stakeholder engagement is critical for the successful development and implementation of a water resource management plan. It is important to engage with all relevant stakeholders, including the community, industries, and agricultural sectors, to ensure that their needs are considered in the plan
Investigating alternative water sources. (This activity involves identifying potential alternative water sources, such as groundwater, and wastewater reuse).	• Feasibility studies: Conducting feasibility studies to identify and assess the viability of various alternative water sources, such as rainwater harvesting, groundwater extraction, and stormwater capture. • Hydrological assessments: Undertaking hydrological assessments to determine the water availability and potential yield of alternative water sources, such as aquifers and rivers. • Cost-benefit analysis: Conducting cost-benefit analysis of alternative water sources to determine the economic and environmental costs and benefits of investing in them. • Water quality assessments: Conducting water quality assessments to determine the suitability of alternative water sources for various uses, such as drinking water, irrigation, and industrial processes. • Stakeholder engagement: Engaging with stakeholders, including communities, businesses, and other water users, to identify their water needs and preferences and to get their input on the development of alternative water sources. • Regulatory compliance: Ensuring that any proposed alternative water sources comply with relevant regulations and standards, such as those related to water quality, health and safety, and environmental impact. • Implementation planning: Developing implementation plans for any viable alternative water sources, including detailed designs, procurement of equipment, and construction and operational plans.
Investing in alternative water sources. (Once alternative water sources have been identified, the programme will invest in the infrastructure and technology needed to	• Researching and evaluating potential alternative water sources: This may involve identifying and assessing the feasibility of various water sources, such as wastewater reuse, rainwater harvesting, or groundwater. • Developing infrastructure for alternative water sources: This may involve the construction of treatment plants and pipelines necessary for the collection, treatment, and distribution of alternative water sources. • Developing partnerships and collaboration: This may involve partnering with other stakeholders, such as neighbouring

extract, treat, and distribute these water sources. This may include drilling new boreholes, and upgrading wastewater treatment facilities).	municipalities, government agencies, and private sector entities, to develop and implement alternative water source projects. • Identifying and securing funding: This may involve identifying and securing funding from various sources, such as grants, loans, or public-private partnerships. • Educating and raising public awareness: This may involve educating and raising public awareness about the importance of alternative water sources, how they work, and their benefits, to encourage community support and participation in the development and implementation of these projects.
Develop and implement a treated effluent reuse strategy for sustainable water management.	• Assessing the feasibility and potential benefits of a treated effluent reuse strategy for the TMDM. • Identifying and prioritising potential sites for treated effluent reuse, including public spaces, industrial sites, and agriculture. • Developing a comprehensive treated effluent reuse plan, including infrastructure and system requirements, stakeholder engagement, and potential risks and mitigation strategies. • Conducting a cost-benefit analysis of the treated effluent reuse plan and identifying potential funding sources. • Building and implementing the treated effluent reuse infrastructure, including treatment facilities and distribution systems. • Conducting monitoring and evaluation activities to assess the effectiveness of the treated effluent reuse strategy and identify opportunities for improvement.

4.4.5. Programme 4: Groundwater Management

Groundwater is a critical water resource for the TMDM and is increasingly vulnerable to the impacts of climate change. Implementing a sustainable groundwater use and development strategy is essential for adapting to climate change impacts, ensuring groundwater sustainability, and securing the continued supply of safe water. Implementing a sustainable groundwater use and development strategy is an important step towards adapting to climate change impacts in the TMDM.

- Conducting groundwater resource assessments: Given the potential reduction in groundwater recharge due to climate change and increasing demand, it's important to accurately assess the availability and quality of groundwater. These assessments will provide a clear understanding of the current state of groundwater resources, serving as the basis for all subsequent management actions.
- Establishing sustainable groundwater use policies and guidelines: Based on the assessment findings, the district can formulate and implement policies and guidelines to promote efficient and effective use of groundwater. These regulations may include, for instance,

restrictions on groundwater extraction during certain periods or for certain purposes to avoid overuse and depletion.

- Implementing groundwater monitoring programmes: Constant monitoring of groundwater levels and quality is essential to ensure the sustainability of these resources. Monitoring helps in the early detection of potential problems like falling water levels, contamination, or over-extraction, allowing for timely interventions.
- Promoting groundwater conservation and efficiency: encouraging the adoption of water-saving technologies and practices can significantly reduce the pressure on groundwater resources. This could involve promoting the use of water-efficient appliances and fixtures, advocating for water-wise behaviours, or implementing agricultural practices that conserve water.
- Developing groundwater recharge and artificial recharge strategies: Enhancing the natural replenishment of aquifers or creating artificial means to recharge groundwater resources can help offset the predicted decrease in recharge rates due to climate change. Techniques might include the construction of recharge basins, or the redirection of runoff or treated wastewater into aquifers.
- Implementing land-use planning and zoning regulations: Protecting groundwater resources from pollution and overuse can also involve managing land use. Regulations can be established to prevent activities that might contaminate or excessively draw on groundwater in certain areas, like industrial operations or intensive agriculture.
- Developing an information management system for groundwater data: Accurate, accessible data on groundwater is crucial for informed decision-making. A robust information management system can provide updates to water users, decision-makers, and the public, supporting transparency and collaborative efforts towards groundwater sustainability.

The combination of these actions under the "*Groundwater Management*" programme presents a comprehensive approach to ensure water security under a changing climate. By addressing issues like infrastructural complications, groundwater dependency, and legal requirements, this programme supports the broader strategic priority of ensuring water security in the TMDM.

Table 10: Programme 4: Implementing sustainable groundwater use and development strategy.

Programme 4: Implementing Sustainable Groundwater Use and Development Strategy	
ACTIONS	POSSIBLE KEY ACTIVITIES
Conducting groundwater resource assessments to establish the availability and quality of groundwater in the TMDM area.	• Desk-based research: Conduct a review of existing literature, data, and reports to gain an understanding of the historical and current state of groundwater resources in the area, as well as any previous studies that have been conducted. • Field investigations: Collect and analyse data from monitoring wells, boreholes, and other sources to determine the quantity and quality of groundwater in the area. This may involve drilling new boreholes or installing monitoring wells to collect data on

	groundwater levels, water quality, and other relevant parameters. • Hydrogeological modelling: Develop and use computer models to simulate the behaviour of groundwater resources in the area, including the movement of water through the aquifers and the interaction between surface water and groundwater. • Stakeholder engagement: Engage with local communities, water users, and other stakeholders to understand their needs and concerns related to groundwater resources in the area. • Developing a groundwater management plan: Use the data collected and the models developed to develop a plan for the sustainable management and use of groundwater resources in the TMDM area. This may include measures such as setting sustainable yield limits, establishing groundwater protection zones, and implementing monitoring programmes to track the status of the resource over time.
Establishing sustainable groundwater use policies and guidelines to promote efficient and effective groundwater management.	• Conduct a review of existing policies and guidelines related to groundwater use to identify gaps and areas for improvement. • Consider local conditions and needs, developing new policies and guidelines that promote sustainable and efficient groundwater management. • Develop a stakeholder engagement process to gather input from water users, industry representatives, and other stakeholders in developing sustainable groundwater use policies and guidelines. • Establish mechanisms for ongoing review and revision of policies and guidelines to ensure they remain relevant and effective in promoting sustainable groundwater use.
Implementing groundwater monitoring programmes to monitor water levels, water quality, and potential pollution sources, enabling early detection of potential problems and timely intervention.	• Install and maintain a network of groundwater monitoring wells and equipment to collect data on groundwater levels, water quality, and potential pollution sources. • Conduct regular field visits to measure and record groundwater levels and collect water quality samples for laboratory analysis. • Analyse data collected from monitoring programmes to detect changes in groundwater levels, identify trends in water quality, and assess the impact of potential pollution sources. • Develop and implement early warning systems to alert water users and decision-makers to potential problems, enabling timely intervention. • to promote awareness and informed decision-making, providing regular reports on groundwater conditions and trends to water users, decision-makers, and the public. • Collaborate with other agencies and stakeholders to share data and coordinate monitoring efforts to ensure comprehensive coverage of the groundwater resources.
Promoting groundwater conservation and	• Encourage water conservation pricing mechanisms, such as tiered water rates, incentivise water users to reduce their water

efficiency by encouraging the adoption of water-saving technologies and practices in all sectors.	use, water-efficient irrigation systems, drought-resistant crops, and low-flow fixtures. • Develop and implementing water conservation standards for new and existing municipal buildings and properties. • Encourage the adoption of water reuse and recycling technologies to reduce the demand for fresh groundwater resources. • Promote the use of rainwater harvesting systems in households, buildings, and public spaces to reduce demand for groundwater resources.
Developing groundwater recharge and artificial recharge strategies to enhance aquifer recharge rates and improve groundwater storage capacity.	• Conduct studies to identify suitable sites for groundwater recharge, including areas with high permeability, favourable soil conditions, and sufficient rainfall. • Identify potential sources of water for recharge, such as stormwater runoff, treated wastewater, and excess surface water. • Develop and implement recharge infrastructure, such as recharge basins, injection wells, and spreading grounds. • Monitoring and evaluating the effectiveness of recharge strategies, including assessing changes in water levels, water quality, and aquifer storage capacity. • Developing outreach and education programmes to promote groundwater recharge benefits and encourage participation from stakeholders, such as farmers, local governments, and water users.
Implementing land-use planning and zoning regulations to protect groundwater resources from pollution and overuse.	• Conduct a groundwater vulnerability assessment to identify areas where groundwater resources are most at risk from pollution and overuse. • Develop and enforce land-use planning and zoning regulations that limit activities that may threaten groundwater quality, such as restricting the construction of hazardous waste facilities near groundwater sources. • Establish setback requirements that limit the distance between certain land uses and groundwater sources. • Develop best management practices for land uses that have the potential to impact groundwater quality, such as agriculture, mining, and construction. • Encourage the adoption of sustainable development practices that reduce the demand for groundwater, such as green roofs, rainwater harvesting, and greywater recycling. • Establish monitoring programmes to track changes in groundwater quality and quantity over time, and to detect and respond to potential threats to groundwater resources. • Providing education and outreach to stakeholders, including landowners, developers, and the public, about the importance of protecting groundwater resources and the regulations and guidelines in place to do so.

Develop a information management system for groundwater data to provide accurate and timely information to water users, decision-makers, and the public.	• Conduct a comprehensive inventory of all groundwater monitoring wells in the TMDM area and assessing their condition and functionality. • Establish a standard methodology for groundwater data collection, analysis, and reporting to ensure consistency and accuracy of information. • Develop a database and web-based portal for storing and accessing groundwater data, including water levels, quality, and other relevant information. • Establish protocols for sharing groundwater data among relevant stakeholders, including water users, regulators, researchers, and the public. • Develop data visualisation tools and models to help decision-makers interpret and use groundwater data effectively. • Establish procedures for quality control and quality assurance to ensure the accuracy and reliability of groundwater data. • Provide training and technical assistance to water users, regulators, and other stakeholders on collecting, analysing, and using groundwater data effectively. • Conduct regular reviews and updates of the groundwater information management system to ensure that it remains current, relevant, and effective.

4.5. Climate Change Goal 2: Ecosystem Conservation

Goal:	To conserve and sustainably manage natural resources, maintain healthy ecosystems, and enhance their ability to mitigate the impacts of climate change, including the implementation of effective air quality management strategies.
Outcome:	A sustainable and climate-resilient natural environment with improved protected natural resources, promoting ecological well-being for the community.

4.5.1. Rationale/Context

Thabo Mofutsanyana District Municipal Area, with its rich natural resources and stunning landscapes like the Golden Gate National Park, is not just a tourist haven but a testimony to South Africa's ecological wealth. Dominated predominantly by the Grassland biome, this district holds a special place in South Africa's agricultural and ecological tapestry. Grasslands, characterized by a unilayered expanse of grass influenced by rainfall and grazing patterns, are pivotal to South African agriculture. Further accentuating its ecological significance, this biome, boasts the second-highest level of biodiversity after the Fynbos biome.

However, with looming environmental threats like veld fires, deforestation, air pollution from wood and coal fires, pollution from littering and uncontrolled refuse dumping, inefficient sanitation management, and overgrazing, the pressing need for holistic environmental management and conservation in the TMDM becomes evident. Prioritizing biodiversity conservation can pave the way for enhanced ecosystem resilience against climate change impacts, such as temperature spikes, flooding, and escalating wildfire risks. By fostering biodiversity, the district can not only safeguard its native species and habitats but also promote critical ecosystem services like pollination, water purification, and soil enrichment. In this light, the goal is clear: ensure environmental sustainability, protect the health of the community, and fortify the resilience of natural systems in the face of climate change.

Several programmes have been identified through which it will aim to achieve the goal and targets of this outcome:

4.5.2. Programme 5: Conserve, Protect and Restore Natural Open Spaces, Ecosystems with Climate Change Adaptation Benefits

The programme involves several activities to ensure the protection and restoration of natural resources. The first activity involves assessing natural resources in the municipality and developing strategies to conserve and protect them. This can include identifying and mapping natural open spaces, ecosystems, and resources and identifying undeveloped open spaces that can potentially be used for green infrastructure.

Open spaces such as wetlands can be harnessed to absorb and filter stormwater runoff, which reduces the risk of flooding and erosion. Restoration of degraded ecosystems and natural resources is another important aspect of the programme, which includes planting trees, restoring natural habitats for endangered or protected species, and increasing the resilience of the ecosystem and the services they provide.

Valuations of ecosystem services can be conducted to assess the value of natural resources and open spaces. These valuations highlight the importance of natural resources and open spaces to the local economy and encourage greater investment in their conservation and protection. Overall, this programme aims to safeguard the natural resources and open spaces in TMDM to ensure a sustainable future for its residents, and by implementing these key activities, the municipality can enhance its resilience to climate change impacts while also providing a range of other benefits, such as improved water quality, enhanced biodiversity, and increased recreational opportunities.

Table 11: Programme 5: Conserve, protect and restore natural open spaces, ecosystems and natural resources.

Programme 5: Conserve, Protect and Restore Natural Open Spaces, Ecosystems and Natural Resources.

ACTIONS	KEY ACTIVITIES
Assessing natural resources and ensuring that natural open spaces, ecosystems, and resources are conserved, protected and restored.	• Conduct a comprehensive inventory of natural resources, including land, water, and biological resources, to identify areas of high conservation value and areas of concern. • Assess the current state of natural open spaces, ecosystems, and resources to determine their condition and any threats or vulnerabilities they may face due to climate change. • Develop conservation plans and management strategies for high conservation value areas, ensuring that they are integrated into municipal spatial plans and protected through legislation, policy and land use management. • Implement measures to restore degraded natural open spaces and ecosystems, such as wetlands and riparian areas, to improve their function and resilience in the face of climate change. • Establish protected areas and ensure that they are managed effectively to ensure the conservation of natural resources and ecosystems.
Harnessing the potential of open spaces to absorb and mitigate the impacts of climate change.	• Conducting a green infrastructure assessment to identify natural areas that can provide climate benefits such as carbon sequestration, stormwater management, and temperature regulation. • Developing a plan to integrate green infrastructure practices into new development and redevelopment projects, such as using permeable pavement, green roofs, and bioswales to manage stormwater runoff and reduce the urban heat island effect. • Planting trees and other vegetation in strategic locations provides shade, reduces air pollution, and improves overall air quality. • Establishing community gardens and urban agriculture programmes to increase access to fresh, healthy food and provide opportunities for residents to engage with natural areas and learn about sustainable practices. • Protecting and enhancing existing natural areas by preserving wetlands, riparian corridors, and other important habitats. • Creating and maintaining trails, bike paths, and other recreational infrastructure to encourage outdoor activity and promote physical and mental health.
Implementing programmes focused on mitigating the impact of climate change and severe weather, particularly in climate-risk zones.	• Conducting vulnerability assessments to identify areas and communities most at risk from the impacts of climate change and severe weather events. • Developing and implementing early warning systems and emergency response plans to enable timely evacuation and disaster relief efforts.

	• Promoting nature-based solutions, such as restoration of wetlands, and green infrastructure, to help mitigate the impacts of climate change and severe weather events. • Encouraging the adoption of sustainable land use practices, such as low-impact development, agroforestry, and sustainable agriculture, to help build resilience in the face of climate change. • Providing education and awareness campaigns to inform residents and businesses about the risks of climate change and the actions they can take to mitigate their impacts. • Encouraging community participation in climate adaptation and resilience planning efforts, through stakeholder engagement and collaboration with local organisations and community groups. • Establishing partnerships with other municipalities, government agencies, and non-governmental organisations to leverage resources, share best practices, and coordinate efforts in addressing the impacts of climate change and severe weather.

4.5.3. Programme 6: Enhanced Natural Resource Management

This programme comprises a series of activities designed to monitor and improve the quality of natural resources and reduce their pollution levels.

The first key action is to monitor and improve water quality. The municipality can participate in a comprehensive water quality monitoring programme to track the pollution levels in its water resources, including rivers, wetlands, and the ocean. This programme can identify sources of degradation and implement measures to reduce them, such as promoting best management practices for agriculture and industry, and enforcing regulations to prevent sewage and industrial discharges into the waterways. Additionally, the municipality can invest in water treatment technologies to improve the quality of drinking water and wastewater discharge.

A key issue in terms of environmental degradation is soil erosion resulting from the removal of natural vegetation and changing rainfall patterns. The municipality can implement measures to prevent soil erosion and preserve natural vegetation, such as the implementation of sustainable land-use practices, tree planting, and soil conservation measures. This program can also promote sustainable forestry practices and agroforestry to reduce deforestation and land degradation.

In conclusion, the programme to enhance natural resources by improving the quality of soil, and water resources is a critical climate change response programme for the TMDM. It can help reduce the impact of climate change on natural resources, improve the health of ecosystems and communities, and support sustainable economic development.

Table 12: Programme 6: Enhanced natural resource management and use of ecosystem services.

Programme 6: Enhanced Natural Resource Management and Use of Ecosystem Services.	
ACTIONS	ACTIVITIES
Ensuring the quality of water resources is critical to the sustainable development of TMDM, as they play a vital role in maintaining the health of ecosystems, human health, and socio-economic development.	• Conducting regular water quality monitoring to track the levels of various pollutants, including pathogens, nutrients, and chemicals, in water bodies. • Developing and implementing pollution prevention measures to reduce the number of pollutants entering water sources, such as through agricultural and industrial runoff or sewage discharge. • Encouraging the use of environmentally-friendly practices in households, businesses, and industries to reduce the discharge of pollutants into water resources. • Developing and implementing water treatment technologies to remove pollutants from wastewater before discharge or reuse. • Creating public awareness campaigns to educate the public about the importance of protecting water resources and reducing their impact on the environment. • Participating in the Development and implementation of regulations and policies to manage and regulate the use of water resources, particularly in areas where water scarcity is a concern. • Collaborating with neighbouring municipalities and stakeholders to manage shared water resources and prevent transboundary pollution.
Monitoring and preventing soil erosion is crucial to ensure the long-term health and productivity of natural ecosystems, as well as to maintain the quality of water resources. (*Preventing soil erosion requires a multifaceted approach that involves monitoring, planning, and implementing strategies that protect natural resources).*	• Conducting soil erosion risk assessments on municipal land to identify areas that are most vulnerable to erosion and prioritise action. • Developing and implementing erosion control plans to minimise soil erosion, such as the use of vegetation cover. • Promoting the use of sustainable land use practices that preserve natural vegetation and minimise soil disturbance. • Monitoring soil erosion levels through regular assessments and surveys, and implementing remedial measures where necessary. • Educating the public about the importance of preventing soil erosion and promoting sustainable land use practices through outreach and education campaigns.

Provide training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines. *(Providing training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines is an important aspect of ensuring compliance with these regulations. The training can help to build capacity and knowledge of these regulations, ensuring that those involved in natural resource management have the skills and understanding needed to comply with the regulations and guidelines effectively).*	• Developing a training programme that covers key biodiversity and natural resource management regulations and guidelines, as well as the penalties for non-compliance. • Identifying the staff and stakeholders that require training based on their roles and responsibilities in natural resource management. • Delivering the training through a variety of methods, including workshops, seminars, and online courses. • Evaluating the effectiveness of the training programme through feedback from participants and monitoring compliance with regulations after the training has been delivered. • Updating the training programme regularly to reflect changes to regulations and guidelines and new developments in natural resource management practices. • Providing ongoing support and guidance to staff and stakeholders to ensure they have the necessary resources to comply with regulations and guidelines
Establish a District Environmental Management Forum (DEMF) to enhance collaboration and coordination between sectoral departments, conversation organisation and agencies related to natural resource management.	• Identifying key stakeholders to participate in the forum, such as municipal departments, conservation organisations, and other relevant agencies. • Developing a forum structure, including goals, objectives, and a work plan. • Conducting regular meetings to discuss progress, challenges, and opportunities related to natural resource management. • Coordinating joint efforts on natural resource management, such as collaborative projects or initiatives. • Identifying and leveraging resources to support the goals and objectives of the Forum. • Tracking progress and assessing the impact of the forum on natural resource management. • Updating the forum structure and work plan as needed to ensure continued effectiveness and relevance.

	• Attach Key Performance Indicators (KPIs) for various sectoral departments to the attendance of the Forum.

4.5.4. Programme 7: Integration of Ecological Support Areas and Ecosystem Services into SDFs

The integration of these areas into the spatial framework will enable the municipality to identify and map natural open spaces, ecosystems, and natural resources. Furthermore, it will allow for the incorporation of these inventories into the Spatial Development Framework, the Open Space Framework, and other relevant plans. This strategic inclusion of these critical and endangered ecosystems will facilitate their protection and management, contributing to the overall resilience of the municipality to climate change impacts.

Assessing the value of open spaces and ecosystems is also an important activity associated with this programme. This involves conducting assessments to determine the economic, social, and ecological value of open spaces and ecosystems. By understanding the value of these areas, the municipality can develop plans that ensure their protection and conservation, as well as the implementation of measures that improve their ecological functionality and resilience.

Table 13: Programme 7: Integrate critical biodiversity areas and ecological support areas into the spatial development framework.

Programme 7: Integrate Critical Biodiversity Areas and Ecological Support Areas into the Spatial Framework.	
ACTIONS	KEY ACTIVITIES
Ensuring critical biodiversity and ecological support areas are integrated into municipal spatial plans at all scales. *(This involves identifying areas of high ecological value and ensuring that they are given due consideration in the municipality's spatial planning activities).*	• Conduct a comprehensive analysis of existing municipal spatial plans and policies to determine where critical biodiversity and ecological support areas are currently included or excluded. • Identify critical biodiversity areas and ecological support areas within the municipality, using relevant data and information sources, such as aerial imagery, ecological surveys, and other mapping tools. • Analyse and map the spatial distribution of critical biodiversity areas and ecological support areas to determine their location and extent, as well as any potential threats or vulnerabilities. • Conduct stakeholder consultations with relevant departments, experts, and community members to gather input and feedback on the inclusion of critical biodiversity and ecological support areas in municipal spatial plans. • Develop policies, guidelines, and standards for the inclusion of critical biodiversity and ecological support areas in municipal spatial plans, including considerations for zoning, land use, and development regulations. • Integrate critical biodiversity and ecological support areas into the municipal spatial plans at all relevant scales, such as the

	Spatial Development Framework, Open Space Framework, and other relevant plans. • Monitor the implementation and effectiveness of the policies and guidelines for the inclusion of critical biodiversity and ecological support areas in municipal spatial plans and make adjustments as needed to ensure their continued protection and conservation.
Identifying and mapping natural open spaces, ecosystems, and natural resources, and integrating inventories in the Spatial Development Framework and the open space framework.	• Conducting surveys and assessments of the natural resources and ecosystems in the municipality. • Collecting and analysing data on the location, size, and ecological value of open spaces and natural resources, such as wetlands, and water bodies. • Identifying areas of high ecological value, such as critical habitats for threatened or endangered species, and designating them as protected areas. • Mapping the location and extent of identified open spaces, ecosystems, and natural resources, using geographic information system (GIS) technology or other mapping tools. • Integrating the mapping and inventory information into the Spatial Development Framework, open space framework, and other relevant plans, to guide future development and land-use decisions. • Updating the mapping and inventory information regularly to ensure it remains accurate and up-to-date with any changes in the natural environment.
Identifying undeveloped open space with potential for green infrastructure.	• Conducting an inventory of undeveloped open spaces within the municipality. • Evaluating the potential for green infrastructure development in identified spaces. • Assessing the suitability of undeveloped open spaces for different types of green infrastructure (e.g., parks, urban forests, green roofs, bioswales). • Considering factors such as land ownership, existing land use, soil conditions, topography, and hydrology when identifying undeveloped open spaces with potential for green infrastructure. • Prioritising undeveloped open spaces based on their potential to provide multiple benefits, such as biodiversity conservation, climate change mitigation and adaptation, and public health and well-being. • Engaging with stakeholders and the public to gather input and support for identifying and prioritising undeveloped open spaces with the potential for green infrastructure.
Assessing the value of open spaces and ecosystem services	• Conducting ecological assessments to determine the ecological value of open spaces and ecosystems. • Identifying the ecosystem services these areas provide, such as carbon sequestration, water filtration, and habitat provision.

	• Assessing the potential impacts of development or other human activities on these ecosystem services and the overall ecological value of the areas. • Using this information to inform decisions about land use and development ensures that these areas' ecological value is protected and enhanced. • Developing policies and regulations to protect and manage these areas, such as zoning restrictions or conservation easements.

4.6. Climate Change Goal 3: To Reduce the Vulnerability and Exposure of Human and Natural Systems to Climate Change and Extreme Events.

Goal:	To enhance the resilience and well-being of TMDM communities by reducing their vulnerability to the impacts of climate change and extreme weather events through inclusive, community-led risk reduction strategies and improved access to resources and services.
Outcome:	Improved quality of life for all members of the Thabo Mofutsanyana DM community, with reduced risks from the impacts of climate change and extreme weather events, and enhanced opportunities for sustainable livelihoods, social inclusion, and overall well-being.

4.6.1. Rationale/Context

The adverse effects of rising temperatures, heat waves, and uncertain rainfall patterns require the identification and prioritisation of climate change risks, along with the development of effective response measures for settlements.

Incorporating youth and gender considerations into adaptation actions is important to ensure that the actions taken are not only effective but also equitable. By actively engaging youth in these initiatives, we can harness their energy, creativity, and unique perspective while also ensuring inter-generational equity. This could be achieved by promoting youth leadership in climate change response activities. The incorporation of gender perspectives is also crucial, as climate change can disproportionately affect women and girls, particularly in vulnerable communities. Gender-responsive strategies could include ensuring women's participation in decision-making processes, addressing gender-specific climate change risks in health and safety plans, and promoting gender equity in access to resources and opportunities related to climate resilience.

Promoting public health and safety in the face of extreme weather events is essential to address the risks of illness and injury that may arise from such occurrences. Furthermore, ensuring food security by promoting local food production is a crucial element of this strategic priority. This will guarantee access to adequate and nutritious food even during climate change-induced disruptions to food supply chains. Community-based adaptation in high-risk communities is another essential aspect that aims to provide targeted support to the most vulnerable communities and individuals to cope with the impacts of climate change. Public awareness campaigns that involve communities, provide climate change training, and raise awareness are necessary to equip the community with the necessary knowledge and skills to respond to climate change impacts. Several programmes have been identified through which it will aim to achieve the goal and targets of this outcome:

4.6.2. Programme 8: Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements.

Identifying and prioritising climate change risks and developing response measures for settlements is crucial to ensure the long-term resilience of communities to climate change impacts. Informal settlements and vulnerable communities are likely to face exacerbated challenges related to housing, health, and livelihoods due to climate change. to address these challenges, TMDM should consider a programme aimed at achieving resilience and adaptation to climate change by assessing and identifying the risks and impacts of climate change and then developing suitable measures to reduce these risks. This programme could include conducting a vulnerability assessment to identify populations and locations most at risk of climate change impacts, establishing an early warning system, building local capacity for climate change adaptation and resilience through partnerships with stakeholders, and developing and implementing land use planning and zoning regulations that account for climate change impacts. These activities aim to enhance community resilience and ensure the long-term sustainability of settlements in the face of climate change.

Table 14: Programme 8: Identify and prioritise climate change risks and develop response measures for settlements.

Programme 8: Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements.	
ACTIONS	KEY ACTIVITIES
Conducting a vulnerability assessment to identify the populations and locations most at risk of climate change impacts.	• Analysing climate data to determine the frequency and severity of extreme weather events. • Assessing the vulnerability of infrastructure to climate change. • Mapping areas with high concentrations of vulnerable populations.
Developing and implementing an early warning system to help communities prepare for and respond to climate change risks.	• Installing weather monitoring systems to provide real-time data on extreme weather events. • Developing protocols for disseminating warnings to the public. • Establishing community response plans for different types of extreme weather events.
Establishing partnerships with local stakeholders, such as community groups and NGOs, to build local capacity for climate change	• Building partnerships with community groups to identify local needs and priorities for adaptation and resilience measures. • Providing capacity-building training to community members on disaster preparedness and response. • Collaborating with local NGOs to implement small-scale adaptation measures, such as rainwater harvesting and urban agriculture.

adaptation and resilience.	
Developing and implementing land use planning and zoning regulations that take into account the potential impacts of climate change.	• Analysing maps of projected climate change impacts to identify areas at risk. • Developing land use and zoning regulations to ensure that settlements are built in safe and sustainable locations. • Providing technical assistance and support to developers to ensure that new projects are designed to withstand climate change impacts.

4.6.3. Programme 9: Community-Based Adaptation in Communities Most at Risk of Climate-Related Hazards

Community-based adaptation (CBA) is an effective approach to addressing climate change risks in vulnerable communities. Implementing a CBA programme can enhance community resilience to climate change impacts. This can involve identifying community-based adaptation measures such as rainwater harvesting, greywater recycling, and community gardens to improve water security, reduce erosion and soil degradation, and improve food security.

Developing and implementing climate adaptation plans and policies can address the root causes of climate change risks and enhance the capacity of communities to manage and adapt to climate-related hazards. Other potential activities could include providing training and education programmes on climate change and its impacts and promoting traditional knowledge and practices that help communities adapt to changing environmental conditions.

Establishing partnerships and collaborations with relevant stakeholders such as local community-based organisations, NGOs, and government agencies can also be beneficial for the successful implementation of community-based adaptation measures.

Table 15: Programme 9: Community-based adaptation in communities most at risk of climate-related hazards.

Programme 9: Community-Based Adaptation in Communities Most at Risk Of Climate-Related Hazards.	
ACTIONS	KEY ACTIVITIES
Conducting granular risk and vulnerability assessments in communities to identify drivers of risk and develop appropriate adaptation measures.	• Identifying populations most at risk in the community, such as the elderly, children, and those with chronic illnesses, and developing strategies to protect them. • Assessing and mapping the distribution of the drivers of risk and burnability across communities related to exposure and sensitivity to climate hazards.

Developing and implementing community-based adaptation measures to reduce risks and build resilience falls under the purview of relevant departments, including the Department of Forestry, Fisheries, and the Environment (DFFE) at the national level, These departments play a crucial role in promoting climate-smart agricultural practices, enhancing food security, and building community resilience.	• Support the DFFE and Province and Agriculture extension services to promote the use of climate-smart agricultural practices, such as rainwater harvesting, crop diversification, and soil conservation techniques, to improve food security and build community resilience. • Partnering with stakeholders (such as Provincial and National Department of Human Settlement) to build water security through the installation of rainwater harvesting systems, greywater recycling systems, and other water management strategies. • Supporting national and provincial initiatives to encourage the establishment of community gardens and promote sustainable agricultural practices that enhance community resilience and increase food security.
Providing training and education to build community capacity and promote sustainability.	• Providing training and education to community members on climate change impacts and adaptation strategies. • Building local capacity to design, implement, and monitor adaptation measures. • Promoting sustainable land-use practices and sustainable resource management to reduce pressure on natural resources and build community resilience.
Comprehensive community engagement and public awareness initiative on climate change. *This initiative aims to raise awareness, educate, and involve the community in addressing climate change. By engaging local organisations, schools, and community groups, the programme will ensure that the campaign is inclusive,*	• Organising community events to enhance climate change awareness and its impacts. • Designing and distributing educational materials on climate change, both physically (like pamphlets and brochures) and digitally, using an online and social media presence to boost outreach and engagement. • Implementing training and education programmes for community members through workshops and seminars. • Holding public meetings and forums to discuss climate change, gather community input, and feedback. • Partnering with local organisations and community groups to ensure the campaign's relevance and accessibility. • Developing a comprehensive public awareness campaign tailored to the diverse needs of the municipality, including vulnerable populations. • Conducting community engagement and outreach activities to raise awareness of climate change impacts and teach communities about mitigation and adaptation strategies.

accessible, and relevant to all members of the community.	• Providing capacity-building sessions for local leaders and stakeholders on topics such as sustainable energy practices and eco-friendly behaviours. • Utilising various media channels, including social media, print, radio, and television, to disseminate key messages and updates on climate change initiatives. • Fostering collaborations with educational institutions and other stakeholders to expand the campaign's reach. • Establishing feedback mechanisms to assess campaign effectiveness and identify improvement areas. • Using community feedback to refine the campaign and ensure it responds to their needs and concerns. • Building a network of community ambassadors to keep the climate change conversation alive and promote sustainable practices. • Developing partnerships with industry, research institutions, and government agencies to support the development and implementation of CCS technology.

4.6.4. Programme 10: Climate Resilient Spatial Planning

Spatial planning is one of the key entry points for building climate resilience on a local level. Adaptation action involves creating long-term spatial plans to guide development to withstand the impacts of climate change while ensuring growth and development within the municipality. The activities that the programme could entail include ensuring that the spatial planning frameworks consider a long-term view of climate hazards and incorporate ecological infrastructure. The programme could also involve developing local-level climate-resilient planning mechanisms, such as precinct plans that are designed to be adaptable to the impacts of climate change. The municipality should also ensure collaborative strategic planning that incorporates all relevant departments in both strategic planning and project implementation.

Overall, the programme aims to ensure that the TMDM is prepared for the impacts of climate change and that its development is sustainable and resilient. It represents a comprehensive, integrated approach to spatial planning that recognizes the reality of climate change and the importance of building resilience at the community level.

Table 16: Programme 10: Climate-smart spatial planning for climate-resilient growth and development.

Programme 10: Climate-Smart Spatial Planning For Climate-Resilient Growth and Development.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Ensure that spatial planning frameworks consider a long-term	• Conduct a review of current spatial planning frameworks, • Identify climate hazards and vulnerable areas in the municipality,

view of climate hazards and incorporate natural infrastructure.	• Develop guidelines for climate-resilient spatial planning, • Identify natural infrastructure assets that can be incorporated into spatial planning frameworks.
Develop local-level climate-resilient planning mechanisms - precinct plans.	• Conduct vulnerability assessments to identify areas at risk of climate hazards. • Develop climate-resilient precinct plans that incorporate the needs and concerns of the community. • Ensure that the precinct plans are adaptable to the impacts of climate change.
Ensure collaborative strategic planning that incorporates all relevant departments (in both strategic planning and project implementation).	• Identify relevant departments and stakeholders. • Establish a coordination mechanism for collaborative strategic planning. • Develop guidelines for collaboration and coordination in strategic planning and project implementation. • Conduct regular reviews and assessments of the collaboration mechanism to ensure its effectiveness.
Create mechanisms to strengthen public participation in planning and decision-making processes.	• Ensure that the public has access to information about spatial planning frameworks and other climate change response initiatives. • Ensure that public feedback is incorporated into the decision-making process.
Resilient urban and township design and development to minimise the risk and impact of climate change on urban areas.	• Promoting innovative urban and township planning and design, which takes advantage of opportunities provided by the natural infrastructure and economic growth-management strategies. • Identifying ecological corridors or climate change corridors within the Municipal Spatial Development Framework (MSDF) is also an important aspect of innovative urban and township design and development. • Conducting comprehensive research on climate change and its potential impacts on urban areas, including projections of temperature increases, extreme weather events, and sea level rise. • Developing guidelines in collaboration with reliant government departments, for innovative urban and township design that take into account climate change risks, including those related to flooding, extreme heat, and drought. • Establishing partnerships and networks with key stakeholders in urban planning and design, including government agencies, non-governmental organisations and academic institutions, to promote knowledge sharing and collaboration. • Encouraging the use of green infrastructure in urban design, such as green roofs, permeable pavements, and rain gardens, to help manage stormwater and reduce the urban heat island effect.

To identify climate risk zones and hotspots that affect vulnerable municipal infrastructure and assets.	• Conducting vulnerability assessments for critical infrastructure and assets. • Analysing historical climate data to identify areas that have been particularly vulnerable in the past. • Developing climate models to assess future risks and understand the potential impacts of climate change. • Mapping vulnerable infrastructure and assets to understand where they are located in relation to climate risk zones and hotspots. • Identifying risks and prioritising action based on the level of vulnerability and potential impact of climate change on infrastructure and assets. • Developing and implementing strategies to manage risks and protect infrastructure and assets from climate change impacts.

4.6.5. Programme 11: Sustainable Development of a Resilient Tourism Industry

As tourism is an important sector of the TMDM, this program aims to enhance the resilience of the tourism industry to the impacts of climate change. This programme promotes the integration of climate change considerations into tourism planning and development, in order to protect tourism infrastructure developments from fire, flooding and storms. Furthermore, this programme promotes the conservation of biodiversity that is important to the tourism sector, by developing and implementing ecosystem-based adaptation measures and integrating important biodiversity areas into the SDF and EMF. Lastly, the programme encourages eco-tourism practices and involves communities in developing ecotourism initiatives that are sustainable and beneficial to both the environment and the local economy.

Table 17: Programme 11: Sustainable development of a resilient tourism industry.

Programme 11: Sustainable Development of a Resilient Tourism Industry	
ACTIONS	POSSIBLE KEY ACTIVITIES
Climate change considerations in tourism planning and development.	• Plan tourism infrastructure developments so that they are protected from fire, flooding in river buffers and wetlands, and damage from storms.
Identify biodiversity as important for the tourism sector and promote ecosystem-based adaptation to maintain these biodiversity areas.	• Identification of biodiversity that is important to the tourism sector. • Develop and implement ecosystem-based adaptation measures to maintain biodiversity that is important to the tourism industry. • Integrate important biodiversity areas into the SDF and environmental plans/frameworks.

Promote ecotourism practices.	• Identify and promote sustainable tourism practices. • Involve communities in developing ecotourism initiatives that are sustainable and beneficial to both the environment and the local economy. • Include employment opportunities for local communities in the ecotourism industry. • Assess the effects of climate change on special designated natural areas that attract tourists such as national parks and forests. • Ensure accurate information reaches current and potential tourists on behaviours and uses that ensure environmental quality and ecosystem resiliency at popular travel destinations.

4.6.6. Programme 12: Wind Resilience Initiative

One of the key risks that the TMDM faces is strong winds. This programme aims to target the risk by developing a wind resilience initiative. This initiative entails strengthening infrastructure to withstand high winds, retrofitting homes and buildings to be more wind resilient and promoting the use of wind-resistant building materials in new construction projects. This programme also promotes the development of an early warning system to disseminate warnings to communities, as well as the establishment of an emergency response plan and providing training and resources to community members to help them prepare for and respond to strong winds.

Table 18: Programme 12: Wind resilience initiative.

Programme 12: Wind Resilience Initiative	
ACTIONS	POSSIBLE KEY ACTIVITIES
Strengthening infrastructure to withstand high winds.	• Retrofitting homes and buildings to be more wind resilient. • Promote the use of wind-resistant building materials in new construction projects. • Encourage the development of building codes and standards that take into account the risks associated with strong winds.
Development of early warning systems.	• Installing weather monitoring equipment. • Developing communication networks to disseminate warnings to communities, such as radio, television and social media platforms. • Establishing emergency response plans to mobilise resources in the event of a storm. • Provide training and resources to community members to help them prepare for and respond to strong winds.

4.6.7. Programme 13: Climate-Smart Transport Strategy for Resilience and Efficiency

In the TMDM context, this programme aims to improve accessibility, affordability, and resilience of transport infrastructure and services, while mitigating their environmental impact. The programme takes into consideration the unique challenges faced by the region including poor road conditions, oversupply of taxis in urban areas with insufficient service in rural areas, the inability of the transport system to meet basic accessibility needs, unaffordability of transport services for vulnerable populations, lack of flexibility in response to customer demands, and inadequate infrastructure development.

- Establish a baseline and assess vulnerability: This action entails understanding the current state of the transport system in both urban and rural areas. This includes evaluating the number of taxis, the condition of roads, the accessibility of the transport system, and the affordability of services. This baseline will inform vulnerability assessments, considering how climate change could exacerbate these existing challenges - for example, how more frequent extreme weather events might further degrade road conditions.
- Develop and Implement a low-carbon, inclusive transport plan: This action will focus on designing a transport system that addresses the region's specific challenges. Solutions may include improving the distribution of taxis between urban and rural areas, developing more flexible transport services that can better meet varying customer needs, and increasing affordability for vulnerable groups such as pensioners and school learners. Importantly, these solutions will be designed with a low-carbon framework, promoting the use of energy-efficient vehicles, optimizing routes for fuel efficiency, and encouraging public transit, walking, or cycling where feasible to reduce carbon emissions.
- Enhance the resilience of local transport infrastructure to climate shocks: Given the region's poor road conditions, this action is crucial. It involves strengthening transport infrastructure, such as roads and taxi stands, to withstand the impacts of climate change, including more frequent or intense floods, storms, or heatwaves. This may involve using climate-resilient materials in road construction, improving drainage to prevent flood damage, or building shade structures at taxi stands to protect against heat.
- Monitor, evaluate, and continually improve the transport plan and infrastructure resilience: Finally, the programme will ensure a cycle of continuous improvement through regular monitoring and evaluation. This will involve tracking the performance of the new transport plan, assessing how well the improved infrastructure is withstanding climate shocks, and making necessary adjustments. This ongoing process will ensure that the transport system remains resilient to climate change, continues to meet the needs of the community, and contributes to the overall goal of creating a climate-resilient, low-carbon, diverse, and inclusive rural economy.

Table 19: Programme 13: Climate-smart transport strategy for resilience and efficiency.

Programme 13: Climate-Smart Transport Strategy for Resilience and Efficiency	
ACTIONS	POSSIBLE KEY ACTIVITIES

Establish a baseline and assess vulnerability.	• Establish a transport working group involving representatives from various municipal departments, transport operators, and civil society organizations. • Collect and analyse data on travel patterns, transportation infrastructure, and emissions from transportation. • Conduct a vulnerability assessment of the transport system to climate change impacts, such as flooding and extreme weather events.
Develop and implement a low-carbon, inclusive transport plan.	• Develop a vision and goals for the transport system that align with climate change objectives and social equity considerations. • Identify low-carbon mobility options and design measures to promote their adoption, such as expanding cycling infrastructure and improving public transportation services. • Improve the efficiency of the transportation system, for example by optimizing routes and schedules, implementing intelligent transportation systems, and promoting the use of alternative fuels. • Ensure the accessibility and social equity of the transport system by providing accessible public transportation services, integrating land use and transportation planning, and implementing measures to address the needs of disadvantaged communities.
Enhance the resilience of local transport infrastructure to climate shocks.	• Conduct climate change risk assessments specifically for the local transport network. • Develop robust climate resilience plans and strategies tailored to municipal local transport systems. • Implement diligent monitoring and maintenance programmes for municipal transport infrastructure. • Invest in innovative technologies that enhance the resilience of the local transport network.
Monitor, evaluate, and continually improve the transport plan and infrastructure resilience.	• Monitor and evaluate the transport plan at regular intervals to ensure that it remains relevant and effective. • Continually evaluate the effectiveness of existing climate resilience strategies and identify areas for improvement. • Promptly develop and implement action plans to address identified areas of improvement.

4.6.8. Programme 14: Energy Efficiency Initiative for Climate Change Adaptation

As energy is an important sector of the TMDM, this programme aims to promote an energy efficiency initiative, with the aim of increasing resilience to climate change. The programme encourages the improvement of energy efficiency in homes, settlements and buildings through providing education and resources as well as encouraging the use of energy-efficient lighting and appliances to reduce electricity consumption. Furthermore, the programme also promotes

the use of renewable energy sources such as solar and wind power to reduce reliance on fossil fuels, as well as supporting research and development of new energy technologies that can improve energy efficiency.

Table 20: Programme 14: Sustainable development of a resilient tourism industry.

Programme 14: Sustainable Development of a Resilient Tourism Industry	
ACTIONS	POSSIBLE KEY ACTIVITIES
Improving energy efficiency in homes, settlements and buildings.	• Providing education and resources to community members on how to reduce energy consumption in their homes and buildings. • Encouraging the use of energy-efficient lighting and appliances to reduce electricity consumption.
Promoting the use of renewable energy sources such as solar and wind power to reduce reliance on fossil fuels and improve energy security in times of crisis.	• Assess the feasibility of using renewable energy sources (such as solar and wind power). • Design and promote the use of renewable energy sources. • Encourage the development of community-based renewable energy systems such as microgrids that can provide power to critical facilities during power outages. • Provide education and resources to community members on how to choose and install renewable energy resources that meet their needs. • Develop guidelines for the installation and operation of renewable energy systems to ensure safety and reliability.
Supporting research and development of new energy technologies that can improve energy efficiency.	• Providing funding for research and development of new energy technologies such as energy-efficient appliances. • Establish partnerships with universities and research institutions to support research and development of new energy technologies.

4.7. Climate Change Goal 4: Fire Management

Goal:	To implement measures to enhance fire management in the TMDM through an integrated fire management programme that aims to develop a comprehensive evaluation of fire hazards, to ensure community preparedness and facilitate post-fire restoration.
Outcome:	To implement a robust integrated fire management programme for fire resilience, and to foster resilient communities, infrastructure and ecosystems to wildfires in the TMDM.

4.7.1. Rationale/Context

In the Thabo Mofutsanyana District Municipal Area (TMDM), the escalating risks associated with wildfires, particularly along the wildland-urban interfaces in the eastern, western, and southern settlements, have heightened the necessity for robust fire management in the context of climate change adaptation. The region's susceptibility to wildfires can be attributed to multiple interlinked factors. The changing climate brings with it unpredictable weather patterns, which, coupled with socio-economic vulnerabilities, pose a significant threat to the well-being and livelihoods of local communities. For instance, those engaged in subsistence farming—a substantial portion of the population—face pronounced risks from droughts, floods, and temperature variations, all of which can indirectly amplify the wildfire threat by altering vegetation and soil moisture conditions.

Moreover, the socio-economic dynamics of the district further exacerbate these vulnerabilities. Given the challenges posed by limited access to essential services like healthcare and education and the absence of timely early warning systems, many residents find themselves ill-prepared to respond adequately to wildfire threats. The looming shadows of poverty and unemployment in the district further weaken the community's adaptive capacity. With most settlements bracing for a moderate increase in wildfire risk and only a few expecting a minor rise, integrating fire management as a central goal in the climate change adaptation plan is not just strategic but essential for the district's sustainable future. The following programme has been identified through which it will aim to achieve the goal and targets of this outcome.

4.7.2. Programme 15: Integrated Fire Management for Climate Resilience

This programme seeks to systematically mitigate the risk and consequences of wildfires through a series of focused activities. Firstly, a "*comprehensive evaluation of fire hazards*" will entail the examination of fire ecotypes, the likelihood and severity of wildfire occurrences, and their socioeconomic repercussions. This will help pinpoint high-risk areas and guide strategic planning.

Next, the "*strategic fire deterrence roadmap*" will define preventative steps and actions to alleviate wildfire risk, such as maintaining firebreaks, controlling flammable vegetation, and applying safe land-use practices. "*community engagement and fire safety education*" will entail raising awareness about fire risks, preventative measures, and actions to take during a wildfire.

An "*advanced fire detection and monitoring infrastructure*" will be established to keep track of wildfires, potentially employing remote sensing technologies and early warning systems. In the event of a fire breakout, an "Emergency Preparedness and Response Strategy" will ensure prompt and effective containment and rescue operations.

Post-fire, the "*post-fire restoration and ecosystem rehabilitation*" action will involve efforts to restore the ecosystem and rehabilitate affected regions. Concurrently, "Policy and By-Law Development" will involve establishing regulations that bolster wildfire management and climate resilience.

"*Innovation and research in fire management techniques*" will stimulate studies into improved wildfire management strategies. Cooperation will be pursued in "Inter-Organizational Collaboration and Strategic Partnerships" to exchange knowledge, resources, and support.

Lastly, the "*strengthening fire management capacities and effective resource utilization*," this activity will focus on boosting the competencies of wildfire management personnel, ensuring efficient use of resources, and improving infrastructure where necessary.

In essence, this programme aims to bolster TMDM's resilience against wildfires in a thorough and integrated way, taking into account the projected impacts of climate change.

Table 21: Programme 15: Integrated fire management for climate resilience.

Programme 15: Integrated Fire Management for Climate Resilience.	
ACTIONS	POSSIBLE KEY ACTIVITIES
A comprehensive evaluation of fire hazards.	• Hazard identification: Identify areas prone to wildfires due to factors such as vegetation type, topography, climate, and historical fire patterns. • Vulnerability assessment: Analyze the vulnerability of human settlements, critical infrastructure, and ecosystems in the identified high-risk areas. • Climate change impact analysis: Assess how climate change could affect fire risk in the future, considering factors such as increasing temperatures, changing rainfall patterns, and frequency of extreme weather events. • Resource evaluation: Evaluate the current capacity and resources (human, technical, and financial) available to manage fire risks and respond to fire incidents. • Infrastructure assessment: Assess the condition of existing fire management infrastructure, such as fire breaks, firefighting equipment, and emergency access routes. • Fire behaviour modelling: Use fire behaviour models to predict how fires could spread under different conditions in the identified high-risk areas. • Risk mapping: Develop risk maps using GIS tools to visualize areas of high fire risk, the potential spread of fires, and vulnerable ecosystems or infrastructure.

	• Review and update: Regularly review and update the fire risk assessment to account for changes in land use, climate, and other relevant factors.
Strategic fire prevention roadmap.	• Firebreak creation: Identify and create strategic firebreaks to halt the progress of wildfires. This may involve clearing vegetation or using controlled burns to remove fuel sources. • Controlled burns: Conduct controlled or prescribed burns to reduce excess vegetation that could fuel wildfires. This needs to be done under strict supervision and under specific weather conditions. • Public education campaigns: develop and deliver education programs to raise community awareness about fire risks and prevention measures. This can include information on safe practices for outdoor burning, campfires, and disposal of cigarettes. • Legislation and policy: Advocate for and implement local regulations that reduce fire risk, such as restrictions on burning during high-risk periods and regulations around building materials and designs in fire-prone areas. • Vegetation management: Implement a program for managing vegetation, including the removal of dead or dying trees, pruning overgrown areas, and planting fire-resistant species in high-risk areas. • Infrastructure planning: Plan infrastructure considering fire prevention, such as the design and location of roads, utilities, and buildings to minimize fire risks. • Emergency access routes: Ensure clear and accessible emergency routes for firefighters and residents in the event of a fire. This includes regularly inspecting and maintaining these routes. • Community fire plans: Help communities in high-risk areas develop comprehensive fire plans, including evacuation routes, emergency contact numbers, and plans for livestock and pets. • Fire detection systems: install and maintain early fire detection systems to identify and respond to fires as quickly as possible. • Collaboration and cooperation: Cooperate with regional, national, and international fire management agencies, sharing knowledge, resources, and best practices in fire prevention.
Community engagement and fire safety education.	• Community workshops and seminars: conduct educational workshops and seminars about climate change, fire risks, and fire prevention. Explain the connections between climate change and increased fire risks, and what actions individuals can take to mitigate these risks. • Development of educational materials: develop and distribute educational materials such as brochures, posters, and online resources that provide information on fire prevention,

	response measures, and the importance of environmental management. • Fire safety training: Organize practical fire safety training sessions, including demonstrations on how to use firefighting equipment, evacuation drills, and basic firefighting skills. • School programs: Implement education programs in schools to raise awareness among younger generations about climate change and fire prevention. • Community fire plans: Assist communities in developing comprehensive fire management plans, including evacuation routes and emergency procedures. Ensure each member of the community understands the plan and their role in it. • Public meetings: Hold regular public meetings to discuss fire risks, prevention strategies, and any updates or changes to the fire management plan. • Social media campaigns: utilize social media platforms to disseminate information, provide updates on fire incidents, and engage the community in dialogues about fire management. • Collaborative community projects: organize community projects such as tree planting, vegetation management, and firebreak maintenance. This not only helps reduce fire risks but also fosters community involvement in environmental conservation. • Emergency services open days: organize open days at local fire stations to educate the community about their work, demonstrate equipment, and provide information on volunteering opportunities. • Partnerships with local organizations: Collaborate with local NGOs, community groups, and businesses to spread the message of fire prevention and climate change mitigation.
Advanced fire detection and monitoring infrastructure.	• Satellite monitoring: Utilize satellite imagery to monitor fire incidents across the district. Satellites can provide real-time data on the location, size, and spread of fires. • Ground-based sensors: Deploy ground-based sensors in high-risk areas that can detect smoke or heat and send an immediate alert when a fire starts. • Drone surveillance: Use drones equipped with thermal cameras for real-time surveillance of high-risk areas, especially during high-risk periods. Drones can provide detailed images of fires, helping to assess their severity and direction of spread. • Fire towers: Construct or make use of existing fire towers where personnel can visually monitor large areas for signs of smoke, especially in remote or inaccessible regions. • Community reporting systems: establish a clear and efficient system for community members to report suspected fires. This could be a dedicated phone line or a mobile app.

	• Weather monitoring: Regularly monitor weather conditions, as certain conditions such as high temperatures, low humidity, and strong winds can increase fire risk. • Fire risk mapping: Use GIS and remote sensing data to create dynamic fire risk maps that can help in prioritizing monitoring efforts. • Data integration and analysis: integrate data from different monitoring sources and use advanced analytics to identify patterns, predict fire behaviour, and improve response strategies. • Regular system maintenance and upgrades: regularly maintain and upgrade monitoring equipment to ensure it is functioning correctly and taking advantage of the latest technology. • Collaboration with national and regional agencies: collaborate with national and regional agencies for data sharing and to improve the effectiveness of fire monitoring efforts.
Emergency preparedness and response strategy.	• Emergency response plan development: develop comprehensive emergency response plans outlining procedures for fire detection, suppression, evacuation, communication, and post-fire recovery. • Evacuation plans: Create evacuation plans for at-risk communities, including clear escape routes, assembly points, and emergency shelters. • Firefighting equipment and infrastructure: ensure the availability of adequate firefighting equipment and infrastructure, such as fire trucks, water supplies, and protective clothing. Regularly check and maintain these resources to ensure they are always ready to use. • Training and drills: Conduct regular training exercises and drills for emergency services and the community to ensure everyone understands their roles and responsibilities during a fire incident. • Emergency communication systems: Establish reliable communication systems to quickly alert emergency services, community members, and neighbouring regions about a fire incident. • Collaboration and coordination: Coordinate with local, regional, and national fire services, law enforcement, healthcare providers, and other relevant stakeholders to ensure a cohesive response during an emergency. • Public education: Educate the public about what to do in case of a fire, including when and how to evacuate, the importance of adhering to alerts and directives, and basic fire safety measures. • Resource mobilization: Ensure mechanisms are in place for quick mobilization of resources such as personnel, equipment, and financial assistance during a fire emergency.

	• Post-fire assessment and recovery: develop and implement strategies for rapid post-fire assessment and recovery, including immediate steps to prevent further damage (like soil erosion) and long-term plans for rehabilitation and restoration. • Regular plan review and update: regularly review and update the emergency preparedness and response plan based on lessons learned from previous fire incidents, changes in the community or environment, and advancements in technology.
Post-Fire restoration and ecosystem rehabilitation.	• Damage Assessment: Conduct post-fire assessments to determine the extent of the damage to ecosystems, infrastructure, and communities. This will guide the restoration efforts. • Erosion control: Implement immediate erosion control measures to prevent soil loss and water pollution, especially in areas where vegetation has been destroyed by fire. • Revegetation: Undertake revegetation efforts, which may include planting native trees and plants or facilitating natural regeneration processes. • Soil restoration: Implement measures to restore soil health, such as adding organic matter or compost, which can help to promote plant growth and restore soil fertility. • Wildlife management: Implement measures to protect and support wildlife after a fire, including providing temporary food and water sources, creating safe habitats, and monitoring injured animals. • Infrastructure repair and rebuilding: Repair or rebuild damaged infrastructure, considering fire-resistant materials and designs to reduce future fire risks. • Monitoring: Regularly monitor the progress of rehabilitation and restoration activities to assess their effectiveness and make necessary adjustments. • Community support: Provide support to affected communities, which may include psychological support, temporary housing, financial assistance, and help with rebuilding efforts. • Research and Learning: Conduct research to understand the impact of the fire and the effectiveness of restoration efforts, and use the findings to improve future rehabilitation strategies. • Adaptive management: Apply an adaptive management approach to restoration, which involves learning from ongoing activities and adjusting management strategies accordingly.
Policy and by-law development.	• Policy and by-law development: Develop local policies and by-laws related to fire management and environmental conservation, such as regulations on controlled burns, vegetation management, and building codes in fire-prone areas. • Policy review and revision: regularly review and revise existing policies and by-laws to ensure they are up-to-date,

	effective, and aligned with current fire management practices and climate change realities. • Legislation advocacy: Advocate for state and national legislation that supports fire management, climate resilience, and environmental conservation efforts. This might involve lobbying, partnership with other municipalities, and collaboration with NGOs and civil society organizations. • Compliance monitoring: Set up systems to monitor compliance with local by-laws and policies related to fire management and environmental conservation. • Enforcement measures: Establish and implement measures to enforce local by-laws, such as fines for non-compliance, and ensure these measures are well-publicized and understood by the community. • Public consultation: Engage in public consultation when developing or revising policies and by-laws to ensure they reflect community needs and perspectives, and to encourage community buy-in and compliance. • Interdepartmental coordination: Coordinate with other local government departments to ensure policies and by-laws are integrated across different sectors and align with broader municipal strategies and plans. • Training and education: Conduct training and education programs for local government staff, stakeholders, and the community about new and existing policies and by-laws, why they are important, and what is required for compliance. • Policy research: Conduct and use research to inform policy development, including best practices from other municipalities and regions, and evidence on the effectiveness of different fire management strategies. • Partnerships: Build partnerships with other levels of government, research institutions, NGOs, and the private sector to support policy development and legislation efforts.
Innovation and research in fire management techniques.	• Collaborative research initiatives: establish collaborations with local universities, research institutions, and NGOs to conduct R&D projects related to fire management and climate change adaptation. • Consultant Appointments: Hire consultants with expertise in fire management, climate change, and related fields to conduct research, analysis, and provide recommendations. • Grant applications: Apply for research grants from national, provincial, or international funding sources. These funds can be used to conduct R&D projects or hire consultants. • Data gathering and analysis: Conduct surveys, interviews, and community meetings to gather local knowledge and experiences related to fire management. Analyze this data to inform strategies and policies.

	• Technology adoption: Explore and adopt existing technologies for fire detection, monitoring, and management, taking into account local conditions and resources. • Research dissemination and utilization: ensure that research findings are communicated to all relevant stakeholders, including local communities, and are used to inform policies, programs, and practices. • Training and capacity building: organize training sessions and workshops to increase the capacity of local staff in using and interpreting research findings. • Policy Impact research: Commission or conduct studies to assess the impact of current policies and programs, and use the findings to improve them. • Community-based research: Engage local communities in research activities, such as citizen science projects, to leverage local knowledge and increase community buy-in. • Monitoring and evaluation: Monitor and evaluate the effectiveness of R&D activities and use the findings to improve future R&D efforts.
Inter-organizational collaboration and strategic partnerships.	• Inter-municipal collaboration: collaborate with other district municipalities to share knowledge, best practices, and resources related to fire management and climate adaptation. This can involve formal agreements or more informal networks. • Partnerships with higher levels of government: Work closely with provincial and national government agencies responsible for the environment, fire management, and disaster response. This can help to align strategies, access resources, and advocate for supportive policies. • Partnerships with universities and research institutions: establish partnerships with academic and research institutions to access technical expertise, conduct joint research projects, and provide training opportunities. • Community engagement: work closely with local communities, involve them in decision-making processes, and tap into local knowledge and resources. This can increase community buy-in and resilience. • Private sector engagement: engage with the private sector, including businesses and industry groups, to leverage their resources, skills, and influence. This can involve partnerships for specific projects or initiatives, sponsorship agreements, or corporate social responsibility programs. • Collaboration with non-governmental organizations (NGOs): Partner with local, national, or international NGOs that focus on the environment, climate change, or disaster response. NGOs can provide various types of support, from technical expertise and funding to advocacy and community mobilization.

	• International collaboration: Engage with international networks, organizations, and initiatives focused on climate adaptation and fire management to share experiences, learn from others, and access international resources and funding. • Joint funding applications: Collaborate with partners to apply for funding from national, provincial, or international sources. Joint applications can be more competitive and enable larger and more impactful projects. • Collaborative training and capacity building: work with partners to organize training programs and capacity-building activities for municipal staff, community members, and other stakeholders. • Joint monitoring and evaluation: Collaborate with partners to monitor and evaluate the impact of partnership activities, learn from experiences, and improve future collaboration.
Strengthening fire management capacities and efficient resource allocation.	• Training programs: Organize training programs for municipal staff, community members, and other stakeholders to enhance their knowledge and skills related to fire management, climate change adaptation, environmental conservation, policy development, and other relevant topics. • Recruitment and staffing: Hire and retain qualified personnel with the necessary skills for effective fire management and climate change adaptation. This may also involve providing ongoing professional development opportunities. • Volunteer programs: Develop and manage volunteer programs to supplement municipal efforts. Training local volunteers in fire management and climate adaptation techniques can not only boost capacity but also increase community resilience. • Resource assessment: Conduct regular assessments of resource needs (financial, human, technical, etc.) and develop strategies to fill any gaps. • Resource mobilization: Seek funding and other resources from national, provincial, and international sources. This may involve grant writing, advocacy, and establishing partnerships. • Equipment acquisition and maintenance: Secure and maintain necessary equipment for fire management and climate adaptation, such as fire trucks, firefighting gear, monitoring equipment, etc. • Information management systems: develop and manage systems for information and data management to support decision-making and coordination. • Community capacity building: implement programs to build capacity at the community level, such as training in fire preparedness, risk reduction, and climate adaptation. • Stakeholder engagement: Build capacity among various stakeholders, including local businesses, schools, community

	organizations, and others, to effectively contribute to fire management and climate adaptation efforts. • Evaluation and Improvement: Regularly evaluate capacity building and resource mobilization activities to ensure they are effective and make improvements as needed.

4.8. Climate Change Goal 5: Agricultural Production

Goal:	To enhance the resilience and well-being of the DM's agricultural communities and the agricultural sector by enhancing the resilience of agricultural production and distribution systems and communities to the impacts of climate change.
Outcome:	Improved resilience of the agricultural sector and communities to the impacts of climate change, such as storms and drought, and increased protection of food security.

4.8.1. Rationale/Context

Agriculture lies at the heart of the Thabo Mofutsanyana District Municipality (TMDM), contributing 12.8% to its Gross Value Added and playing a pivotal role in employment and local livelihoods, making it the second-largest employment sector. Statistics from the 2011 South African Census underline its significance, revealing that almost 40% of the District's households are directly involved in agricultural activities, suggesting a strong dependency on the sector for sustenance and economic well-being. This can be visualized in Figure 6, which showcases the depth of agricultural engagement across various local municipalities in the District. The region is endowed with some of the most fertile and productive lands in the Free State Province, accounting for approximately 3,000 hectares dedicated to diverse agricultural pursuits ranging from crop production, animal farming, and horticulture to specialized agri-activities such as fruit production in Ficksburg and horticulture in locales like Reitz, Bethlehem, and Clarens.

Yet, the sector faces significant challenges, many of which are exacerbated by the shifting paradigms of climate change. Recent declines in agricultural output are closely tied to changing weather patterns, which influence land productivity. The potential impacts of climate change, such as intensified droughts or unpredictable weather conditions, can further strain a sector already grappling with issues like limited water availability, high production costs, accessibility to markets, and inadequate support for small-scale farmers. Moreover, infrastructural challenges, exemplified by the district's deteriorating road network, impede the movement of

goods, affecting the livelihoods of many. Given these concerns, combined with other pressing challenges like inadequate government support, deteriorating land conditions, and infrastructural decay, prioritizing agricultural production as a key goal in TMDM's climate change adaptation plan is essential. Recognizing and addressing the vulnerabilities of this sector is crucial not only for ensuring food security but also for safeguarding the district's economic backbone and the livelihoods of its populace. The following two programmes have been identified through which it will aim to achieve the goal and targets of this outcome.

4.8.2. Programme 16: Enhanced Resilience of Agricultural Production and Distribution Systems from Climate Change

Given the importance of agricultural production to TMDM's economy and the susceptibility of the sector to the impacts of climate change, this programme is developed to enhance the resilience of agricultural production and distribution systems from climate change. Given that TMDM is at risk of increased temperatures and drought conditions, it is particularly important for the agricultural sector to adapt to the impacts of climate change, in order to protect livelihoods and food security.

This programme aims to develop a knowledge base on the vulnerability of agriculture to the impacts of climate change through conducting a district-level vulnerability and risk assessment for the agriculture sector as well as the promotion of climate-resilient crop and livestock production systems and technologies in the commercial sector. It is also vital to foster partnerships as well as to align relevant plans in order to contribute to the enhanced resilience of the agricultural sector.

Table 22: Programme 16: Enhanced resilience of agricultural production and distribution systems from climate change.

Programme 16: Enhanced Resilience of Agricultural Production and Distribution Systems from Climate Change.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Develop a knowledge base on the vulnerability of agriculture to the impacts of climate change.	• Conduct a district-level vulnerability and risk assessment for the agricultural sector. • Promote climate-resilient crop and livestock production systems and technologies in the commercial sector. • Establish partnerships with institutions for targeted research and dissemination of results. • Establish a platform for collating weather data and analysis in the context of climate change and develop channels for communicating weather information to farmers across the district. • Align Climate Change Response Plans, Disaster Management Plans, Spatial Development Framework, Rural Development/ Growth and Development/ Local Development Strategies.

Align climate change response plans, disaster management plans, spatial development framework, rural development/ growth and development/ local development strategies.	• Management/ rehabilitation of land owned by the DM to address the concern regarding the loss of agriculturally productive land and natural resources. • Develop a subsistence farming irrigation policy to facilitate the responsible use of water for irrigation.

4.8.3. Programme 17: Climate-Resilient Agricultural Communities

In line with Programme 16, this Programme aims to respond to the risk that climate change poses on the agricultural sector, such as increased temperatures and increased drought conditions, and to enable farming communities to respond and adapt to the impacts of climate change, in order to protect livelihoods and food security.

This Programme considers enhancing the capacity for climate change adaptation in farming communities and industry through supporting subsistence farmers in accessing extension services, support of knowledge sharing and well as the development and implementation of community gardens that can be utilised for agriculture and food production. Additionally, this Programme promotes enhanced social protection for farming communities, which considers supporting farmer organisations in accessing financing and insurance products as well as documenting and assessing indigenous knowledge and coping strategies.

Table 23: Programme 17: Climate resilient agricultural communities.

Programme 17: Climate Resilient Agricultural Communities	
ACTIONS	POSSIBLE KEY ACTIVITIES
Enhanced Capacity for Climate Change Adaptation in farming communities and industry.	• Support subsistence farmers in accessing extension services. • Host farmer field schools to support knowledge sharing on climate-resilient practices. • Implementation and utilisation of community gardens for agriculture and food production.
Enhanced social protection for farming communities.	• Support farmer organisations in accessing financing and insurance products. • Implementation and utilisation of community gardens for agriculture and food production. • Document and assess indigenous knowledge and coping strategies.

4.9. Climate Change Goal 6: Flood Management

Goal:	To implement flood management measures to address flood risk in the DM, through a comprehensive stormwater and flood management programme with the aim of managing risks associated with stormwater runoff and flooding events due to climate change
Outcome:	To ensure flood resilience for all members of the TMDM, through stormwater and flood management.

4.9.1. Rationale/Context

In the face of changing global climatic patterns, the Thabo Mofutsanyana District Municipality (TMDM) is becoming increasingly susceptible to heightened flood risks. As an area boasting significant water resources, including major rivers and numerous smaller tributaries, TMDM's terrain and its community structures make it inherently vulnerable to the ravages of floods. With the impacts of climate change leading to erratic rainfall patterns, including intense and unpredictable downpours, the region can anticipate augmented flood occurrences, which can devastate local communities, ecosystems, and the economy.

Primarily, the human settlements in TMDM, particularly those in low-lying regions or close to water bodies, face an existential threat from potential flooding. Such floods can lead to significant loss of life, displacement of populations, and extensive damage to property and infrastructure. Given that many communities in the district rely on local agricultural practices for sustenance, floods can wreak havoc on crops, affecting food security and overall economic stability. Furthermore, the district's valuable natural resources, including its biodiversity-rich grasslands and tourist attractions, could be severely impacted, threatening not only the environment but also the socio-economic fabric of the region.

Lastly, with the district's critical infrastructure — roads, bridges, utilities, and public buildings — located in vulnerable areas, any large-scale flooding can disrupt daily life, impede mobility, and halt economic activities. The repercussions of floods aren't limited to immediate damage; they can strain the district's financial resources due to the need for recovery, rehabilitation, and rebuilding. Consequently, integrating flood management into TMDM's climate change adaptation plan isn't just a choice but an urgent necessity. Proactive planning, alongside infrastructure and community resilience-building, can ensure that the district is prepared to face the challenges that increased flooding, as a result of climate change, poses. The following programme has been identified through which it will aim to achieve the goal and targets of this outcome.

4.9.2. Programme 18: Comprehensive Stormwater and Flood Management Programme

The *comprehensive stormwater and flood management programme,* designed to be implemented within the TMDM, is an extensive initiative aiming to combat and manage the

increasing risks associated with stormwater runoff and flooding events due to climate change. The programme seeks to leverage both traditional and green infrastructure to improve the resilience of communities to these climatic risks. At the heart of this programme is a robust system that assesses, monitors, and adapts to emerging flood and stormwater threats, whilst simultaneously promoting public engagement and awareness.

In the initial phase of the programme, extensive field surveys and data collection will be conducted to assess the current infrastructure in place and to map the district's drainage network. This data will be further analysed using Geographic Information System (GIS) and hydraulic modelling to create a comprehensive picture of the existing situation and to forecast potential future scenarios. With this knowledge in hand, the programme will then move to design and construct the required infrastructure. This infrastructure will not only be traditionally built but will also promote the use of green infrastructure. Green infrastructure, such as rain gardens, permeable pavements, and bioswales, offers the dual benefit of managing stormwater runoff and enhancing local biodiversity.

The programme also incorporates an inclusive and integrative stakeholder engagement strategy, from its initiation to the implementation of monitoring, maintenance, and management plans. The involvement of all stakeholders, including local communities, governmental agencies, and non-governmental organizations, is crucial for the success of this endeavour. The establishment of an early warning system forms another key aspect of the programme, preparing communities for upcoming hazards and facilitating a prompt response to minimize the impact. Additionally, public awareness campaigns and education initiatives will be rolled out to increase community knowledge of stormwater and flood risks, alongside providing training to local officials and community representatives for better management of these risks. Lastly, monitoring and evaluation will be an ongoing process throughout the programme, ensuring that it meets its objectives and can be adjusted as necessary based on evolving conditions and feedback.

Table 24: Programme 18: Comprehensive stormwater and flood management programme.

Programme 18: Comprehensive Stormwater and Flood Management Programme	
Actions	Activities
Assessment of current infrastructure.	• A comprehensive evaluation of current stormwater drainage systems. • Identification of flood-prone areas for upgrade, repair, or new infrastructure needs.
Mapping of drainage network.	• Charting of existing drainage network and district • Evaluation of capacity and conditions. • Identification of bottlenecks, blockages, or flood-prone areas.

Infrastructure design and construction.	• Design and construction of new stormwater drainage and flood management infrastructure. • Integration of future climate scenarios, urban growth trends, and land use changes into planning and design, including the creation or enhancement of floodplains and retention basins.
Green infrastructure advocacy.	• Promotion and integration of green infrastructure like rain gardens, bioswales, and permeable pavements to supplement traditional drainage systems.
GIS and hydraulic modelling usage.	• Utilization of Geographic Information Systems (GIS) and hydraulic modelling tools. • Simulation of stormwater flow and identification of areas at risk of flooding.
Implementation of monitoring, maintenance, and management plan.	• Establishment of a detailed monitoring, maintenance, and management plan for stormwater drainage and flood management infrastructure. • Assured routine inspections, debris removal, and efficient system function.
Stakeholder engagement.	• Engagement with engineers, architects, urban planners, landscape architects, local communities, and stakeholders in the design and management of drainage infrastructure, floodplains, and retention basins.
Field surveys and data collection.	• Conduct field surveys and data collection on existing infrastructure, water levels, biodiversity, and usage of flood management areas.
Establishment of early warning system.	• Creation of an early warning system, including the installation of monitoring equipment for real-time data collection and analysis. • Development of efficient communication channels for disseminating information.
Public awareness campaigns and education.	• Implementation of public awareness campaigns and educational programmes on stormwater management, flood risk awareness, responsible waste management, and emergency preparedness. • Emphasis on the importance of maintaining clean stormwater drains.
Training.	• Provision of training for maintenance crews, engineers, and urban planners. • Ensuring they are equipped with the necessary skills and knowledge for effective infrastructure maintenance, management, and development.
Monitoring and evaluation.	• Regular monitoring and evaluation to assess the effectiveness of the programme, flood risk reduction, and necessary system upgrades.

5. Implementation Framework

5.1.Implementation Framework

Table 25: Implementation Framework

	Key Risk/Vulnerability Addressed	Responsible Department	Target	Implications and costs	Timeframe			Priority Level
					0-2 years	3- 5 years	6 – 10 years	
Adaptation Goal: Water Resource Management								
Adaptation Programme 1: Integrated Approach to Water Augmentation, Use and Management.								
Water Sensitive Urban Design (WSUD)	Drought	Water and Sanitation	Year 0-2: Completed feasibility studies and preliminary design, private sector uptake of water re-use technologies. Year 3 – 5: Green infrastructure pilot projects, all new residential development applying water efficient designs. Year 6-10: Scaling green infrastructure	High	Feasibility studies and design. Promotion of water reuse and water-efficient design.	Implementation of green infrastructure stormwater attenuation.	Implementation of green infrastructure stormwater attenuation.	High
Addressing Human Resources Constraints for Effective Water Management	Drought	Water and Sanitation	Year 0-2: Complete needs assessment, assign funds implement WRM KPI's Year 3-5: Recruit water resource manager and establish partnerships.	Low	Advocate for and secure funding for a dedicated water resources manager position.	Recruit a qualified water resources manager.	Maintain	High

Review Bulk Water Master Plan	Drought	Water and Sanitation	Year 0-2: Status quo assessment, Develop Plan, Assign budget. Year 3-5: Implement	Medium	Status Quo Assessment and Plan Development	Execution of the Bulk Water Master Plan		High
Developing a Water Safety Plan (WSP)	Drought	Water and Sanitation	Year 0 – 2: Develop Emergency Response Plan Year 3-5: Implementation and Review. Improved Blue Drop Scores. Year 6-10: Review of plan and continuous improvement.	Medium	Development and Implementation of a Water Safety Plan	Implementation, Monitoring and Evaluation	Execution of the Bulk Water Master Plan	
Adaptation Programme 2: Protect and Conserve Water Through Monitoring Mechanisms and Water Conservation through Water Conservation and Water Demand Management (WCWDM).								
Implementing monitoring mechanisms and protecting water sources by reducing pollution.	Drought	Water and Sanitation	Year 0 – 2: Develop monitoring schedule, establish buffer zone and integrate in spatial frameworks Year 3-5: Implement by-laws	Medium	Implement a regular water quality monitoring schedule, create and manage municipal buffer zones and develop by-laws to regulate effluent discharge.	Implement	Implement	High
Implementing water conservation measures.	Drought	Water and Sanitation	Year 0-2: Achieve set number of awareness	Low to High	Establish targets for awareness campaigns and loss reduction.	Water re-use systems installed on municipal property.	Large scale water re-use systems implement for	High

			campaigns and loss reduction. Year 3-5: Implement greywater-based irrigation on municipal land. Year 6-10: Large scale re-use systems operational.		Feasibility Studies and pilot projects		non-potable uses.	
Alien Invasive Species Clearing Initiatives In Catchment Areas.	Flooding	Water and Sanitation	Year 0-2: Mapp alien invasive hotspots. Continue current operation and campaigns. Source funds. Year 3-5: Scale alien invasive clearing and establish green economy initiatives. Year 6-10: Self-sustaining operations in key areas.	Medium	Identify, map and control areas containing alien invasive species.	Scale	Scale	
Enforce 'Green' Approaches in Residential Areas and Developments.	Drought	Water and Sanitation	Year 0-2: Guidelines developed for residential and commercial development Year 3-5: Establish technical and funding	Low	Developing and implement guidelines and standards for sustainable residential and commercial development	Incentive programme. Enforcement	Enforcement.	

			partnerships in order to establish incentive programme.					
Adaptation Programme 3: Assessing the Feasibility and Sustainability of Alternative Water Sources for Climate Change Adaptation.								
Water Resource Management Planning	Drought	Water and Sanitation	Year 0-2: Status quo assessment of water resources. Integrated drought management plan developed.	Medium	Conduct a water resource assessment, develop a drought management plan and develop and implement water conservation strategies.	Implement	Implement	Medium
Investigating alternative water resources	Drought	Water and Sanitation	Year 0-2: Completion of feasibility studies Year 3-5: Pilot project implemented.	Medium	Conduct a feasibility study to identify alternate water sources, and undertake hydrological assessments to determine water availability and potential yield of alternative water sources.	Implement	Implement	High
Investing in alternative water resources	Drought	Water and Sanitation	Year 3 – 5: Pilot Projects Year 6 – 10: Scaling	High	Feasibility studies and pilot projects.	Pilot projects	Scaling	
Develop and Implement a Treated Effluent Reuse Strategy For Sustainable Water Management.	Drought	Water and Sanitation	Year 0-2: Develop Strategy and Resource. Year 3 – 5: Implement	Medium	Developing a comprehensive treated effluent reuse plan, including infrastructure and system	Implement	Implement	

					requirements, stakeholder engagement, and potential risks and mitigation strategies.			
Adaptation Programme 4: Implementing Sustainable Groundwater Use and Development Strategy								
Conducting Groundwater Resource Assessments to Establish the Availability and Quality of Groundwater in the TMDM Area.	Drought	Water and Sanitation	Year 0-2: Completion of groundwater management plan.	Medium	Develop a groundwater management plan	Implement	Implement	Medium
Establishing Sustainable Groundwater Use Policies and Guidelines to Promote Efficient and Effective Groundwater Management.	Drought	Water and Sanitation	Year 0 – 2: Updated policy and guidelines. Year 3 – 5: Source Additional funding and partnerships for for enforcement.	Medium	Conduct a review of existing policies and guidelines related to groundwater use to identify gaps and areas for improvement.	Implement	Implement	Medium
Implementing Groundwater Monitoring Programmes to Monitor Water Levels, Water Quality, and Potential Pollution Sources, Enabling Early Detection of	Drought	Water and Sanitation	Year 0 – 2: Establish partnerships with irrigation boards and large water users.	Medium	Establish Partnerships	Install and maintain a network of groundwater monitoring wells and equipment to collect data on groundwater levels, water quality, and		High

Potential Problems and Timely Intervention.						potential pollution sources.		
Promoting Groundwater Conservation and Efficiency by Encouraging the Adoption of Water-Saving Technologies and Practices in all Sectors.	Drought	Water and Sanitation	Year 0-2: Awareness campaigns. Year 3 -5: Launch technical partnership with speres of government or private sector to promote water efficient technologies.	Medium	Develop and implement water conservation standards for new and existing municipal buildings and properties and encourage the adoption of water reuse/recycling technologies.	Establish technical support structure.	Maintain	
Developing Groundwater Recharge and Artificial Recharge Strategies to Enhance Aquifer Recharge Rates and Improve Groundwater Storage Capacity.	Drought	Water and Sanitation	Year 0-2: Feasibility and recharge sites established. Year 3-5: Recharge infrastructure established	Medium	Conduct studies to identify suitable sites for groundwater recharge, including areas with high permeability, favourable soil conditions, and sufficient rainfall.	Implement	Maintain	Medium
Implementing Land-Use Planning and Zoning Regulations to Protect Groundwater Resources from	Drought	Water and Sanitation/ Planning and Economic Development	Year 0-2: Define setback lines Year 3-5: Monitoring and evaluation programme implemented	Medium	Conduct a groundwater vulnerability assessment and develop and enforce land-use planning and zoning regulations.	Implement and monitor.	Implement and monitor	

Pollution and Overuse.								
Develop a Information Management System for Groundwater Data to Provide Accurate and Timely Information to Water Users, Decision-Makers, and The Public.	Drought	Water and Sanitation	Year 0-2: Partner with DWS to establish system.	Low	Develop and update a database and web-based portal for storing and accessing groundwater data, including water levels, quality, and other relevant information.	Maintain	Maintain	
Climate Change Goal 2: Ecosystem Conservation								
Programme 5: Conserve, Protect and Restore Natural Open Spaces, Ecosystems and Natural Resources.								
Assessing natural resources and ensuring that natural open spaces, ecosystems, and resources are conserved, protected and restored.	Flooding/Drought / Wildfires	Environmental Management	Year 0-2: Identify high ecological value areas Year 3 – 5: Integrate into SDF on review.	Medium	Develop conservation plans and management strategies for high conservation value areas	Integrate into SDF	Review.	Medium
Harnessing the potential of open spaces to absorb and mitigate the impacts of climate change.	Flooding	Environmental Management	Year 0-2: Ecosystem service supply and demand assessment including status quo.	Medium	Compile natural resources inventory and ecosystem services assessment.	Implement maintenance and restoration project.	Establish new protected areas.	High
Implementing programmes focused on	Flooding	Environmental Management	Year 0-2: Develop Ecosystem Based Adaptation Plan.	Medium	EBA Plan	Implement	Implement	High

mitigating the impact of climate change and severe weather, particularly in climate-risk zones.			Year 3-5: Resource Plan and Implement					
Adaptation Programme 6: Enhanced Natural Resource Management								
Ensuring the quality of water resources is critical to the sustainable development of TMDM, as they play a vital role in maintaining the health of ecosystems, human health, and socio-economic development.	Health	Water and Sanitation	Year 0-2: Water quality monitoring sites identified and monitored.	Low	Conducting regular water quality monitoring to track the levels of various pollutants, including pathogens, nutrients, and chemicals, in water bodies.	Conducting regular water quality monitoring to track the levels of various pollutants, including pathogens, nutrients, and chemicals, in water bodies.	Conducting regular water quality monitoring to track the levels of various pollutants, including pathogens, nutrients, and chemicals, in water bodies.	High
Monitoring and preventing soil erosion is crucial to ensure the long-term health and productivity of natural ecosystems, as well as to maintain the quality of water resources.	Flooding	Environmental Management	Year 0-2: Erosion Risk Assessment Year 3-5: Develop and implement erosion control plans for high-risk areas.	Medium	Conduct a soil erosion risk assessment on municipal land.	Implement control plans for high priority areas.	Review and maintain.	High
Provide training to municipal staff and stakeholders on biodiversity and	Flooding/ Drought/ Fire/ Heat Stress	Environmental Management	Year 0-2: Number of officials trained.	Low	Implement training programme.	Monitor	Monitor	Medium

natural resource management regulations and guidelines.			Year 3-5: Number of officials trained. Monitoring and evaluation. Year 6-10: Number of officials trained. Monitoring and evaluation.					
Establish a Municipal Environmental Management Forum (MEMF) to enhance collaboration and coordination between Sectoral Departments, Conversation Organisation and agencies related to natural resource management.	Flooding/ Drought/ Fire/ Heat Stress	Environmental Management	Year 0-2: Establish forum with terms of reference	Low	Conduct regular meetings. Track progress and performance.	Conduct regular meetings. Track progress and performance. Review Terms of Reference.	Conduct regular meetings. Track progress and performance. Review Terms of Reference.	Medium
Adaptation Programme 7: Integrate Critical Biodiversity Areas and Ecological Support Areas into the Spatial Development Framework								
Ensuring critical biodiversity and ecological support areas are integrated into municipal spatial plans at all scales.	Flooding/ Fire/ Heat Stress/ Drought	Disaster Management	Year 0-2: Integrate critical biodiversity and ecological support areas into municipal spatial plans Year 3-5: Implement Year	Low	Integrate critical biodiversity and ecological support areas into the municipal spatial plans.	Implement municipal spatial plans.	Implement municipal spatial plans.	High

Identifying and mapping natural open spaces, ecosystems, and natural resources, and integrating inventories in the Spatial Development Framework and the open space framework.	Drought/ Flooding/ Heat Stress	Environmental Management	Year 0-2: Integrate and map the inventory information into the SDF Year 3-5: Implement	Low	Integrating the mapping and inventory information into the Spatial Development Framework, open space framework.	Integrate and implement the mapped inventory information from the SDF.	Monitor.	High
Identifying undeveloped open space with potential for green infrastructure.	Flooding	Environmental Management	Year 0-2: Assess the suitability for undeveloped open spaces. Year 3-5: Implement	Low	Assess the suitability of undeveloped open spaces for different types of green infrastructure.	Implement green infrastructure.	Implement green infrastructure.	High
Assessing the value of open spaces and ecosystem services	Health	Water and Sanitation	Year 0-2: Develop policies and regulations to assess the value of open spaces. Year 3-5: Implement	Low	Develop policies and regulations to protect and manage these areas.	Implement	Implement	High
Climate Change Goal 3: Social Equity and Vulnerable Populations								
Programme 8: Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements.								
Conducting a vulnerability assessment to identify the populations and locations most at risk of climate change impacts.	Wildifire/ flooding/ heat/ drought	Environmental Management	Year 0-2: Assess the vulnerability of infrastructure to climate change. Year 3-5: Implement	Medium	Assess the vulnerability of infrastructure to climate change.	Develop and implement climate-resilient infrastructure.	Implement and maintain.	Medium

Developing and implementing an early warning system to help communities prepare for and respond to climate change risks.	All	Disaster Management	Year 0-2: Install weather monitoring systems. Year 3-5: Enforce early warning system.	Medium	Install weather monitoring systems to provide real-time data on extreme weather events and develop warning protocols.	Enforce early warning system	Enforce early warning system	High
Establishing partnerships with local stakeholders, such as community groups and NGOs, to build local capacity for climate change adaptation and resilience.	Flooding/ Drought	Disaster Management	Year 0-2: Building partnerships. Year 3-5: Implement	Low	Building partnerships with community groups.	Collaborate with local NGOs to implement small-scale adaptation measures.	Implement.	
Developing and implementing land use planning and zoning regulations that take into account the potential impacts of climate change.	Wildifire/ flooding/ heat/ drought	Planning and Local Economic Development	Year 0-2: Develop land use and zoning regulations Year 3-5: Implement	Medium	Developing land use and zoning regulations to ensure that settlements are built in safe and sustainable locations.	Implement land use and zoning regulations	Implement	
Programme 9: Community-Based Adaptation in Communities Most at risk of climate-related hazards								
Conducting granular risk and vulnerability assessments in communities to identify drivers of risk and develop	Wildifire/ flooding/ heat/ drought	Environmental Management	Year 0-2: Develop adaptation measures. Year 3-5: Implement	Low	Develop adaptation measures for populations most at risk.	Implement	Implement	

appropriate adaptation measures.								
Developing and implementing community-based adaptation measures to reduce risks and build resilience falls under the purview of relevant departments.	Flooding/ Drought	Environmental Management	Year 0-2: Develop adaptation measures. Year 3-5: Support and Implement	Low	Support the DFFE and Province and Agriculture extension services to promote the use of climate-smart agricultural practices.	Support and implement sustainable agricultural practices.	Implement and monitor.	
Providing training and education to build community capacity and promote sustainability.	All	Environmental Management	Year 0-2: Provision of training Year 3-5: Design, implementation and monitoring of adaptation measures.	Low	Providing training and education to community members on climate change impacts and adaptation strategies.	Design, implement and monitor adaptation measures.	Implement and monitor adaptation measures.	
Comprehensive Community Engagement and Public Awareness Initiative on Climate Change.	All	Environmental Management	Year 0-2: Climate change awareness raising. Year 3-5: Implement training and education programmes	Low	Raise climate change awareness for communities.	Implement training and education programmes for community members.	Continue awareness raising, developing partnerships and capacity building.	
Adaptation Programme 10: Climate Resilient Spatial Planning for Climate Resilient Growth and Development								
Ensure that spatial planning frameworks consider a long-	All	Planning and Local Economic Development	Year 0-2: Develop guidelines for	Low	Develop guidelines for climate-resilient spatial planning.	Implement guidelines	Implement and monitor	

term view of climate hazards and incorporate natural infrastructure.			climate-resilient spatial planning. Year 3-5: Implement guidelines					
Develop local-level climate-resilient planning mechanisms - Precinct Plans.	All	Planning and Local Economic Development	Year 0-2: Develop climate resilient precinct plans Year 3-5: Implement	Low	Develop climate-resilient precinct plans that incorporate the needs and concerns of the community.	Implement precinct plans	Implement and monitor	
Ensure collaborative strategic planning that incorporates all relevant departments (in both strategic planning and project implementation).	All	Planning and Local Economic Development	Year 0-2: Develop guidelines for collaboration in strategic planning and project implementation. Year 3-5: Implementation of guidelines.	Low	Develop guidelines for collaboration and coordination in strategic planning and project implementation.	Implement guidelines	Implement and monitor guidelines	
Create mechanisms to strengthen public participation in planning and decision-making processes.	All	Planning and Local Economic Development	Year 0-2: Ensure that public feedback is incorporated into the decision-making process. Year 3-5: Ensure that public feedback is incorporated into the decision-making process.	Low	Ensure that public feedback is incorporated into the decision-making process.	Ensure that public feedback is incorporated into the decision-making process.	Ensure that public feedback is incorporated into the decision-making process.	

Innovative urban and township design and development is an essential component of climate change response, as it helps to minimise the risk and impact of climate change on urban areas.	All	Planning and Local Economic Development	Year 0-2: Develop guidelines. Year 3-5: Implement guidelines.	Medium	Developing guidelines in collaboration with reliant government departments, for innovative urban and township design that take into account climate change risks.	Implement guidelines.	Implement guidelines.	
To identify climate risk zones and hotspots that affect vulnerable municipal infrastructure and assets.	All	Planning and Local Economic Development	Year 0-2: Develop strategies to manage risks and protect infrastructure and assets from climate change impacts. Year 3-5: Implement strategies.	Medium	Develop strategies to manage risks and protect infrastructure and assets from climate change impacts.	Implement strategies.	Implement and monitor strategies.	
Programme 11: Sustainable Development of a Resilient Tourism Industry								
Climate Change Considerations into Tourism Planning and Development	Flooding/ Fire	Local Economic Development	Year 0-2: Plan tourism infrastructure developments so that they are protected from fire, flooding and storms. Year 3-5: Implement	Medium	Plan tourism infrastructure developments so that they are protected from fire, flooding and storms.	Implement	Maintain	

Identify biodiversity important for tourism sector and promote ecosystem based adaptation to maintain these biodiversity areas.	Flooding/ Fire	Local Economic Development	Year 0-2: Identification of biodiversity that is important to the tourism sector. Year 3-5: Develop and implement ecosystem-based adaptation measures to maintain biodiversity that is important to the tourism industry.	Medium	Identification of biodiversity that is important to the tourism sector.	Develop and implement ecosystem-based adaptation measures to maintain biodiversity that is important to the tourism industry.	Implement	
Promote ecotourism practices	Flooding/ Fire	Local Economic Development	Year 0-2: Assess the effects of climate change on special designated natural areas that attract tourists such national parks and forests. Year 3-5: Identify and promote sustainable tourism practices. Involve communities in developing ecotourism initiatives that are sustainable	Medium	Assess the effects of climate change on special designated natural areas that attract tourists such national parks and forests	Identify and promote sustainable tourism practices. Involve communities in developing ecotourism initiatives that are sustainable and beneficial to both the environment and local economy.	Implement	

			and beneficial to both the environment and local economy.					
Programme 12: Wind Resilience Initiative								
Strengthening Infrastructure to Withstand High Winds	Strong Winds	Environmental Management/ Disaster Management	Year 0-2: Encourage the development of building codes and standards that take into account the risks associated with strong winds. Year 3-5: Promote the use of wind resistant building materials in new construction projects. Retrofitting homes and buildings to be more wind resilient.	Medium	Encourage the development of building codes and standards that take into account the risks associated with strong winds.	Promote the use of wind resistant building materials in new construction projects. Retrofitting homes and buildings to be more wind resilient.	Implement	
Development of Early Warning Systems	Strong Winds	Environmental Management/ Disaster Management	Year 0-2: Installing weather monitoring equipment and developing communication networks to disseminate	Medium	Installing weather monitoring equipment and developing communication networks to disseminate warnings to communities.	Establishing emergency response plans. Providing training and resources to community members.	Maintain	

			warnings to communities. Year 3-5: Establishing emergency response plans. Providing training and resources to community members.					
Programme 13: Climate-Smart Transport Strategy for Resilience and Efficiency								
Establish a Baseline and Assess Vulnerability	Flooding, Environmental Health issues, Heat Stress, Wildfires, and Drought.	Infrastructure	Create the group and gather data in the first 2 years. Complete the assessment in 3-5 years.	Low-High	Have a working group and data within 2 years..	Complete the assessment within 5 years		High
Develop and Implement a Low-Carbon, Inclusive Transport Plan	Environmental Health, Heat Stress.	Infrastructure	Vision and goals ready within 2 years. Low-carbon options identified and efficiency improvements in place within 5 years. Accessibility and equity ensured within 10 years.	Low-High	Develop vision and goals in the first 2 years.	Identify low-carbon options and improve efficiency in 3-5 years.	Ensure accessibility and social equity in 6-10 years.	
Enhance the Resilience of Local Transport Infrastructure to Climate Shocks	Flooding, Environmental Health, Heat Stress, Wildfires, Drought.	Infrastructure	Risk assessments done within 2 years. Resilience plans developed and maintenance programmes initiated within 5	Medium-High	Conduct risk assessments in 0-2 years.	Develop resilience plans and start maintenance programmes in 3-5 years.	Invest in resilience technologies in 6-10 years	High

			years. Investments in resilience technologies made within 10 years.					
Monitor, Evaluate, and Continually Improve the Transport Plan and Infrastructure Resilience	Flooding, Environmental Health, Heat Stress, Wildfires, Drought.	Infrastructure	Establish a monitoring and evaluation system within 1 year. Complete evaluation of resilience strategies within 2 years. Implement action plans within 5 years.	Medium-High	Monitoring and evaluation to be started immediately and conducted regularly over 0-10 years. Evaluation of resilience strategies in 0-2 years.	Development and implementation of action plans in 3-5 years.		High
Programme 14: Energy Efficiency Initiative for Climate Change Adaptation								
Improving energy efficiency in homes, settlements and buildings.	Extreme weather events	Department of Energy	Year 0-2: Providing education and resources to community members on how to reduce energy consumption in their homes and buildings. Encouraging the use of energy-efficient lighting and appliances to reduce electricity consumption.	Medium	Providing education and resources to community members on how to reduce energy consumption in their homes and buildings. Encouraging the use of energy-efficient lighting and appliances to reduce electricity consumption.	Continue	Continue	

Promoting the use of renewable energy sources such as solar and wind power to reduce reliance on fossil fuels and improve energy security in times of crisis.	Extreme weather events	Department of Energy	Year 0-2: Assess the feasibility of using renewable energy sources (such as solar and wind power). Year 3-5: Encourage the development of community-based renewable energy systems such as microgrids that can provide power to critical facilities during power outages.	Medium	Assess the feasibility of using renewable energy sources (such as solar and wind power).	Encourage the development of community-based renewable energy systems such as microgrids that can provide power to critical facilities during power outages.	Continue	
Supporting research and development of new energy technologies that can improve energy efficiency.	Extreme weather events	Department of Energy	Year 0-2: Establish partnerships with universities and research institutions to support research and development of new energy technologies. Year 3-5: Providing funding for research and development of new energy technologies such as energy-	Low	Establish partnerships with universities and research institutions to support research and development of new energy technologies.	Providing funding for research and development of new energy technologies such as energy-efficient appliances.	Continue	

			efficient appliances.					
Goal 4: Fire Management								
Adaptation Programme 15: Integrated Fire Management for Climate Resilience								
Comprehensive Evaluation of Fire Hazards	Fire	Disaster Management	Year 0-2: Hazard identification and risk mapping	Low	Hazard identification and risk mapping			High
Fire Prevention Roadmap	Fire	Disaster Management	Year 0-2: Identify firebreaks, develop community fire plans and install fire detection systems. Year 3-5: Implement	Medium	Identify firebreaks, develop community fire plans and install fire detection systems.	Implement	Implement	High
Community Engagement and Fire Safety Education	Fire	Disaster Management	Year 0-2: Hold community workshops and seminars and distribute educational materials	Low	Hold community workshops and seminars and distribute educational materials	Hold community workshops and seminars and distribute educational materials	Hold community workshops and seminars and distribute educational materials	
Advancing Fire Detection and Monitoring Infrastructure	Fire	Disaster Management	0-2 years: Assess infrastructure required for advanced fire detection and monitoring	Medium	Assess infrastructure required for advanced fire detection and monitoring.	Install infrastructure.	Maintain	
Emergency Preparedness and Response Strategy	Fire	Disaster Management	0-2 years: Develop an emergency response plan.	Medium	Develop an emergency response plan.	Implement	Implement	
Post-fire Restoration and	Fire	Disaster Management	0-2 years:	Medium	Damage assessment and	Damage assessment and	Damage assessment and	

Ecosystem Rehabilitation			Damage assessment and implementation of restoration measures including erosion control, revegetation and wildlife management		implementation of restoration measures including erosion control, revegetation and wildlife management	implementation of restoration measures including erosion control, revegetation and wildlife management	implementation of restoration measures including erosion control, revegetation and wildlife management	
Policy and By-law Development	Fire	Disaster Management	0-2 years: Develop policies and by-laws	Medium	Develop policies and by-laws	Implement	Implement	
Innovation and Research in Fire Management Techniques	Fire	Disaster Management	0-2 years: Collaborative research initiatives, research dissemination and utilisation and community-based research.	Low	Collaborative research initiatives, research dissemination and utilisation and community-based research.	Continue	Continue	
Inter-Organisational Collaboration and Strategic Partnerships	Fire	Disaster Management	0-2 years: Inter-municipal collaboration, partnerships with universities and research institutions and private sector engagement.	Low	Inter-municipal collaboration, partnerships with universities and research institutions and private sector engagement	Continue	Continue	
Strengthening Fire Management Capacities and Efficient Resource Allocation	Fire	Disaster Management	Year 0-2: Training programmes, recruitment and staffing, volunteer	Low	Training programmes, recruitment and staffing, volunteer programmes and	Continue	Continue	

			programmes and community capacity building.		community capacity building.			
Goal 5: Agricultural Production								
Adaptation Programme 16: Enhanced Resilience of Agricultural Production and Distribution Systems from Climate Change								
Develop a knowledge base on vulnerability of agriculture to the impacts of climate change.	Drought/ Heat Stress/ Flooding	Environmental Management	0-2 years: Conduct a district level vulnerability and risk assessment for the agricultural sector. Establish partnerships with institutions for targeted research and dissemination of results. 3-5 years: Establish a platform for collecting weather data.	Low	Conduct a district level vulnerability and risk assessment for the agricultural sector. Establish partnerships with institutions for targeted research and dissemination of results.	Establish a platform for collating weather data and analysis in the context of climate change and develop channels for communicating weather information to farmers across the district.	Maintain	
Align Climate Change Response Plans, Disaster Management Plans, Spatial Development Framework, Rural Development/ Growth and Development/ Local Development Strategies.	Drought/ Heat Stress/ Flooding	Environmental Management	0-2: Align Climate Change Response Plans, Disaster Management Plans, Spatial Development Framework, Rural Development/ Growth and Development/ Local	Low	Align Climate Change Response Plans, Disaster Management Plans, Spatial Development Framework, Rural Development/ Growth and Development/ Local	Implement	Implement	

			Development Strategies		Development Strategies			
Adaptation Programme 17: Climate Resilience Agricultural Communities								
Enhanced Capacity for Climate Change Adaptation in farming communities and industry.	Drought/ Heat Stress/ Flooding	Environmental Management	Year 0-2: Support subsistence farmers in accessing extension services.	Low	Support subsistence farmers in accessing extension services	Implementation and utilisation of community gardens for agriculture and food production.	Implementation and utilisation of community gardens for agriculture and food production.	
Enhanced social protection for farming communities.	Drought/ Heat Stress/ Flooding	Environmental Management	Year 0-2: Document and assess indigenous knowledge and coping strategies. Year 3-5: Support farmer organisations in accessing financing and insurance products.	Low	Document and assess indigenous knowledge and coping strategies.	Support farmer organisations in accessing financing and insurance products	Maintain	
Goal 6: Flood Management								
Adaptation Programme 18: Comprehensive Stormwater and Flood Management Programme								
Assessment of Current Infrastructure	Flooding	Infrastructure	0-2 years: Conduct a comprehensive evaluation of current stormwater drainage systems and identify flood-prone areas	High	Complete the evaluation of the stormwater drainage systems, identify and prioritize flood-prone areas	Initiate and complete smaller upgrade projects, start large-scale projects, all based on the priority	Complete all large-scale projects and maintain the upgraded infrastructure	High

			3-5 years: Upgrades 6-10 years: Maintenance					
Mapping of drainage network	Flooding	Infrastructure services	0-2 years: Complete charting half of the drainage network and district 3-5 years: Finish the charting process, identify all bottlenecks and blockages, and identify all flood-prone areas 6-10 years: Maintain the charting and continue to evaluate capacity, conditions and identify bottlenecks	Medium	Start charting existing drainage networks and districts, evaluate their capacity and conditions	Complete the evaluations and identification of bottlenecks, blockages, and flood-prone areas	Implement improvements based on the findings and continue monitoring for new issues	High
Infrastructure design and construction	Flooding	Infrastructure services	0-2 years: Design the new stormwater drainage and flood management infrastructure 3-5 years: Begin the construction of the designed infrastructure	High	Complete the design of the new stormwater drainage and flood management infrastructure	Finish 50% of the construction	Finish all the construction, and evaluate the effectiveness of the infrastructure	High

			6-10 years: Complete the construction and start maintenance, evaluation, and potential improvements					
Green infrastructure advocacy	Flooding	Infrastructure services	0-2 years: Complete the identification and planning of suitable areas for green infrastructure. 3-5 years: Achieve 50% completion of the planned green infrastructure projects. 6-10 years: Achieve 100% completion of all planned green infrastructure projects.	Medium	Complete the identification and planning of suitable areas for green infrastructure	Achieve 50% completion of the planned green infrastructure projects.	Achieve 100% completion of all planned green infrastructure projects.	Medium
GIS and hydraulic modelling usage	Flooding	Infrastructure services/ GIS	0-2 years: Acquire necessary GIS and hydraulic modelling tools, train staff in their use, and begin	Medium	Acquire and implement GIS and hydraulic modelling tools; staff trained and initial data collection started.	Completion of initial stormwater flow simulations and identification of high-risk areas	Regular updates to models and predictions based on new data; strategies are adjusted based on	High

			modelling and analysis. 3-5 years: Complete initial analysis and use results to inform flood risk management and infrastructure planning. 6-10 years: Continue to update and refine models as new data becomes available, and use them to monitor and adjust strategies as needed.				modelling outcomes.	
Development of monitoring, maintenance and management plans	Flooding	Infrastructure services	0-2 years: Establishment of a detailed maintenance and management plan. Begin regular inspections and maintenance tasks. 3-5 years: Maintenance tasks are being performed regularly, and the system's	Medium	0-2 years: Develop a comprehensive maintenance and management plan. Begin implementing routine inspections and necessary system maintenance.	3-5 years: Continue regular system maintenance. Refine and adjust management plans based on the outcomes of inspections and system performance.	6-10 years: Continue maintenance according to the management plan. Update the plan as necessary to adapt to changing conditions or new infrastructure.	High

			efficiency is improving. 6-10 years: Regular maintenance and inspections continue, and the system functions efficiently.					
Stakeholder engagement	Flooding	Infrastructure services/ Disaster Management	0-2 Years; Engagement Occurred	Low	Initiate engagement	Continue	Continue	Medium
Field surveys and data collection	Flooding	Infrastructure services	0-2 years: Develop survey methodologies, train personnel, and begin conducting field surveys and data collection. 3-5 years: Continue data collection efforts, begin data analysis, identify initial trends and areas of concern. 6-10 years: Continue data collection and analysis efforts, refine methodologies based on previous years' experience,	Medium	Development of survey methodologies, training of staff, and initiation of data collection efforts	Consistent and reliable data is being collected and analysed, with insights beginning to inform decision-making.	Established system of regular data collection and analysis, with findings integrated into municipal planning and decision-making.	High

			adjust strategies based on findings.					
Establishment of early warning sytems	Flooding	Infrastructure services/ Disaster management	0-2 years: Define the requirements for the early warning system, procure the necessary equipment, and begin installation. Set up initial communication channels for disseminating information. 3-5 years: Complete the installation of monitoring equipment and fine-tune the data collection and analysis process. Enhance the communication channels based on feedback and lessons learned. 6-10 years: Regularly review, update, and improve the early warning system and communication	High	Commence the set up of an early warning system and define the communication strategy.	Have a fully functional early warning system in place and ensure information is effectively disseminated to the public.	Have a well-established, reliable early warning system with efficient information dissemination methods, which are regularly updated based on changing needs and technologies	High

			channels as required.					

5.2. Enabling Mechanisms for Implementation

5.2.1. Institutional Arrangements

In TMDM, the establishment of a Climate Change Response Plan is a significant step towards adapting to the impacts of climate change. However, to effectively implement this strategy, it is essential to optimise the institutional arrangements within the municipality.

It is also crucial for the District Municipality to align the Climate Change Response Strategy with the various plans and policies of each department. This alignment will ensure that climate change goals are integrated into all aspects of municipal operations, and KPIs are linked to each department's responsibilities. For instance, the IDP, Spatial Development Framework, and Environmental Management Plan/Framework can incorporate targets and actions related to climate change.

Furthermore, having District and Municipal forums/ platforms that discuss and engage on climate change-related issues is an important step in mainstreaming climate change. This provides an opportunity to engage cross-departmentally, across different levels of government and across various stakeholder groups in order to foster knowledge-sharing and collaborative decision-making. It should be noted that there is an existing Environmental Management Forum, a Disaster Management Forum and a Wetland Management Forum.

In conclusion, optimising institutional arrangements for addressing climate change in the TMDM requires assigning clear responsibilities for each department and aligning the Climate Change Response Strategy with each department's plans and policies. This alignment will help to integrate climate change goals into all aspects of municipal operations and ensure that progress towards the goals is tracked and reported. By working collaboratively and leveraging the expertise, resources, and capacity of each department, the municipality can effectively address the impacts of climate change in the area.

5.2.2. Governance Considerations

It is recommended that the TMDM ensures that each department has clear responsibilities for addressing climate change and that those responsibilities are linked to key performance indicators (KPIs) to track progress towards climate goals. This can be achieved by aligning existing plans and policies with climate change goals and tracking progress towards those goals through specific KPIs. The Department of Economic Development and Strategic Services can align its plans, such as the Integrated Development Plan (IDP), Spatial Development Framework, and Local Economic Development Strategy, with climate change goals.

The department can also develop KPIs, such as the number of local businesses that have adopted sustainable practices or the amount of renewable energy generated in the municipality, to track progress towards climate goals. The municipality should prepare to respond to natural disasters, such as floods and wildfires, which are expected to increase in frequency and severity due to climate change. By aligning climate change goals with existing plans and policies and tracking progress through KPIs, municipalities can ensure that climate change is integrated into all aspects of municipal operations. This will help to ensure that the municipality is making progress towards a more sustainable future and is prepared to deal with the impacts of climate change.

5.2.3. Information Management

Implementing the climate change response plan in TMDM effectively necessitates the cultivation of a risk avoidance mindset among all stakeholders. This entails empowering officials, politicians, residents, and other participants through comprehensive education, training, and public awareness campaigns, underpinned by scientific research. By enhancing awareness and understanding of climate change impacts and responses, a sense of responsibility and ownership among stakeholders can be fostered.

To achieve this, the TMDM can undertake the following actions:

- Firstly, the municipality can develop and implement an integrated education and training programme on climate change and its impacts on the Municipality. This should be targeted at officials, politicians, and residents to ensure a common understanding of climate change and the importance of taking action.
- Secondly, the TMDM can use scientific research and data to inform education and training materials and ensure that stakeholders receive accurate and up-to-date information. This can also help identify critical risk areas and areas where action is most urgently needed.
- Thirdly, the municipality can promote public awareness campaigns on climate change and its impacts. This can be done through various channels, such as social media, community workshops, and public events. Such campaigns can help raise public awareness and understanding of climate change and the need for action, as well as provide practical guidance on steps individuals can take to mitigate their impact.
- Fourthly, the municipality can encourage participation in climate change mitigation and adaptation actions by residents, civil society organisations, and the private sector by providing opportunities for engagement and collaboration. This can include establishing partnerships with relevant stakeholders to develop and implement joint initiatives and providing resources and support to individuals and organisations that are taking action.
- Finally, TMDM can establish partnerships with academic institutions and research organisations to ensure ongoing access to the latest research and expertise in the field of climate change. This can help to ensure that the municipality is up-to-date with the latest

developments in the field and can leverage the latest knowledge and tools to inform its decision-making and actions.

By promoting a culture of risk avoidance and capacitating all role players, TMDM can create a supportive environment for effective climate change response plan implementation, ultimately helping to build a more resilient and sustainable District Municipality. This will require ongoing commitment and effort, as well as continued engagement with stakeholders to ensure that their needs and perspectives are reflected in climate change policies and initiatives.

5.2.4. Funding Mechanisms

Climate change is an increasingly pressing challenge for local municipalities in South Africa, and addressing it requires significant funding. Various funding mechanisms are available to support climate change response initiatives, including national and international grants, public-private partnerships, and municipal budgets. However, local municipalities may face issues such as insufficient funds, limited capacity to manage funds effectively, and limited access to funding sources.

One such mechanism is the Municipal Infrastructure Grant (MIG). The MIG provides funding to municipalities for the development of basic infrastructure such as water, sanitation, and solid waste management. The MIG can be used to fund climate change response projects that are related to these infrastructure needs. However, the MIG is limited in scope, and municipalities may struggle to fund all necessary climate change projects using this mechanism alone.

Another funding mechanism available to municipalities is the Green Fund. The Green Fund is a national funding mechanism that provides financing for green initiatives. The Green Fund can be used to finance projects related to renewable energy, energy efficiency, and climate change adaptation and mitigation. However, the Green Fund has limited resources, and there is significant competition for funding from other municipalities and organisations.

Municipalities can also access funding from international organisations such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF). These organisations provide financing for climate change response programmes in developing countries. However, accessing funding from these organisations can be challenging, as there are stringent requirements that municipalities must meet to be eligible for funding.

In addition to these funding mechanisms, municipalities can explore public-private partnerships (PPPs) as a means of financing climate change response programmes. PPPs involve collaboration between the public and private sectors to finance and implement infrastructure projects. PPPs can provide municipalities with access to additional funding sources, as well as 164 private sector expertise in project management and implementation. However,

municipalities must ensure that the terms of the partnership are equitable and that the private sector partner is committed to the project's goals.

There are several issues that municipalities may face when accessing funding for climate change response programmes. One challenge is the lack of technical expertise within municipalities to develop and implement climate change projects. This can make it difficult for municipalities to access funding from organisations such as the Green Fund, as these organisations often require detailed project proposals and technical expertise.

Another issue is the limited resources available to municipalities for climate change response. Many municipalities in South Africa are already facing significant financial constraints, and funding climate change response programmes may be seen as a lower priority than other basic service delivery needs. This can make it challenging for municipalities to allocate resources to climate change response programmes.

To overcome these challenges, municipalities should focus on building technical capacity in-house and forming partnerships with private sector organisations to access additional funding sources. Municipalities should also explore innovative financing mechanisms such as green bonds and crowdfunding, which have been successful in other jurisdictions.

In conclusion, funding mechanisms are available for local municipalities in South Africa to finance their climate change response programmes. However, municipalities must navigate a complex landscape of funding sources and ensure that they have the technical expertise and capacity to develop and implement successful projects. Municipalities can access the resources they need to build more resilient and sustainable communities by exploring innovative financing mechanisms and forming partnerships with private sector organisations.

5.3. Recommendations for mainstreaming

Mainstreaming climate adaptation within the TMDM necessitates a multifaceted approach that takes into account the current institutional structures, processes, and instruments within the district. This comprehensive strategy should aim to integrate climate-responsive thinking into all aspects of the municipality's work, making it a standard consideration rather than a separate concern.

1. Opportunities for Mainstreaming: There exist various opportunities for mainstreaming within TMDM. For instance, the District Development Model (DDM), with its integrated approach to planning and delivery across different spheres of government, provides an excellent platform for embedding climate adaptation into existing strategies. Climate adaptation considerations can be introduced into the joint "One Plan" approach that the DDM utilises.
2. Leveraging Existing Decision-making Structures: Existing decision-making structures, like the Project Management Unit (PMU), can be harnessed for climate adaptation. For example, the PMU's framework for assessing and approving projects can be updated to incorporate climate responsiveness/adaptation/sustainability, thereby ensuring that all new initiatives are climate-friendly.
3. Targeting Planning Instruments for Mainstreaming: Key planning instruments such as the Integrated Development Plan (IDP), Spatial Development Framework, and Local Economic Development Strategy can be targeted for mainstreaming climate adaptation. These documents can be revised to include climate evidence and adaptation actions.

Some specific mainstreaming recommendations include:

- Key Performance Indicators (KPIs): Climate response/adaptation/sustainability outcomes should be included in the KPIs of all departments, ensuring that progress towards climate goals can be tracked and measured.
- Raising Awareness: Conducting awareness training with groups like the Project Management Unit, Strategic Procurement, Councillors, and other relevant entities can facilitate mainstreaming. By improving their understanding of climate change and the need for adaptation, these groups can better integrate climate considerations into their work.
- Policy and Plan Updates: Existing policies and plans should be updated to reflect the climate risk profile and adaptation actions. This could include incorporating climate change considerations into land use plans, infrastructure development strategies, and emergency management plans.
- Funding: TMDM should explore existing and new revenue streams to support climate adaptation/response efforts. This could include applying for grants from government agencies, engaging in public-private partnerships, and incorporating climate adaptation into budget planning processes.

- Capacity Building: There is a need for ongoing training and capacity building of officials in all departments to enhance their understanding of climate change and their ability to incorporate climate considerations into their work.
- Establishing Networks or Partnerships: TMDM should consider establishing networks or partnerships with civil society organisations, the private sector, government, and other relevant entities to bolster climate adaptation efforts.

To conclude, mainstreaming climate adaptation in the TMDM requires a comprehensive, integrated approach that leverages existing structures and processes, builds capacity, and involves all stakeholders. By taking these steps, TMDM can ensure a more sustainable and resilient future for its people and the environment.

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