GREENBOOK
adapting settlements for the future

uMgungundlovu District Municipality

Climate Change Adaptation Plan: Draft 1

uMGUNGUNDLOVU
UMASIPALA WESIFUNDA
DISTRICT MUNICIPALITY
DISTRIK MUNISIPALITEIT

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Abbreviations

°C	Degree Celsius
AR5	Fifth Assessment Report
CABLE	CSIRO Atmosphere Biosphere Land Exchange model
CCAM	conformal-cubic atmospheric model
CDRF	Climate and Disaster Resilience Fund
CMIP5	Coupled Model Intercomparison Project 5
CoGTA	Department of Cooperative Governance and Traditional Affairs
CRVA	Climate Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DDM	District Development Model
DEA	Department of Environmental Affairs
DM	District Municipality
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EcVI	Economic Vulnerability Index
EnVI	Environmental Vulnerability Index
GCM	General circulation model
GRiMMS	Groundwater Drought Risk Mapping and Management System
GVA	Gross Value Added
GDP	Gross Domestic Product
ICT	Information and Communications Technology
IDP	Integrated Development Plan
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
km	kilometre
KZN	KwaZulu-Natal
l/p/d	Litres Per Person Per Day
LM	Local Municipality
MAR	Mean Annual Runoff
mm	millimetre
NDMC	National Disaster Management Centre
PVI	Physical Vulnerability Index
RCP	Representative Concentration Pathways
SCIMAP	Sensitive Catchment Integrated Modelling and Prediction
SDF	Spatial Development Framework
SEVI	Socio-Economic Vulnerability Index

SPI	Standardised Precipitation Index
SPLUMA	Spatial Planning and Land Use Management Act
THI	Temperature Humidity Index
UMDM	uMgungundlovu District Municipality
URP	uMngeni Resilience Project
WMAs	Water Management Areas
WMO	World Meteorological Organisation
WRYM	Water Resources Yield Model
WUI	Wildland-Urban Interface

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

The GreenBook was initially co-funded by the International Development Research Centre (IDRC) and the Council for Scientific and Industrial Research (CSIR), i.e., from 2016-2019, and in partnership with the National Disaster Management Centre (NDMC). With more partners coming on board since 2019 to support further research and development, and the roll-out and uptake of the GreenBook. More recently, Santam, the Climate and Disaster Resilience Fund (CDRF), and the CSIR established the GreenBook Roll-out Initiative to facilitate the uptake of the GreenBook and support resilience-building within local government. The initiative aims to roll out the GreenBook to 32 District Municipalities (DMs) by 2025 by supporting each District's climate change response and adaptation planning and implementation efforts through the GreenBook. Each of the Districts targeted for support is guided along a value-chain towards the implementation of climate change response and adaptation plans in municipalities (See Figure 1.1 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.

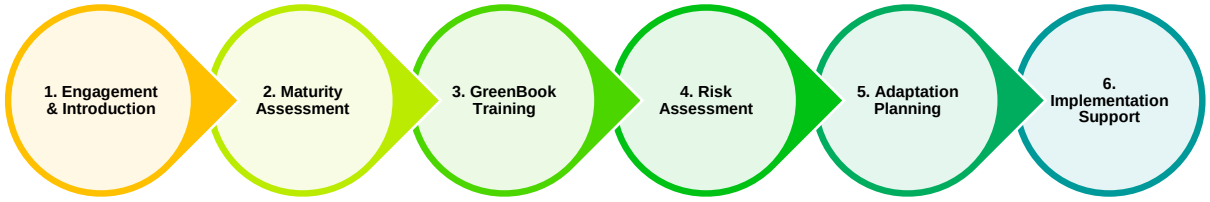

Figure 1: The value-chain towards the implementation of climate change response and adaptation in municipalities

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

uMgungundlovu District Municipality (UMDM) (DC22), situated approximately 80 km west of the eThekwini Metropolitan Municipality, is one of ten District Municipalities within the KwaZulu-Natal (KZN) Province. The district, central to the KZN Midlands, encompasses an area of roughly 9,603 km² and includes seven Local Municipalities: Msunduzi, uMshwathi, uMngeni, Richmond, Mkhambathini, Mpofana and Impendle. Its western border abuts the Kingdom of Lesotho, also encapsulating a portion of the uKhahlamba Drakensberg Park World Heritage Site.

UMDM, comprising both rural and urban areas, is home to 10% of the province's total population, with a population density of approximately 110 people per km² (UMDM, 2021; UMDM, 2022a). A significant portion of the district's populace resides in the Msunduzi Local Municipality. Key settlements in the district include Pietermaritzburg, the provincial capital and the district's seat, and smaller towns such as Howick, Nottingham Road, Mooi River, Wartburg, Impendle, and Richmond. The N3, a vital national transport corridor, intersects the district from the northwest to the southeast, linking KZN and Durban Harbour with the Free State and Gauteng, the country's industrial hub. The district also boasts a rich tourism industry and houses some of the province's premier schools (CoGTA, 2020).

UMDM contributes 10% to KZN's Gross Value Added (GVA) and 12% to its employment (CoGTA, 2020). The tertiary sector, encompassing community and personal services, trade, accommodation, finance and business services, along with transport, storage, communication, and government services, drives 69% of the district's economy. The secondary sector, predominantly manufacturing but also utilities and construction, contributes 23% to the economy. The primary sector, primarily agriculture and forestry, accounts for 7% of the economy (CoGTA, 2020; UMDM, 2022b). Roughly 33% of UMDM's land is agricultural, with commercial forestry primarily located in Richmond and uMshwathi Local Municipalities and, to a lesser extent, uMngeni Local Municipality (UMDM, 2017; UMDM, 2022a).

UMDM is distinguished by six significant rivers and five major dams, making it an area of strategic importance due to its rich water resources (DEA, 2018). These water bodies include the uMngeni River and the Mpofana River, among others. They provide crucial water supply not only to the local municipalities within UMDM, but also to eThekwini, an industrial and logistics hub.

This extensive water network, which provides for residential, agricultural, and industrial use, is a vital asset for the district's development and economy.

The major dams within the district include the Albert Falls Dam, Inanda Dam, and Nagle Dam, each playing a vital role in water storage, supply, and flood control. They not only provide a reliable source of water but also offer recreational opportunities, thereby contributing to local tourism. Combined with the district's fertile lands, these abundant water resources greatly enhance UMDM's agricultural production potential. The district's agricultural sector, which spans dairy, livestock, and crop farming, heavily depends on the availability of water. A significant proportion of the land within UMDM, about 33%, is used for agricultural purposes, including both subsistence and commercial farming.

The alignment of these factors - fertile land, abundant water supply, and a varied agricultural sector - contributes significantly to UMDM's economic stability and growth. As such, it elevates the district among the country's top areas for agricultural yield potential (CoGTA, 2020). It underscores the district's role not only as a significant contributor to the province's economy but also as a key player in the national food security network.

UMDM, however, faces numerous development challenges, as outlined in the UMDM Spatial Development Framework (SDF). These issues range from the pressures of urbanisation and the subsequent rise of informal settlements, to poverty, service backlogs, environmental degradation, and economic stagnation. The challenges further extend to the underinvestment in rural areas, particularly within traditional council territories, compounded by land issues and deteriorating infrastructure, most notably in urban centres (UMDM, 2022a).

Despite the district's strategic importance, owing to its abundant water resources, there exists a necessity for cautious and thoughtful management. Ensuring the sustainable use of these resources is imperative to mitigating any adverse impacts on water quality and quantity due to climate change and other anthropogenic activities. This pressing need highlights the importance of a well-informed and effective climate change adaptation strategy for UMDM, aiming to secure its vital water resources for future generations.

1.1.1. Key Risks

The climatic risk profile of UMDM is defined by four fundamental components, each driven by anthropogenic influences and escalating climate change:

- Drought;
- Heat stress;
- Wildfires;
- Severe weather; and
- Flooding.

The climate risk profile of the UMDM is driven by several fundamental components, all intensifying due to escalating climate change and anthropogenic influences. These include drought, heat stress, wildfires, severe weather events, and flooding. Importantly, these climate-related risks are interlaced with the district's developmental challenges - such as high population growth pressures due to increased migration to urban and peri-urban areas, and numerous vulnerable communities that heavily rely on natural resources. Therefore, integrating a climate change response into UMDM's planning and operations is of paramount importance.

UMDM faces a foreseen arid future brought about by more frequent droughts and extended dry periods, posing a serious threat to the district's water security. A predicted decrease in water levels across the district's reservoirs, rivers, and groundwater systems could have significant socio-economic and environmental implications. These are set to challenge the water supply vital for consumption, agriculture, and industry, especially given the large areas of the district supporting intensive farming and forestry activities.

Projected changes in climate patterns suggest that by 2050, UMDM will experience an additional seven days of extreme heat annually under a low mitigation scenario. These changes could make the district warmer and wetter until mid-century, but drier towards the end. This could catalyse the formation of urban heat islands, particularly in populated areas, exacerbating public health risks and increasing the vulnerability of the agricultural sector. Irregular rainfall patterns and extreme weather events could threaten crop productivity and livestock health, potentially intensifying poverty and food insecurity.

The threat of wildfires is also a significant climate risk for UMDM, especially in the context of anticipated dry conditions and high temperatures. Wildfires are common after dry winters when temperatures start rising, and summer rains are yet to arrive. They pose not only an immediate danger in terms of loss of life, property, and injury but also a long-term risk regarding poor air quality, ecosystem degradation, and soil loss.

Moreover, UMDM is vulnerable to flooding, with the potential for extreme rainfall events triggering flash floods and causing increased surface runoff, soil erosion, sediment yield in streams, and infrastructure damage. Urbanization, vegetation, and land degradation amplify these risks, as do anticipated climatic changes.

Finally, the district's rich biodiversity and diverse natural ecosystems are significantly impacted by these climatic changes. Shifts in temperature and precipitation patterns can disrupt habitats, causing changes in biodiversity and potential impacts on the crucial ecosystem services they provide.

Given this extensive climatic risk panorama, the development of robust adaptation and mitigation strategies is essential for the district's resilience and sustainability. Subsequent sections will delve deeper into these projected changes and their potential impacts, laying the groundwork

for a comprehensive climate change adaptation plan. This complex interaction between climatic and developmental risks necessitates a well-rounded approach to UMDM's climate change response.

1.1.2. Adaptation Goals and Priorities

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

- *To ensure water security in the face of climate change.*
- *To protect natural resources and ecosystems.*
- *To reduce the vulnerability and exposure of human and natural systems to climate change and extreme events.*
- *To increase the resilience of the agricultural sector.*

1.2. Outline of the Climate Change Adaptation Plan

The figure detailed below provides a schematic representation of the structure of the report, outlining the development process and constituent elements of the Climate Change Adaptation Plan for the District Municipality, informed by the GreenBook tool. The initial chapter delivers an overview of the GreenBook tool and a broad context of the District Municipality, alongside the identification of key climate risks. Chapter 2 proceeds to delve into the intricacies of the adaptation planning process, detailing stakeholder engagement and providing an understanding of the climate policy landscape. Chapter 3 elucidates the Climate Risk Profile tailored for the District Municipality, including an analysis of climate hazards, impacts, and prioritised risks and vulnerabilities. In Chapter 4, the focus pivots to the Adaptation Programmes, Actions, and key activities tailored for the District Municipality, underpinned by the identified goals, priority risks, and developmental priorities of the district. Chapter 5, the final segment, presents a robust framework for the execution of the adaptation programmes and actions, specifying the pivotal departments for implementation, cost estimates, priority levels, indicators, and timelines. Additionally, Chapter 5 proposes strategies for integrating climate change considerations into the District Municipality's operations, contemplating institutional arrangements, governance, information management, and funding mechanisms.

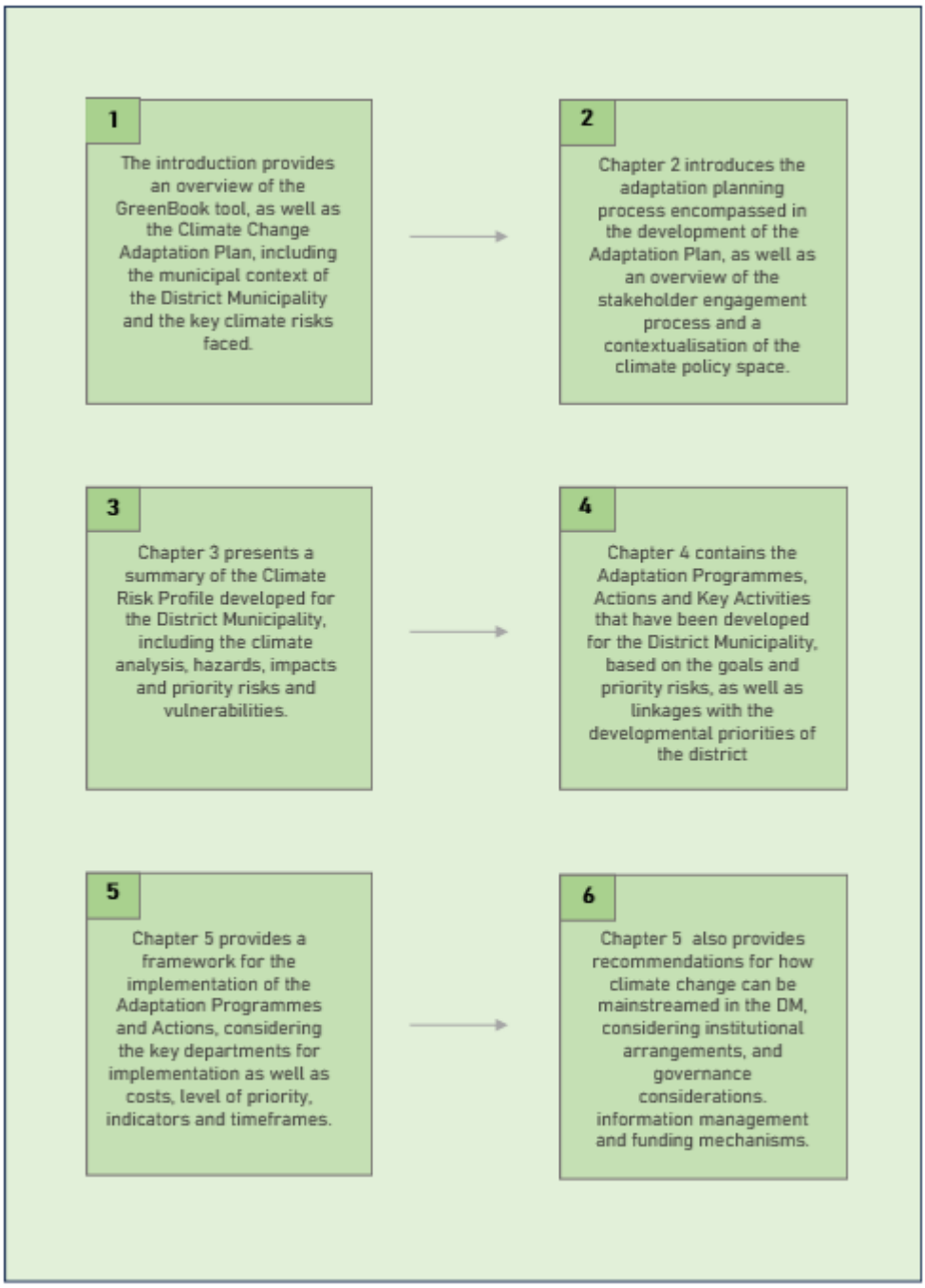

Figure 2: Outline of the Climate Change Adaptation Plan

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 UMDM 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

- Balancing the incremental costs with the municipal development objectives and the economic, environmental, and social benefits produced through integrated climate change response.

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

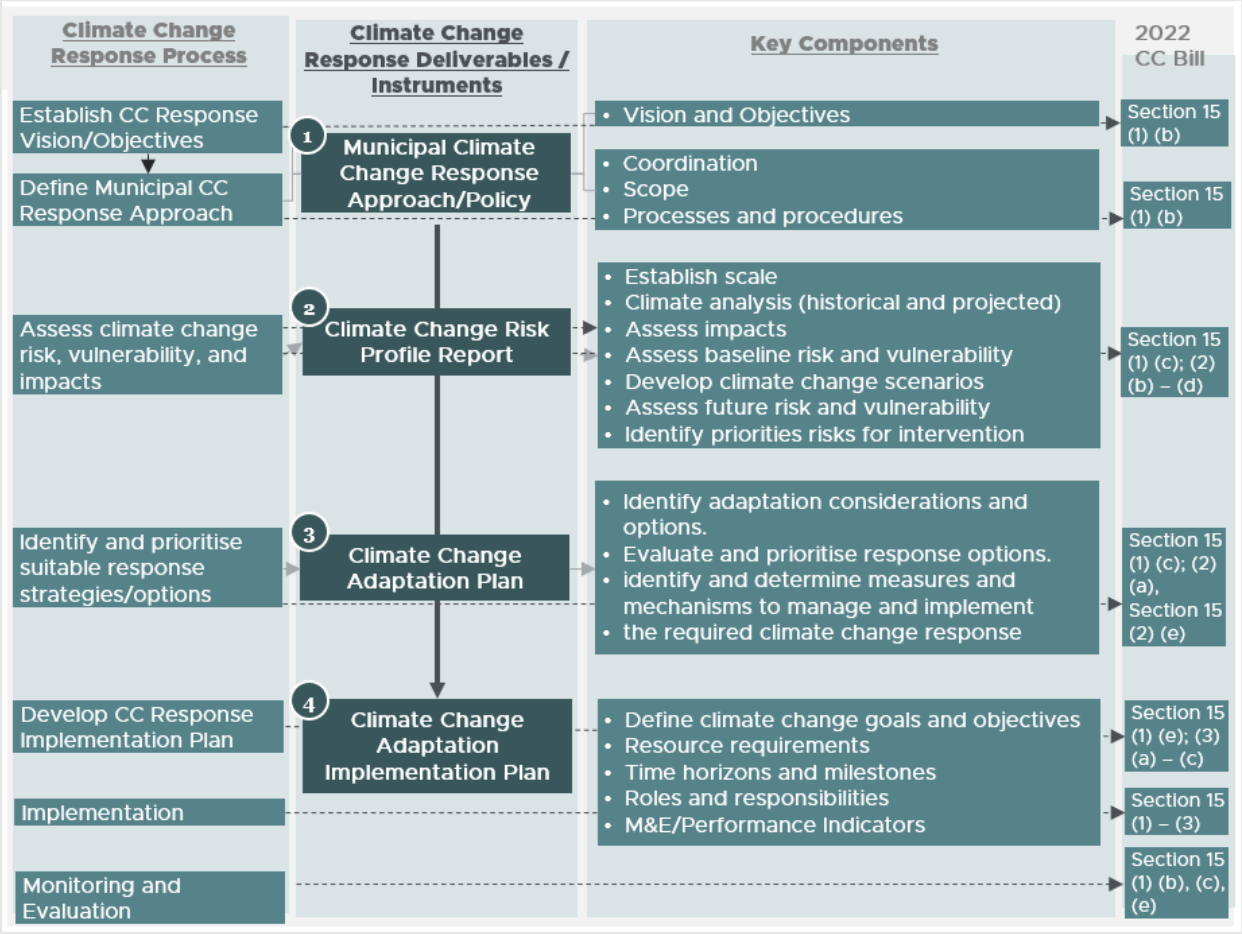

Figure 3: The municipal climate change response process (Brink and Modack, 2022).

Figure 3 illustrates the climate change response process proposed for the UMDM, 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 UMDM 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.

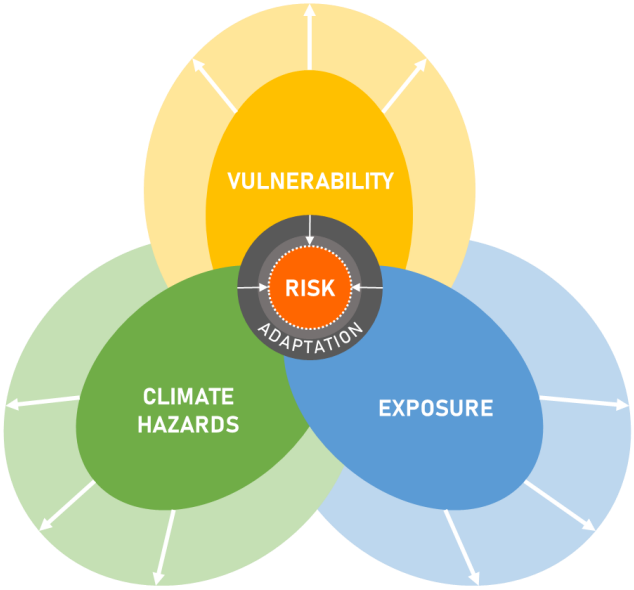

Figure 4: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021).

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 Table 2.

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

In constructing a Climate Change Adaptation Plan that aligns with the specific needs of the District Municipality and adeptly addresses its key risks, an integrated stakeholder engagement phase was incorporated into the adaptation planning process. This consolidated engagement framework was designed to be an efficient platform that seamlessly combines the Risk Profile Engagement and Implementation Engagement into one cohesive workshop. This workshop further allowed District Municipalities (DMs) to benefit from a capacity development module aimed at enhancing their proficiency in using the GreenBook tool. The engagement invitations were channelled to relevant DM departments including Environmental Management, Disaster Management, Spatial Planning, and Water and Sanitation, among others.

The condensed workshop format began with an interaction between the DMs and the CSIR, focused on the Risk Profile engagement. This phase was targeted at validating the primary risks

and vulnerabilities identified for the DM through the GreenBook Municipal Risk Tool, as outlined in the Risk Profile Report. A salient outcome of this engagement was the delineation of climate change adaptation goals, designed to confront the DM's significant risks and lay the foundation for the initial draft of the Climate Change Adaptation Plan.

Immediately following the Risk Profile validation, the Implementation Engagement was introduced within the same workshop. This segment showcased the preliminary Climate Change Adaptation Plan, encapsulating the Adaptation Programmes and Actions, providing the DM with an opportunity for review and commentary. The session also featured a presentation on the Implementation Framework crafted for the Adaptation Plan and included a discourse around the strategies for integrating climate change adaptation within the district.

Overall, the integrated stakeholder engagement workshop offered an efficient mechanism for interacting with District stakeholders, fostering a more nuanced understanding of the DM's context. The feedback received from these consolidated engagement processes has been carefully considered and subsequently incorporated 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 1: Summary of both international and national policy instruments relevant to climate change mitigation and adaptation.

International	
United Nations Framework Convention on	The UNFCCC is the primary multilateral global treaty governing actions to combat climate change through adaptation and mitigation efforts.

Climate Change (UNFCCC)	
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 Low-Carbon Economy"	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' ensuring environmental sustainability and an equitable transition to a low-carbon economy.
National Climate Change	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.

Adaptation Strategy (2020)	
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.

2.3.2. Desired Adaptation Objectives

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 UDM 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

The context of local policy within the UMDM has shown considerable engagement and commitment in addressing the prevailing climate-related challenges. Acknowledging that climate change is anticipated to result in the district becoming warmer and wetter, thereby exacerbating the risk of severe weather events, flooding, and droughts, the local government has put forward several initiatives. Importantly, they have secured funding from the United Nations for the uMngeni Resilience Project. This project aims to demonstrate, through four pilot initiatives, how communities can adapt to changing weather patterns that are expected due to climate change.

The UMDM has launched the project named "*Building Resilience in the Greater uMngeni Catchment*" (the uMngeni Resilience Project), backed by a generous fund of $7,500,000 from the Adaptation Fund. Spanning over five years (2015-2020), the project was implemented with the uMDM as the lead project partner and executing agency. Its implementation also involved the collaboration of the University of KwaZulu-Natal's School for Agriculture, Earth and Environmental Sciences (UKZN SAEES) and the South African National Biodiversity Institute (SANBI). The latter, along with the Department of Environmental Affairs (DEA), is responsible for project oversight and strategic direction.

Based on a consultative process and influenced by climate change vulnerability assessments, three areas have been selected as the primary focus of the project's interventions. These include Ward 8 of uMshwathi Municipality (Swayimane area), Ward 5 of Richmond Municipality (Nhlazuka

area), and parts of Ward 8, 7, and 39 of Msunduzi Municipality (Vulindlela area, previously only Ward 8 under the pre-2016 demarcation).

The uMngeni Resilience Project comprises four core components:

- Early warning systems: To ensure a proactive response to flood and fire, this project focuses on the timely dissemination of hydro-climatological and fire information and warnings to communities and disaster response officials.
- Climate-proof settlements: The project aims to strengthen and climate-proof 300 households and includes the construction of 10km stormwater drainage and the removal of 1000 ha of alien invasive clearing in Ward 5, Richmond LM.
- Climate-resilient agriculture: The project focuses on enhancing agricultural resilience by constructing a packhouse for 634 farmers from KwaSwayimani and investing in market access and a borehole to assist farmers during dry seasons.
- Capacity building and learning: This component encompasses conducting reflection workshops to learn and improve the project's implementation, and to facilitate the exchange of ideas and experiences.

In response to the identified need to respond to climate change, the UMDM drafted a District-level Climate Change Response Strategy. The strategy highlights several strategic priorities, including the development of early warning systems for fires and floods, risk monitoring and assessment, partnership building to augment the UMDM Disaster Management Department's capacity, waste management, and irrigation demand studies. Other strategies include the commission of studies and workshops to develop stormwater system criteria, ecological infrastructure awareness campaigns, audits of stormwater drain clearing contracts, dam and reservoir maintenance support for farmers, implementation of advanced warning systems, promotion of the Energy Efficiency Target (EET) within municipal buildings, the investigation into off-peak electricity usage by industries, the establishment of a relationship with Working for Water for alien invasive plant species control, consultation for optimizing bush clearing schedules, creation of a spatial information database from EIAs, and organization of a summit for tourist facility owners to discuss the changing weather and promote recycling, renewable power, and green initiatives within the tourism industry.

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 several 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 defence 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, 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 sync with worldwide developments, UMDM is facing the implications of climate change, which are anticipated to cause an increased severity and regularity of climate-related disasters in the forthcoming years. Understanding the enormity of this issue, the municipality has emphasized the critical need to boost resilience and protect its citizens, natural resources, economic activities, and livelihoods from the effects of climate change.

The subsequent sections offer a condensed review of climate vulnerability in UMDM and the high-priority risks and climate impacts which form the foundation for the identification of appropriate climate change adaptation measures.

3.3. Overview of Baseline and Future Climate Risk.

As part of the UMDM CC Adaptation Plan, a sophisticated methodological approach was taken to construct a comprehensive climate profile. This methodology hinges on the use of an ensemble of six General Circulation Models (GCMs) from the fifth phase of the Coupled Model Intercomparison Project (CMIP5). These models were instrumental in creating both baseline and future climate change scenarios, adhering to Representative Concentration Pathways (RCPs) 4.5 and 8.5. These RCPs provide a range of plausible future climate scenarios based on different concentrations of greenhouse gases and aerosols.

To improve the spatial granularity of these climate scenarios, the Conformal-Cubic Atmospheric Model (CCAM) was employed. This regional climate model enhanced the spatial resolution of the GCM projections from an initial resolution of 50 kilometres to a more precise 8-kilometre scale. The higher resolution allows for a more detailed representation of climatic variations across uMgungundlovu, better capturing the complex interactions of land, atmosphere, and sea across the diverse geography of the district.

The climate analysis within the UMDM CC Adaptation Plan covers two distinct timeframes. The first, referred to as the baseline period, spans from 1961 to 1990. This timeframe provides a reference climate against which future changes can be measured and understood. The second timeframe, the future period, extends from 2021 to 2050. By comparing these two periods, it is possible to discern projected trends and changes in climate variables, enabling the identification of potential vulnerabilities and the development of effective adaptation strategies.

This combination of sophisticated modelling tools, stringent climate scenarios, and clearly defined temporal scales provides a robust framework for assessing the potential impacts of climate change in uMgungundlovu. This framework lays a solid foundation for the development of the UMDM CC Adaptation Plan, geared towards promoting resilience and sustainability amidst a changing climate.

3.3.1. Climate Analysis

3.3.1.1. Average Temperatures

The climatic profile of the UMDM exhibits distinct variations in annual average temperatures, forming a marked east-west gradient. This characteristic is evident as temperatures range between a moderate 7 °C and a relatively warm 18 °C. The regions of uMshwathi, Msunduzi, and Mkambathini Local Municipalities, situated in the eastern part of the District Municipality, register higher annual averages. In contrast, the western mountainous regions, encompassing the Impendle and Mpofana Local Municipalities, exhibit cooler temperature patterns.

Future climate projections for the District Municipality outline an evolution of the thermal landscape, with anticipated shifts that will bring about a discernible rise in temperature. The temperature increases are projected to be between 2.3 °C and 3.1 °C across the District Municipality, indicating a substantial modification to the current climatic state of uMgungundlovu.

In this context, the rise in air temperature is expected to be ubiquitous across the District Municipality, signifying a prevalent trend towards warming. However, it is crucial to note that the increases might exhibit a degree of spatial variation. Specifically, the north-western regions of the Impendle Local Municipalities may witness relatively smaller temperature increments. This spatial heterogeneity in warming provides additional layers of complexity to the overall climate change narrative. In light of these projected changes, it is incumbent upon us to develop and implement effective adaptation and mitigation strategies to fortify the resilience of the UMDM in the face of future climatic uncertainties.

3.3.1.2. Rainfall

In the climatic narrative of the UMDM, precipitation features as a key protagonist, with average annual rainfalls currently oscillating between 1,300 mm and 2,500 mm. This figure, however, awaits confirmation from historical meteorological records. The District's geographical quilt showcases varying rainfall averages, with the south-western and north-eastern swathes registering higher precipitation levels. In contrast, the remainder of the District Municipality records a slightly moderated average rainfall, forming a delicate balance in the precipitation gradient across the area.

The prognostic models for the District's hydrological future sketch a fluid tapestry of change. They outline average annual rainfall alterations oscillating between a decrement of 104 mm and a potential increment of 165 mm by the year 2050. This is in the context of a low mitigation scenario that would allow for significant changes in the climate. The pendulum of these fluctuations leans towards higher rainfall in the eastern precincts of the District, suggesting a possible geographical shift in precipitation concentration.

Meanwhile, the western areas of the District Municipality display lower projected increases in rainfall, maintaining a semblance of the existing climatic patterns. The rest of the District Municipality is forecasted to experience less dramatic shifts in average annual rainfall, thus demonstrating a relative constancy amidst the wider environmental alterations.

This projected hydrological scenario underscores the need for thoughtful adaptation strategies. These must encompass the full spectrum of impacts on natural resources, infrastructure, and the socio-economic dynamics inherent to the UMDM, ensuring the sustainability and resilience of this dynamic and unique region.

3.3.2. Climate Hazards

A summary of the climate hazards is included below:

3.3.2.1. Drought

Under the prevailing (baseline) climatic conditions, the central interior of the uMgungundlovu District, stretching from the northern region of Howick in uMngeni Municipality into the Mpofana Municipality, exhibits higher susceptibility to drought compared to the district's southern and eastern parts. This encompasses regions such as the south-eastern parts of Richmond municipality, the majority of Mkhambathini Municipality, and the south-eastern peripheries of the uMshwathi Municipality, which comparatively register lower drought tendencies.

Projections for future climatic conditions portray a more pronounced prevalence of drought across the District, particularly in the central and northern areas. This climatic scenario implies that larger regions within the District, including the majority of Msunduzi Municipality, all settlements within the uMngeni Municipality, and the entirety of the uMshwathi Municipality, may face heightened drought risks. This trend demonstrates an emergent necessity for focused drought resilience efforts in these identified high-risk areas.

Conversely, certain regions of the District are projected to witness a decline in drought tendencies in the future. This includes small portions within the Impendle, Richmond, and Mkhambathini Municipalities. This observation underscores the spatially heterogeneous nature of drought risks within the District. It is a critical reminder that adaptation efforts need to be location-specific, with tailored strategies that align with the unique needs of different regions within the UMDM.

3.3.2.2. Heat

The analysis of thermal trends for the UMDM is critical to understanding the district's climate profile. We define "very hot days" as those when the maximum temperature at a GCM grid point exceeds 35°C. The present analysis considers the baseline (current) period of 1961–1990, and contrasts it with the projected changes for the future period of 2021–2050.

Under the baseline climatic conditions, the annual count of very hot days, numbering between 11 to 20, is pervasive across the entire stretch of the UMDM. This consistent manifestation of thermal extremes characterizes the present climate dynamic within the district.

Future projections suggest a minor increase in the number of very hot days across most parts of the District. The uptick is expected to be within a range of 0-2 additional days. However, specific areas along the district's north-eastern boundary and pockets in the north-western corner of Impendle and central Richmond are predicted to experience slightly higher increases, adding 2-3 more very hot days annually. These geographic nuances in heat augmentation underscore the varying degrees of thermal shifts across different regions within the District.

Heatwave events, on the other hand, are projected to maintain a level of uniformity across the District, barring a pocket located north of Albert Falls where the probability of such events is set to increase slightly.

With respect to heat stress risk, almost all settlements in the uMgungundlovu District fall into the low-risk category. Few isolated settlements, such as Richmond, Albert Falls, Wartburg, and Dalton, are categorised as being at very low risk. These findings offer valuable insights into the spatial distribution of heat-related risks across the District, forming a critical basis for tailoring location-specific climate adaptation and mitigation strategies. Moreover, the impacts of increased heat and drought could have significant repercussions on infrastructure, exacerbating issues related to resource availability and distribution.

3.3.2.3. Wildfire

In the uMgungundlovu District, wildfire risk is a potent and multidimensional issue. The analysis considers two primary components: the hazard presented by fire-ecotypes (encompassing the likelihood and severity of fires) and the socio-economic consequences, namely the potential for significant economic and social losses. The interplay of these factors determines the overall fire risk.

Under current conditions, a substantial proportion of settlements in the uMgungundlovu District are prone to wildfires at the wildland-urban interface. Areas particularly susceptible include large swaths of Pietermaritzburg within the Msunduzi Municipality, all settlements in the uMngeni Municipality (spanning Howick, Hilton, Lidgetton, Nottingham Road), all major centres

in the uMshwathi Municipality (Albert Falls, New Hanover, Wartburg, and Dalton), and the Hopewell area within the Richmond municipality. Richmond and Mooirivier settlements present a possibility, albeit not a certainty, for wildfire occurrences.

Looking ahead, projections suggest that the wildfire risk may escalate, leading to a moderate increase in hazard across most, if not all, of the aforementioned settlements. This anticipated amplification of wildfire risks underlines the urgent need for effective mitigation strategies and concerted efforts towards bolstering the resilience of these communities. An incisive understanding of these wildfire risks can facilitate the creation of tailored risk-reduction measures, contributing to a safer, more sustainable future for the uMgungundlovu District.

3.3.2.4. Flooding

The flood hazard assessment represents an intricate tapestry of information, converging various elements, including the prevailing climate, documented flood occurrences, and characteristics of the water catchments that contribute to their flood proneness. This multi-faceted approach allows for a more comprehensive and nuanced understanding of flood risks.

The heterogeneity of the flood hazard index across the UMDM is striking, spanning the spectrum from very low to very high. Most prevalent across this district are medium to very high probabilities, indicative of substantial flood risks in these areas.

Future projections sketch a diverse portrait of changing rainfall patterns across the District Municipality. Expectations range from moderate decreases to significant increases in the number of extreme rainfall days. The north-west and central area of uMshwati Municipality are anticipated to witness a diminishing trend in extreme rainfall days. Conversely, the southern areas, including the southern parts of Richmond and Mkhambathini, are projected to face potential significant increases in such events.

The envisaged shifts in rainfall patterns hold significant implications for the flood risk profile of the District Municipality. Therefore, the design and implementation of an effective flood risk management strategy are essential to safeguard communities and ensure the sustainability of socio-economic activities within the uMgungundlovu District.

3.3.3. Climate Impacts

3.3.3.1. Water Resources

Within South Africa, groundwater serves a pivotal role, propelling economic development and upholding water security. A multitude of rural and urban settlements partially or entirely rely on this critical resource. However, the availability and distribution of groundwater, being a natural resource, are considerably influenced by the capricious nature of climate variability and change.

uMgungundlovu District's water resources are a mosaic of surface and groundwater dependencies. Central to this system are the city of Pietermaritzburg, Howick, Hilton, and Mooirivier, which rely primarily on surface water. Conversely, the majority of the District's settlements have a hybrid water supply, depending on a combination of surface and groundwater. Dalton, in particular, is entirely dependent on groundwater.

In most areas within the District Municipality, groundwater recharge potential is significantly high. However, medium recharge potential zones exist, predominantly in the south-western swathes of the Impendle and Mkhambathini Municipalities. Future projections indicate a variance in recharge potential across the District. While vast areas may likely remain unchanged, minute sections may undergo a decrease, and the rest of the region may witness a marginal increase in projected recharge levels.

Groundwater depletion risk, though present, is constrained to specific settlements only. Predominantly, this risk is low, encompassing settlements such as Richmond, Hopewell (Richmond Municipality), Nottingham Road (uMngeni Municipality) Albert Falls, Wartburg, and Dalton (uMshwati Municipality). Two settlements face a heightened risk of depletion. The majority of settlements relying on groundwater, or a blend of ground and surface water, confront a low risk of groundwater depletion.

As seen below in the table, the evaluation of the current water supply vulnerability per local municipality portrays a distinct picture for each locality. Mpofana exhibits equal values for water demand and supply per capita (259.57 l/p/d), presenting a vulnerability index of 1. Impendle experiences a higher demand (136.46 l/p/d) compared to supply (100.55 l/p/d), indicating a vulnerability index of 1.36. No data is available for uMngeni. uMshwathi reports a higher demand (61.59 l/p/d) than supply (46.51 l/p/d), revealing a vulnerability index of 1.32. The Msunduzi shows a near parity in demand (242.57 l/p/d) and supply (224.93 l/p/d), with a vulnerability index of 1.08. In contrast, Richmond experiences a higher supply (122.31 l/p/d) than demand (104.36 l/p/d), denoting a vulnerability index of 0.85. Data remains unavailable for Mkhambathini.

Table 2: Current water supply and vulnerability across UMDM (based on the GreenBook Risk Profile Tool)

Local Municipality	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
Mpofana	259.57	259.57	1
Impendle	136.46	100.55	1.36
uMngeni	No data	No data	No data
uMshwathi	61.59	46.51	1.32
The Msunduzi	242.57	224.93	1.08
Richmond	104.36	122.31	0.85
Mkhambathini	No data	No data	No data

**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.*

These assessments underline the importance of strategic management and conservation of water resources in the uMgungundlovu District, given the climatic uncertainties and the intricate dependence on these resources for socio-economic well-being.

3.3.3.2. Sectors

In the economic landscape of the uMgungundlovu District Municipalities, the Agricultural, Forestry, and Fisheries sector assumes a notable position. The sector contributes a substantial 7% to the primary economic sector of the District.

There exists a promising potential for expansion within the District, given its favourable agro-climatic conditions. This could provide significant opportunities for the evolution and development of value chains, while concurrently stimulating job creation. Currently, the District Municipality's agricultural tableau is replete with a variety of commodities. Predominant among these are beef, milk, cream, sugarcane, citrus, and potatoes. These commodities form the bedrock of the District's agricultural output and are central to its socioeconomic structure.

However, the climatic projections for the area sketch a potentially challenging scenario for the sector. The region is likely to transition towards a hotter and wetter climate. This shift could generate both opportunities and threats for agricultural output and livestock management. In the short term, an increase in temperature and rainfall could potentially catalyze increased crop yields, particularly for sugarcane. On the other hand, the escalating heat stress could detrimentally impact the volume and quality of crops produced in the area.

Additionally, livestock would bear the brunt of the intensified heat stress, which could stunt growth rates and reproductive efficiency. Furthermore, the hotter and wetter conditions could cultivate a conducive environment for the proliferation and spread of parasites and diseases, threatening both crop production and livestock health. These prospective changes underline the necessity for proactive, strategic planning, and adaptive measures to maintain and enhance the sustainability and resilience of the Agricultural, Forestry, and Fisheries sector within the uMgungundlovu District.

3.3.4. Priority Risks and Vulnerabilities

3.3.4.1. 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 uMgungundlovu 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-the-national average for vulnerability. Scores are provided for both 1996 and 2011, where a lower score in 2011 compared to 1996 indicates an improvement and a higher score indicates worsening vulnerability. Trend data are only available for Socio-Economic Vulnerability and Economic Vulnerability.

Table 3: Vulnerability indicators across UMDM.

LOCAL MUNICIPALITY	SEVI 1996	SEVI 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
Mpofana	5.8	5.7	↘	3.9	4.5	↗	4.2	N/A	6.8	N/A
Impendle	6.8	7.6	↗	5.5	4.4	↘	4.8	N/A	9.4	N/A
uMngeni	4.0	3.6	↘	4.9	6.2	↗	5.0	N/A	7.1	N/A
uMshwathi	7.4	6.9	↘	7.2	4.8	↘	5.3	N/A	4.8	N/A
The Msunduzi	3.9	3.9	↘	5.4	6.3	↗	4.9	N/A	7.0	N/A
Richmond	6.9	6.8	↘	7.1	4.5	↘	5.2	N/A	3.7	N/A
Mkhambathini	10.0	9.4	↘	6.9	4.7	↘	4.3	N/A	3.2	N/A

Below are the profiles for each municipality within the uMgungundlovu District:

- Mpofana Municipality: This area displayed a slight decline in Socio-Economic Vulnerability Index (SEVI) from 5.8 in 1996 to 5.7 in 2011. On the contrary, the Ecological Vulnerability Index (EcVI) increased from 3.9 to 4.5 during the same period, indicating a growth in ecological vulnerability. Information regarding the Poverty Vulnerability Index (PVI) and Environmental Vulnerability Index (EnVI) was not available for analysis.
- Impendle Municipality: Socio-economic vulnerability in Impendle rose from 6.8 in 1996 to 7.6 in 2011, suggesting worsening socio-economic conditions. However, ecological vulnerability reduced from 5.5 to 4.4 during the same period, indicating improvement in the ecological health of the area. As with Mpofana, data for PVI and EnVI was not available.
- uMngeni Municipality: This area experienced a reduction in socio-economic vulnerability (SEVI), which dropped from 4.0 in 1996 to 3.6 in 2011. However, the municipality's ecological vulnerability (EcVI) increased from 4.9 to 6.2, indicating a need for increased attention to ecological health. Information for PVI and EnVI was not provided.
- uMshwathi Municipality: uMshwathi displayed a decline in both socio-economic (SEVI) and ecological (EcVI) vulnerabilities from 1996 to 2011. The SEVI decreased from 7.4 to 6.9, while the EcVI dropped significantly from 7.2 to 4.8, indicating some improvements in both socio-economic and ecological health. PVI and EnVI information was not available.
- Msunduzi Municipality: This municipality's socio-economic vulnerability remained stable at 3.9 between 1996 and 2011. However, ecological vulnerability increased from 5.4 to 6.3 over the same period, pointing to worsening ecological conditions. PVI and EnVI information was not available.
- Richmond Municipality: Richmond experienced a slight decline in socio-economic vulnerability (SEVI) from 6.9 in 1996 to 6.8 in 2011, while the ecological vulnerability (EcVI)

decreased notably from 7.1 to 4.5. As in other municipalities, PVI and EnVI data were not available.

- Mkhambathini Municipality: Mkhambathini's socio-economic vulnerability (SEVI) dropped from 10.0 in 1996 to 9.4 in 2011, while ecological vulnerability (EcVI) also decreased from 6.9 to 4.7. However, the relatively high SEVI suggests that socioeconomic challenges remain. Information regarding PVI and EnVI was not provided.

A major challenge in the District is the overwhelming prevalence of poverty (COGTA, 2020), and this is evident in the District's high average socio-economic vulnerability. Socio-economic vulnerability (SEVI) has remained high and fairly constant across all seven of the Local Municipalities within uMgungundlovu District (Table 2), from an average of 6.4 in 1996 to 6.3 in 2011. The only municipality to have shown a significant increase (worsening) in socio-economic vulnerability over these years was Impendle, the municipality with the largest population located in traditional authority areas. The Local Municipality the with highest socio-economic vulnerability in the District was Mkhambathini Local Municipality. In both 1996 and 2011, Mkhambathini Local Municipality had amongst the highest socio-economic vulnerability of all municipalities in the country due to its high rates of child-headed households, unemployment, poor healthcare and child mortality, low levels of literacy and education and high incidence of violent crimes. Impendle, uMshwathi and Richmond Local Municipalities also have notably high socio-economic vulnerability.

3.3.4.2. Settlement Vulnerability

The unique set of six (6) indicators listed below highlights the multi-dimensional vulnerabilities of the settlements within the Mopani District and its Local Municipalities.

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

Table 4: Anticipated settlement vulnerability.

Local municipality	Anticipated settlement vulnerability
Mpofana Local Municipality	• The major settlements in this Local Municipality are Rosetta and Mooi Rivier: – Mooi Rivier is the larger settlement in size and faces the greatest growth pressure combined with high economic and environmental vulnerability. – Rosetta faces the greatest vulnerability to low service access.

Impendle Local Municipality	• Impendle LM is made up largely of traditional settlements (home to 81.9 % of the population). Other settlements include the Impendle settlement and Cibelichle: – Cibelichle is faced with high growth pressure, together with high socio-economic and economic vulnerability. – The District also faces high environmental vulnerability. – The traditional areas are also faced with high socio-economic and economic vulnerability, together with low levels of service access and poor regional economic activity.
uMngeni Local Municipality	• The major settlements in this Local Municipality are Howick and Nottingham Road: – Nottingham Road has the poorest regional economic connectivity. – Howick has moderate service access vulnerability. – Both Howick and Nottingham Road face low to moderate growth pressure, socio-economic vulnerability and economic vulnerability.
uMshwathi Local Municipality	• The major settlements in this Local Municipality include Albert Falls, New Hanover, Wartburg and Dalton: – New Hanover faces large service access vulnerability combined with high growth pressure socio-economic vulnerability. – Albert Falls has one of the largest socio-economic vulnerabilities of settlements in the municipality. – Dalton faces poor regional connectivity. – Albert Falls, New Hanover and Dalton face high economic vulnerability.
Msunduzi Local Municipality	• The main settlement in the Msunduzi Local Municipality is Pietermaritzburg: – Pietermaritzburg also faces the greatest growth pressure, combined with high service access vulnerability.
Richmond Local Municipality	• Settlements in Richmond Municipality include Richmond town, Hopewell, Thornville: – Hopewell faces the greatest economic vulnerability combined with high environmental pressure and high socio-economic vulnerability. – Richmond and Thornville are faced with high growth pressure while the traditional areas (55.36% of the population) have the highest socio-economic vulnerability and poor regional connectivity.

Mkhambathini Local Municipality	• The major settlement in this Local Municipality is Camperdown, while 66.65 % of the population live in traditional areas: – Camperdown notably faces high growth pressure coupled with high service access vulnerability.

4. Climate Change Adaptation Plan

4.1. UMDM's Development Goals and the Linkage to Climate Change Adaptation

In alignment with the progressive spirit of sustainable development, the UMDM has instituted a Ten-Point Plan, outlining a multi-faceted strategy to address the district's unique challenges and bolster its development trajectory. Each point of this plan symbolizes a strategic initiative towards creating a resilient, sustainable, and inclusive municipality.

1. Metro: UMDM embarks on a meticulous, stepwise roadmap to foster a shared vision of a metropolitan area that is vibrant, productive, and harmonious.
2. Universal access to basic services: The district pledges to realize a state where every citizen has 100% access to fundamental services, including clean water, sanitation, electricity, and waste management.
3. Maintenance plan: UMDM is committed to developing a robust maintenance plan, ensuring the sustainable and reliable provision of essential services across all sectors.
4. Radical economic transformation: A cornerstone of the Ten-Point Plan is radical economic transformation, including the establishment of a functional Development Agency to facilitate economic growth and stability.
5. Community partnerships: The district advocates for the enhancement of community partnerships, leveraging the Expanded Public Works Programme (EPWP) and Co-operatives as conduits for socio-economic development.
6. Good governance: In the realm of governance, UMDM strives to sustain its achievement of a clean audit, thereby solidifying its commitment to accountability and transparency.
7. Sustainable intergovernmental relations (IGR): The district plans to create a structured Mayor's Forum, fostering sustainable intergovernmental relations and promoting synergistic governance.
8. Monitoring and evaluation: The district's performance and adherence to its strategic objectives will be continuously monitored and evaluated via the Service Delivery and Budget Implementation Plans (SDBIPs).
9. Special programmes: uMDM is committed to instituting special programmes designed to aid and uplift the district's most vulnerable communities, promoting social equity and inclusivity.
10. Achieving sustainable development and climate change mitigation: The district embraces an overarching goal of achieving sustainable development, seeking to incorporate climate change mitigation strategies that protect and preserve the natural environment for future generations.

In response to its key challenges, the district has adopted the seven Strategic Goals of the Provincial Growth and Development Plan (PGDP) i.e., Inclusive Economic Growth, Human Resource Development, Human and Community Development, Strategic Infrastructure, Environmental Sustainability, Governance and Policy, and Spatial Equity. Each goal is mirrored by UMDM's own strategic objectives, creating a symbiotic framework that nurtures district-specific growth and development while aligning with broader provincial and national development ambitions. Through the implementation of the Ten-Point Plan and the strategic alignment with the PGDP goals, UMDM is committed to bettering itself, promoting the welfare of its communities, and ensuring a sustainable future for all.

Table 5: UMDM's development goals and objectives.

UMDM's Development Goals	Link to Climate Change
Metro.	As UMDM embarks on a meticulous, stepwise roadmap towards our shared metropolitan vision, the role of climate change cannot be understated. Our urban planning incorporates strategies for reducing carbon emissions, increasing green spaces, and incorporating renewable energy sources, enabling us to create a vibrant, productive, and climate-resilient metro area.
Universal access to basic services.	UMDM's commitment to 100% access to essential services also serves as a strategy against climate change. Access to clean water, sanitation, electricity, and waste management is integral to building resilient communities that can adapt to climate change while minimizing environmental impact.
Maintenance plan.	Climate change will bring increased pressure on public infrastructure. Our robust maintenance plan considers these climate risks, ensuring sustainable and reliable provision of services under changing environmental conditions.
Radical economic transformation.	The establishment of a Development Agency focuses not just on economic growth but also on sustainable practices. This includes fostering green jobs, promoting renewable energy sources, and supporting climate-smart agricultural practices, all of which serve as potent responses to climate change.
Community partnerships.	Our partnerships with the Expanded Public Works Programme (EPWP) and Co-operatives integrate climate adaptation, mitigation, and resilience strategies. These partnerships provide a platform for climate-conscious community development and socio-economic empowerment.
Good governance.	Maintaining clean audit records also involves ensuring climate change adaptation and mitigation measures are properly financed and accounted for. This approach further

	underscores our commitment to sustainable and responsible governance.
Sustainable intergovernmental relations (IGR).	By fostering structured intergovernmental relations, UMDM aims to coordinate and harmonize climate change responses across different governmental levels, ensuring synergistic and effective climate action.
Monitoring and evaluation.	The commitment to monitoring and evaluating strategic objectives includes tracking the progress of our climate action plan. The Service Delivery and Budget Implementation Plans (SDBIPs) offer a robust framework for ensuring accountability in climate change responses.
Special programmes.	UMDM's special programmes aimed at uplifting vulnerable communities also take climate change into account. By ensuring social equity and inclusivity, these programmes enhance community resilience to climate-related shocks and stresses.
Achieving sustainable development and climate change mitigation.	UMDM is fundamentally committed to sustainable development and climate change mitigation. A climate action plan will include strategies to reduce greenhouse gas emissions, conserve biodiversity, and promote sustainable land and water use, working to protect and preserve our natural environment for future generations.

In conclusion, the development goals of the UMDM reflect a deep comprehension of the complex dynamics between climate change and socioeconomic development. The commitment to metropolitan development, universal access to basic services, radical economic transformation, and good governance, alongside the creation of special programmes for vulnerable communities, embodies a proactive, holistic approach to navigating this pivotal crossroad. The undeniable future challenges brought on by climate change will necessitate robust, strategic planning, but through this comprehensive ten-point plan, the UMDM is well-positioned to not merely withstand the impacts of a changing climate but to thrive amidst these transformations. The vision for a future where mitigation, adaptation, and resilience guide our path represents a firm commitment to creating a prosperous, healthy, and resilient district that exists in harmony with its environment, thereby viewing the climate crisis as an opportunity for growth, innovation, and resilience, rather than as a threat.

4.2. Climate Change Adaptation Vision

In the context of UMDM, mainstreaming climate resilience denotes the integration of key climate response principles within all facets of municipal planning, development, and operations. This approach could facilitate UMDM's adaptation goals, which include ensuring water security, protecting natural resources and ecosystems, reducing the vulnerability and exposure of human

and natural systems to climate change and extreme events, and increasing the resilience of the agricultural sector. In striving to achieve these goals, several practices within the UMDM could be considered:

- Climate-resilient infrastructure and settlements: UMDM 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.
- Preservation of natural resources and ecosystems: The conservation of UMDM's rich landscape, Critical Biodiversity Areas, and various conservation zones is key to the protection of natural resources and ecosystems. This strategy leverages the dual benefit of preserving biodiversity and promoting ecotourism, thereby enhancing the resilience of the local economy.
- Water conservation and efficiency: Given UMDM's goal of ensuring water security in the face of climate change, the municipality can expand its strategies around water conservation. This could involve enhancing public awareness campaigns, implementing advanced leak detection and repair mechanisms, and optimizing water metering and billing systems.
- Agricultural resilience: To bolster the resilience of the agricultural sector, UMDM 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 practices should be seen as potential elements of a more comprehensive approach, which could be complemented by additional strategies tailored to the unique context and needs of UMDM. The key to achieving these adaptation goals lies in the successful integration of these principles into all aspects of municipal decision-making and operations, as well as involving the community in these initiatives.

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

"A future where it leverages the three pillars of mitigation, adaptation, and resilience to transform into a community that proactively and holistically addresses the interconnected challenges of climate change while ensuring inclusive, sustainable development and steadfastly focusing on creating a prosperous, healthy, and resilient district thriving in harmony with its environment, viewing the climate crisis as an opportunity for growth, innovation, and resilience, rather than a threat."

This vision is committed to forging a future in which the UMDM, anchored in the three pillars of mitigation, adaptation, and resilience, transforms into a community that actively and comprehensively addresses the interconnected challenges of climate change. It is an aspiration centred on building a district that thrives in harmony with its environment while ensuring

inclusive and sustainable development and retaining a focus on crafting a prosperous and resilient community.

The objective is to guarantee the safety and prosperity of communities and the preservation of natural resources for future generations. The response to climate change will be characterized by innovative and cost-effective solutions that promote sustainable development and economic growth, viewing the climate crisis as an opportunity for growth and resilience, rather than a threat.

Achievement of this vision hinges on collaboration with stakeholders to ensure that climate change considerations are seamlessly integrated into the planning and decision-making processes. It is of paramount importance that all actions taken are guided by the latest scientific knowledge and best practices to construct a resilient and sustainable future for our municipality. To manifest this vision necessitates the development of a comprehensive suite of climate actions for UMDM that address climate risks, sustainability, adaptation, community safety and prosperity, natural resource preservation, innovation, collaboration, and resilience. The climate actions also promise co-benefits, advocating for equity and a just transition, while safeguarding the health and resilience of our people, natural resources, and economy.

4.3. Climate Change Goals and Programmes

The uMgungundlovu District Municipality (UDM) faces multifaceted climate risks, including extreme weather phenomena, flooding, wildfires, and droughts. These challenges are compounded by socio-economic pressures such as vulnerable communities heavily reliant on natural resources and a rapidly increasing population due to urban migration. These dynamics exacerbate UDM's vulnerability to climate-related hazards, thus reinforcing the necessity of climate change mitigation and adaptation strategies.

Climate change projections indicate that the UDM is likely to experience a warmer, wetter climate by mid-century, transitioning towards drier conditions by the century's end. Specific areas within the District may witness more extreme rainfall events, potentially resulting in increased flood risk if stormwater management is not adequately addressed. The expected increase in rainfall intensity and consequent flooding could escalate surface runoff, exacerbating soil erosion, sediment yield in water bodies, infrastructure damage, and water pollution.

Dry conditions coupled with high temperatures pose significant wildfire risk, particularly after dry winters when temperatures rise, and summer rains are yet to arrive. The enhanced risk of wildfires presents severe repercussions such as loss of life, property damage, health and safety risks, poor air quality due to smoke and ash pollution, and degradation of ecosystems.
Large portions of the District are characterised by intensive farming and forestry activities, while some regions under traditional authorities have communities highly dependent on natural

resources. An anticipated rise in drought risk will threaten water security and quality, and increase the agricultural sector's vulnerability. This change could intensify poverty levels and food insecurity.

To counter these climate risks, the following adaptive goals were put forward:

1. Ensure water security: Given the region's water scarcity challenges, it is crucial to devise holistic strategies for water resource management. This involves investing in efficient and innovative water infrastructure, prioritising maintenance, advocating water conservation practices, implementing rainwater harvesting systems, and exploring alternative water sources such as groundwater and wastewater reuse.
2. Protect natural resources and ecosystems: Emphasis should be placed on protecting and restoring natural ecosystems (e.g., high-priority biomes, wetlands, river ecosystems, riparian areas). Such actions bolster critical ecosystem services, enhance biodiversity, support water resource management, and provide natural buffers against climate-related hazards like wildfires.
3. Reduce vulnerability to climate change and extreme events: Adaptation strategies must prioritise the needs of vulnerable populations, including low-income communities and informal settlements. This involves improving access to basic services, enhancing housing conditions, and establishing early-warning systems. Effective flood management strategies and fire prevention measures, which might include improving stormwater drainage systems, restoring ecosystems, implementing advanced early-warning systems, and identifying areas for designated firebreaks, are also pivotal.
4. Boost agricultural resilience: With food security being a significant concern under future climate change impacts, a robust food security and agricultural policy that considers climate change impacts is essential. This strategy entails bolstering agricultural resilience by supporting commercial and small-scale farmers, promoting drought solutions such as highly efficient irrigation systems, exploring alternative crops, assessing livestock carrying capacity, and implementing effective grazing and fire management strategies.

The identification of adaptation actions followed a sequenced approach initiated by the outcomes of the UMDM 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.

Based upon the CC Risk Profile for UMDM, the Climate Change Adaptation Plan is framed by the following Adaptation Goals:

- *To ensure water security in the face of climate change.*
- *To protect natural resources and ecosystems.*

- *To reduce the vulnerability and exposure of human and natural systems to climate change and extreme events.*
- *To increase the resilience of the agricultural sector.*

The aforementioned list represents the proposed programmes, each meticulously designed to align with the broader climate change goals mentioned above, set to tackle climate-related challenges in a comprehensive and strategic manner in the UMDM:

1. An integrated approach to water augmentation, use, and management.
2. Protect and conserve water through monitoring mechanisms and water conservation and water demand management (WCWDM).
3. Enhancing water conservation awareness and education for sustainable water management in response to climate change.
4. Assessing the feasibility and sustainability of alternative water sources for climate change adaptation.
5. Implementing sustainable groundwater use and development strategy.
6. Conserve, protect and restore natural open spaces, ecosystems and natural resources.
7. Enhanced natural resource management and use of ecosystem services.
8. Integrate critical biodiversity areas and ecological support areas into the spatial framework.
9. Develop and implement a conservation and management plan for vulnerable species.
10. Integrated fire management for climate resilience.
11. Comprehensive stormwater and flood management programme.
12. Infrastructure resilience and public health education programme.
13. Identify and prioritise climate change risks and develop response measures for settlements.
14. Advancing towards a climate-smart circular economy.
15. Community-based adaptation in communities most at risk of climate-related hazards.
16. Climate-smart spatial planning for climate-resilient growth and development.
17. Enhanced climate-resilient agricultural practices.
18. Implementing innovative and climate-smart technologies for enhanced infrastructure and natural resource management.

4.4. Climate Change Goal 1: Ensure Water Security Under a Changing Climate.

Table 6: Climate change goal 1, desired outcome and linkage to UMDM's development priorities.

Goal:	Climate Change Goal 1: Guarantee Water Security in the UMDM in the face of changing climate conditions.
Desired outcome:	By 2030, UMDM has achieved sustainable water management, ensuring equitable, efficient, and reliable access to clean water for all residents, agriculture, and industry, irrespective of climate variations.
Linkage to UMDM's Development Priorities	1. Universal access to basic services: Achieving water security is fundamental to guaranteeing every citizen's access to clean water, a basic essential service. 2. Good governance: Water security requires transparent and accountable governance, fostering trust and participation from all stakeholders. 3. Maintenance plan: A robust maintenance plan for water infrastructure is key to ensuring sustainable water provision. 4. Metro: Water security is a prerequisite for a productive, vibrant metropolitan area, underpinning public health, industry, and agriculture. 5. Achieving sustainable development and climate change mitigation: Efficient water management and conservation are key components of sustainable development and can also contribute to climate change mitigation.

4.4.1. Rationale/Context

The UMDM heavily relies on an extensive network of rivers, dams, and groundwater resources for its water supply, an integral element to the district's economy, environmental health, and residents' well-being. However, the district's water sources are under significant threat. On one side, water quality in the area's rivers and dams is under duress due to nutrient loading, bacterial contamination, and the presence of pathogens from sewage and animal waste. This issue is magnified by the inadequate management of wastewater treatment and stormwater systems. Moreover, wetlands, crucial for water filtration and habitat conservation, are under severe threat from habitat conversion, invasive species, and contamination from fertilizers and insecticides.

Groundwater, a critical resource for the district's water security and economic development, faces a two-fold challenge. Although the district's groundwater recharge potential is generally high, future climate projections indicate variances in recharge potential, suggesting that some areas may face decreases in their recharge levels. Furthermore, although the risk of

groundwater depletion is generally low across the district, specific settlements face a heightened risk of depletion, adding to the complexity of the water security scenario.

Addressing these interconnected challenges requires a comprehensive, targeted, and scientifically informed approach to water management. In this regard, enhancing data collection on climate-related and other indices is crucial. As highlighted in the report, the sharing of data among institutions and departments is encouraged. The Department of Water and Sanitation should assist in sharing pertinent information, where possible, with the District and its B-Municipalities. This collaboration can significantly contribute to mitigating risks, securing the district's water future, and protecting its diverse ecosystems.

In conclusion, ensuring water security amidst a changing climate represents an imperative adaptation strategy directly impacting the district's resilience, development, and prosperity. By emphasizing water security within our climate adaptation framework, UMDM acknowledges the district's vulnerabilities and shows its commitment to safeguarding our communities' well-being and our environment's health, under the uncertain future dictated by climate change.

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.

The initial programme under the UMDM's climate change adaptation plan is labelled "*adopt an integrated approach to water augmentation, water use and water management.*" This programme directly addresses the multifaceted water-related concerns within the district in the context of climate change, presenting a comprehensive and synergistic plan for water resource management. The reasoning behind this programme stems from the interlinked climate predictions, environmental obstacles, and socio-economic factors that influence water availability and quality within the UMDM.

- Water-sensitive urban design (WSUD): In the face of intensified climate extremes, such as increased heatwaves and heightened flooding potential, implementing WSUD is vital for strengthening UMDM's resilience. WSUD principles advocate for sustainable usage and management of water in urban planning and design, recognizing water as a key component of urban ecosystems. The concept involves establishing urban landscapes and infrastructures that mimic natural water cycles, manage stormwater, conserve water, and reduce runoffs. Additionally, WSUD can mitigate water pollution by filtering runoffs before they enter water bodies, thus improving overall water quality.
- Addressing human resources constraints for effective water management: For successful climate change adaptation, effective water management, which hinges on a skilled and robust human resources pool, is essential. Tackling any human resources limitations within the district is critical to successfully implementing and managing the various initiatives

under this programme. Training and capacity building in water management, conservation, and climate change adaptation are vital for enhancing UMDM's ability to adapt to future climate-related water challenges.

- Review bulk water master plan: Given UMDM's ageing and strained water networks, it is vital to review the Bulk Water Master Plan. This review should account for projected increases in water demand due to urbanization and population growth, the potential effects of climate change, and the need for water security. Such a review can help identify necessary infrastructure upgrades or replacements and plan for potential expansions to meet growing demand.
- Developing a water safety plan (WSP): The proposed programme of developing a Water Safety Plan (WSP) involves a series of actions designed to ensure the safety and quality of the water supply. Building climate resilience into WSPs is strongly supported, as it is a key aspect of risk management. In addition to WSPs, this approach should also be extended to Wastewater Risk Abatement Plans (W^2RAPs), to ensure comprehensive water management safety across both clean and wastewater systems.

In conclusion, the rationale for this initial programme is to craft a holistic and future-oriented approach to water management in the UMDM, addressing the various challenges and vulnerabilities linked to climate change, pollution, and socio-economic factors. The ultimate goal is to secure a sustainable water future for the district, despite the changing climate.

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; To maintain water services efficiently, the District 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: Asses feasibility of capturing and re-use of stormwater. • Educating and engaging stakeholders: Promote awareness of the benefits of WSUD and to 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 and 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 should 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: This action involves assessing the risks that can affect the quality and safety of the water supply, including natural hazards and man-made threats. Both the WSPs

	and W²RAPs should take into account the potential impact of climate change on water and wastewater systems. • Determining control measures: Identifying control measures that can be implemented to reduce risks and enhance the safety of the water supply and wastewater systems, such as disinfection, filtration, and monitoring. • Developing an emergency response plan: This action includes the development of a plan for responding to incidents that could affect the water supply or wastewater systems, such as natural disasters or system failures. This plan should consider climate change-induced events, ensuring the systems' resilience. • Implementing monitoring and reporting: Establishing a monitoring programme to ensure that the water supply and wastewater systems remain safe and of good quality. The results of monitoring should be reported to relevant authorities and stakeholders. • Training and educating staff: All staff involved in the water supply and wastewater systems should be trained on WSP and W²RAPs development and implementation, including risk assessment, control measures, and emergency response. • Reviewing and updating the plans regularly: Both WSPs and W²RAPs should be reviewed and updated periodically to ensure they remain relevant and effective in addressing emerging risks and challenges, including those related to climate change.

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 UMDM. 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 UMDM's water resources, as described in the district's environmental profile.

- Implementing monitoring mechanisms and reducing pollution: Given the serious water pollution challenges within UMDM, particularly impacting the likes of Midmar Dam, Springgrove Dam, and the uMsunduzi River, rigorous monitoring mechanisms are essential. These mechanisms 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: A regular testing schedule will be implemented to keep track of the health of water sources and identify potential pollution sources. It is important to stress that Water Waste Treatment Works (WWTWs) should be meticulously managed and maintained so that discharges meet the required standards, and all WWTWs should possess the necessary water use authorisations. This supports the district's mandate of providing and maintaining efficient and sustainable water services and necessitates compliance with the conditions of said authorisations. • Buffer zone establishment: The creation and management of buffer zones around water sources, such as rivers and wetlands, will protect them from pollution. The design of these zones should prevent runoff from agricultural and urban areas from entering the water sources, strengthening the district government's role in coordinating and integrating water management efforts.

	• Sustainable agricultural practices promotion: Awareness campaigns, training, and capacity-building programmes will be facilitated to encourage farmers to adopt environmentally friendly fertilisers and pesticides. Exploring the feasibility of agrivoltaic agriculture for the area could also be a potential research topic for academic institutions. These initiatives align with the provincial government's mandate of developing and implementing plans and programmes for the sustainable use of water resources. • Effluent discharge regulation: By-laws and regulations will be developed to control the discharge of industrial and domestic effluent into municipal sewer systems. A sufficient budget must be allocated for routine maintenance as well as emergency (reactive) maintenance of the sewer network and associated infrastructure to minimise sewer spills into the environment. Regular monitoring of industries will ensure compliance, bolstering the district's mandate of ensuring activities do not negatively impact water resources. • Responsible waste disposal advocacy: Facilities for the disposal of hazardous waste will be provided, and public awareness campaigns on the importance of responsible waste disposal will be intensified. These efforts will help mitigate the risk of water source pollution and align 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 and in 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 and rivers.	• Stakeholder collaboration and equitable contribution: Recognising that catchment areas, especially those affected by alien vegetation encroaching into river systems, might fall outside UMDM boundaries and that various water users utilise it, there is an essential need to collaborate with all stakeholders. Equitable contributions from all parties to manage and enhance water security in these catchments should be determined and facilitated. • Identifying, mapping, and monitoring invasive species: A comprehensive survey of invasive species within the catchment areas, particularly focusing on alien vegetation encroaching into river systems, should be conducted in partnership with relevant stakeholders. This step involves identifying, mapping, and continuously monitoring the areas affected by invasive species. • Removal and control of invasive species: This includes the collaborative removal and control of invasive species, particularly those posing a threat to water security, using various techniques such as mechanical, chemical, and biological control methods. Such an approach should be supported by contributions from all stakeholders. • Rehabilitation of cleared areas: After the successful removal of invasive species, the cleared areas need to be rehabilitated. This can be accomplished through the restoration of indigenous vegetation and the implementation of erosion control measures, effectively enhancing water security in river systems. • Education and awareness: Alongside practical actions, education and awareness campaigns can be implemented in coordination with stakeholders. The aim of these campaigns is to increase understanding of the negative impacts of invasive species on catchment areas, especially concerning water security, and to promote responsible behaviour in preventing the spread of invasive species. • Monitoring and evaluation: The effectiveness of invasive species control measures, and their impact on water security, can be monitored and evaluated in partnership with stakeholders. This ensures the long-term sustainability of the project and allows for assessing the contributions and impact of each stakeholder in enhancing water security.
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: Enhancing Water Conservation Awareness and Education for Sustainable Water Management in Response to Climate Change

As climate projections suggest more frequent periods of water stress due to increased temperature and reduced rainfall for UMDM, it's of paramount importance that the district enhances water conservation awareness and education. This programme is aimed at improving the community's understanding of climate change impacts, particularly the significance of sustainable water management and its role in mitigating these impacts. It's grounded in the belief that an informed and engaged community is pivotal to achieving long-term water security in UMDM in the face of climate change.

Key actions under this programme are:

- Developing water conservation education programs: Educational programs can be designed to increase community awareness about the importance of water conservation and sustainable water management practices. Workshops, community outreach, and public campaigns can be used to relay information about the benefits of water conservation, water-saving techniques, and the long-term impact of these actions on water availability and quality.
- Promoting water conservation in households: This can involve providing households with practical guidance and tools to reduce water consumption. For example, educational materials can be distributed to homeowners about water-efficient appliances, low-flow showerheads and toilets, rainwater harvesting systems, and greywater recycling.
- Encouraging businesses to implement water-saving measures: Businesses can be encouraged to reduce their water footprint through a combination of guidance, support, and incentives. This might involve workshops for businesses on water-efficient practices, providing recognition or incentives for businesses that achieve significant water reductions, and promoting the use of water-efficient technologies in industrial processes.
- Conducting research on water conservation: To ensure the effectiveness of these efforts and adapt to changing circumstances, it is important to conduct regular research on water conservation. This can involve investigating the impact of existing conservation measures, identifying barriers that prevent or hinder water conservation, and exploring innovative approaches and technologies for water conservation.

Through these actions, the *"Enhancing water conservation awareness and education for sustainable water management in response to climate change*" programme seeks to build a culture of water conservation among residents and businesses in UMDM, helping the region become more resilient to the predicted impacts of climate change.

Table 9: Programme 3 - Enhancing water conservation awareness and education for sustainable water management in response to climate change.

Programme 3: Enhancing Water Conservation Awareness and Education for Sustainable Water Management in Response to Climate Change.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Developing water conservation education programs. *(The programs can include activities such as workshops, community outreach, and public campaigns to promote the benefits of water conservation and the importance of sustainable water management)*	• Conducting a needs assessment: This involves identifying the target audience, understanding their knowledge level, attitudes, and behaviours related to water conservation, and identifying the gaps that need to be addressed. • Developing educational materials: This involves creating educational materials, such as brochures, pamphlets, posters, and videos that effectively communicate the importance of water conservation and offer practical tips on how to save water. The materials should be designed to appeal to the target audience and be culturally appropriate. • Conducting education and outreach activities: This involves organizing events and activities, such as workshops, seminars, public presentations, and social media campaigns, to promote water conservation and distribute educational materials to the target audience. • Partnering with community organizations: This involves collaborating with community-based organizations, such as schools, churches, and community centres, to disseminate educational materials and raise awareness of water conservation. • Evaluating the effectiveness of the program: This involves collecting data to measure the impact of the education program on knowledge, attitudes, and behaviours related to water conservation. This data can be used to refine the program and make it more effective.
Promoting water conservation in households.	• Developing and distributing educational materials: This involves developing materials such as brochures, posters, and pamphlets that provide tips and guidelines on how to conserve water at home. These materials can be distributed to households, community centres, and other public places to promote water conservation. • Providing incentives for water conservation: Providing incentives such as rebates for installing water-efficient devices and appliances can encourage households to adopt water

	conservation practices. This can include rebates for low-flow toilets, showerheads, and faucets. • Conducting water audits: Water audits involve identifying and fixing leaks, as well as identifying areas where water can be conserved. Households can conduct their own water audits or seek the assistance of trained professionals. • Encouraging the use of rainwater harvesting systems: Rainwater harvesting involves collecting rainwater and using it for non-potable purposes such as watering plants and flushing toilets. This can help households reduce their reliance on potable water for non-potable uses. • Implementing water-efficient landscaping: Water-efficient landscaping involves planting drought-resistant plants and using irrigation systems that deliver water directly to plants' roots. This can reduce the amount of water needed to maintain a garden or lawn. • Providing training and workshops: Providing training and workshops on water conservation can help households learn about the importance of water conservation and how to implement water conservation practices in their daily lives. • Engaging community leaders and stakeholders: Engaging community leaders and stakeholders in promoting water conservation can help to build momentum and increase participation in water conservation efforts.
Encouraging businesses to implement water-saving measures. *(This can include providing support and guidance on water-efficient practices, offering incentives for businesses to reduce water consumption, and promoting the use of water-efficient technologies)*	• Conducting water audits to identify areas where water savings can be made. • Developing and distributing guidance material to help businesses implement water-saving measures. • Providing financial incentives, such as rebates or tax credits, for businesses that implement water-saving measures. • Working with industry associations to promote water conservation practices and encourage member businesses to take action. • Conducting outreach and education programs to raise awareness among businesses about the importance of water conservation and the benefits of implementing water-saving measures. • Providing training and technical assistance to help businesses implement water-saving measures effectively. • Collaborating with large water users, such as industrial facilities, to develop customized water-saving plans and targets.
Conducting research on water conservation. *(Research can include investigating the effectiveness of water*	• Conducting studies on the water usage patterns of different sectors, including households, agriculture, and industry, to identify areas where water conservation measures can be implemented.

conservation measures, identifying barriers to water conservation, and exploring innovative approaches to water conservation)	• Developing and testing new technologies and practices that promote water conservation, such as efficient irrigation systems, water recycling and reuse, and rainwater harvesting. • Analyzing the economic, social, and environmental impacts of water conservation initiatives, to help decision-makers prioritize and implement effective conservation strategies. • Evaluating the effectiveness of existing water conservation programs, and identifying opportunities for improvement. • Collaborating with other stakeholders, such as government agencies, academic institutions, and non-governmental organizations, to share knowledge and best practices related to water conservation. • Conducting public outreach and education campaigns to promote awareness of the importance of water conservation, and to encourage individuals and organizations to take action to conserve water. • Monitoring and evaluating the implementation and impact of water conservation programs, to ensure that they are achieving their intended goals and objectives.

4.4.4. Programme 4: Assessing Alternative Water Sources

As the climate change projections for UMDM suggest increased temperature and reduced rainfall, water scarcity could become a more pressing issue. To ensure a reliable and sustainable water supply, the programme of "*assessing alternative water sources*" has been designed to identify, develop, and utilize alternative water sources. The rationale of this programme is grounded in the understanding that reducing dependence on a single water source and diversifying the water supply portfolio can enhance resilience to climate change impacts.

Significant water resources within the Mvoti to Umzimkulu Water Management Area, where the Umgungundlovu District Municipality is located, were classified and Resource Quality Objectives (RQOs) were set in 2016. This process not only defined the necessary level of protection for these water resources but also provided information on the Present Ecological State (PES) and the Recommended Ecological Category (REC) of the resources, which will be key in informing the actions of this programme.

Key actions under this programme include:

- Water resource management planning: This entails a comprehensive analysis of the district's water resources, determining current and future demand, and assessing how this demand can be met through a mix of traditional and alternative water sources. In this planning, both the quantity and quality of available water resources are considered. The classification reports will substantially support this information collation.

- Investigating alternative water sources: The identification of potential alternative sources of water is crucial for diversification. These can include the extraction of groundwater and the reuse of treated wastewater. The feasibility of each source, considering economic, environmental, and social factors, needs to be evaluated.
- Investing in alternative water sources: After identifying feasible alternative water sources, the development of necessary infrastructure and technology for the extraction, treatment, and distribution of these water sources will be undertaken. This could involve drilling new boreholes for groundwater extraction and upgrading wastewater treatment facilities to enable wastewater reuse.
- Developing and implementing a treated effluent reuse strategy: Wastewater reuse can be a viable alternative water source, especially for non-potable uses such as irrigation, industrial processes, and toilet flushing. A comprehensive strategy can provide guidelines for the treatment, distribution, and usage of reclaimed water, ensuring its safe and efficient utilization.

Over time, the proposed water quality monitoring will highlight hotspot areas, aligning with the Classification Study's indications. Therefore, it is pivotal to develop water quality recovery plans to improve water quality in the identified nodes/areas. Through the implementation of these activities, the "*assessing alternative water sources*" programme aims to enhance UMDM's resilience to climate change-induced water scarcity, fostering sustainable water management in the face of changing environmental conditions.

Table 10: Programme 4 - Assessing the feasibility and sustainability of alternative water sources for climate change adaptation.

Programme 4: 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: Develop 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 extract, treat, and distribute these water sources. This may include drilling new boreholes, and*	• 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 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.

upgrading wastewater treatment facilities).	• 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 UMDM. • 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 5: Groundwater Management

In South Africa, groundwater serves as a cornerstone for economic development and water security, supporting both rural and urban settlements either partially or fully. However, climate variability and change can significantly affect the availability and distribution of this natural resource. The UMDM water resources comprise both surface and groundwater dependencies. While the cities of Pietermaritzburg, Howick, Hilton, and Mooirivier primarily rely on surface water, most of the District's settlements have a mixed water supply, relying on both surface and groundwater. In particular, Dalton depends entirely on groundwater.

Given the significance and vulnerability of groundwater resources in the face of climate change, the implementation of a sustainable groundwater use and development strategy is paramount for the UMDM. This approach will not only adapt to the impacts of climate change but also ensure the sustainability of groundwater resources, thereby securing the continued supply of safe water for the community. Specific actions under this strategy would include sustainable extraction practices, rigorous monitoring of groundwater levels, recharge potential, and quality, as well as community education about the importance of groundwater conservation.

The UMDM exhibits varied recharge potentials, with the majority of the region showcasing significantly high groundwater recharge potential. However, medium recharge potential zones exist, particularly in the southwestern areas of the Impendle and Mkhambathini Municipalities. Future projections indicate diverse changes in recharge potential across the District. While many areas might remain unchanged, some sections might experience a decrease, and others

may witness a marginal increase in projected recharge levels. The risk of groundwater depletion is present but confined to specific settlements, predominantly at a low-risk level. However, two settlements face a heightened risk of depletion. Assessing the risk and implementing management strategies is crucial to maintain this essential resource.

Each locality within UMDM has a unique water supply vulnerability. Implementing the sustainable groundwater use and development strategy will be crucial in localities with a higher vulnerability index, such as Impendle and uMshwathi, to secure future water supply and reduce the vulnerability of these areas to climate change impacts.

Table 11: Programme 5 - Implementing sustainable groundwater use and development strategy.

Programme 5: 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 UMDM 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 UMDM 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 efficiency by encouraging the adoption of water-saving technologies and practices in all sectors.	• Encourage water conservation pricing mechanisms, such as tiered water rates, incentivise water users to reduce their water 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 UMDM 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: Protect Natural Resources and Ecosystems.

Table 12: Climate change goal 2, desired outcome and linkage to UMDM's development priorities.

Goal:	• Safeguard the Natural Resources and Ecosystems of UMDM, enhancing their capacity to thrive amidst changing climate conditions.
Desired outcome:	• By 2030, UMDM's natural resources and ecosystems exhibit robust health and resilience. They provide vital services, sustain biodiversity, and contribute to the region's socioeconomic well-being and environmental sustainability.
Linkage to UMDM's Strategic Objectives	1. Achieving sustainable development and climate change mitigation: Protecting natural resources and ecosystems is essential for sustainable development and aids in mitigating climate change impacts. 2. Universal access to basic services: Ecosystem services play a fundamental role in providing clean water and managing waste, contributing to citizens' access to basic services. 3. Good Governance: Effective protection of natural resources and ecosystems requires accountable and transparent governance. 4. Maintenance plan: The maintenance and management of natural resources and ecosystems is a key part of any plan to ensure sustainability. 5. Metro: A healthy natural environment contributes to making the metropolitan area vibrant and harmonious.

4.5.1. Rationale/Context

Biodiversity, comprising the richness and variability of life on earth, forms the basis of ecological infrastructure that provides essential services such as water, air, and food. Yet, this foundational cornerstone of sustainable human existence is under significant threat in the UMDM, located in the critical Maputaland-Pondoland-Albany hotspot. The UMDM forms a significant portion of the KZN Midlands, one of the most diverse corridors in the region. Despite the region's ecological significance, its rich biodiversity is fast depleting due to various factors. Therefore, the strategic priority to "Protect Natural Resources and Ecosystems" is a crucial component of the climate adaptation report for UMDM.

The urgency to prioritize this strategic action arises from the alarming rate of natural habitat loss in the region. According to the National Biodiversity Assessment (2011), if current rates persist, almost no natural habitat will remain outside protected areas in KZN by 2050. UMDM is home to critical ecological features, including high-yield water catchment areas and the

uKhahlamba Drakensberg Park World Heritage, a Ramsar Site. These features are vital for ecosystem functioning and the continued provision of ecosystem services.

The primary causes for biodiversity loss within the UMDM encompass habitat transformation due to expanding residential and commercial facilities, transformation for agriculture and forestry, overexploitation of species, the spread of invasive alien species, and land degradation. Approximately 45% of UMDM has already transformed due to agriculture and forestry, with only 13% of the remaining natural vegetation formally protected. Furthermore, invasive alien species pose an imminent threat to indigenous biodiversity and socio-economic aspects, including water security and agricultural land productivity.

For these reasons, prioritizing the protection of natural resources and ecosystems is not just an ecological necessity, but also a socio-economic imperative. The health and resilience of UMDM's ecosystems are directly linked to the district's capacity to adapt to climate change and ensure the livelihoods of its communities. Hence, a strategic focus on conserving and restoring natural ecosystems, managing land sustainably, and promoting biodiversity is key to safeguarding the district's ecological infrastructure and the essential services it provides. By taking these actions, UMDM can build a resilient, sustainable future in the face of an ever-changing climate.

4.5.2 Programme 6: Conserve, Protect and Restore Natural Open Spaces, Ecosystems with Climate Change Adaptation Benefits

With the ongoing climate dynamics in UMDM, the strategic priority "*conserve, protect, and restore natural ecosystems and biodiversity with climate change adaptation benefits*" is a key facet for a resilient future. It acknowledges the considerable risks posed by climatic variations, including drought, heatwaves, and invasive species, on the district's diverse ecosystems, and emphasizes their conservation, protection, and restoration. This approach is geared towards capitalizing on these spaces' inherent ability to sequester carbon, buffer against severe weather, and provide crucial habitats for various species.

The first critical action under this priority is the comprehensive assessment of natural resources, ensuring the conservation, protection, and restoration of ecosystems and biodiversity. This will involve consistent monitoring and scientific analysis of the health of these spaces, including the high-yield water catchment areas, the section of the uKhahlamba Drakensberg Park World Heritage site within the district, and the district's various endangered ecosystems. This evaluation will pinpoint critical biodiversity areas needing urgent protection and will delineate environmental corridors to be maintained for species adaptation and migration.

The second action concentrates on harnessing the potential of natural spaces to mitigate the impacts of climate change. This will necessitate strategic management of these spaces to

enhance their carbon sequestration potential and their capacity to buffer against extreme weather events. Initiatives could include reforestation, restoration of grasslands affected by communal grazing, and combating the spread of invasive species such as Wattle, American Bramble, Lantana, and Triffid Weed, which threaten indigenous biodiversity and socio-economic facets such as water security and agricultural productivity.

The third action involves implementing programmes designed to mitigate the impact of climate change and severe weather, particularly in climate-risk zones. Given UMDM's vulnerability to factors such as drought, heatwaves, and land degradation, these programmes must be tailored to the unique challenges of each risk zone. For instance, in areas where overexploitation of species has led to threatened ecosystems, measures might include strict control of resource extraction and implementation of sustainable land management practices.

Ultimately, this strategic priority underscores the inherent value of natural ecosystems and biodiversity in climate change adaptation, perceiving them not merely as passive victims of climatic shifts but as active contributors to climate resilience. The actions within this priority will work synergistically to secure UMDM's natural wealth, ensure its continued role in mitigating and adapting to climate change, and promote the sustainable development of the district.

Table 13: Programme 6 - Conserve, protect and restore natural open spaces, ecosystems and natural resources.

Programme 6: 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	• Conducting a green infrastructure assessment to identify natural areas that can provide climate benefits such as carbon

spaces to absorb and mitigate the impacts of climate change.	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 7: Enhanced Natural Resource Management

Amidst the rapidly changing climate within the UMDM, the pivotal programme, "*enhanced natural resource management*," emerges as a critical strategy for resilient and sustainable

development. It addresses the urgent requirement for cautious stewardship of the district's natural resources, like water and soil, and aims to reinforce both institutional and community capacity to manage these resources sustainably amid climate change.

The first key action under this programme orbits around ensuring the quality and availability of water resources, crucial to UMDM's sustainable development trajectory. Water is vital to the functioning of ecosystems, human health, and socio-economic development, including the district's high-yield water catchment areas. In the face of potential climate changes, such as possible increases in extreme rainfall events and droughts, the monitoring, protection, and enhancement of water quality become paramount. This activity could involve measures like regular water quality testing, watershed management planning, and the implementation of strategies to combat the large infestation of Wattle and American Bramble trees that threaten water security.

The second action involves monitoring and preventing land degradation and soil erosion, environmental threats that not only risk the health and productivity of ecosystems but also bear implications for water quality. Invasive species, communal grazing and the transformation of land due to agricultural and forestry activities exacerbate these issues in UMDM. Preventing land degradation and soil erosion necessitates a comprehensive approach that includes regular monitoring of vulnerable areas, land-use planning that considers these risks, and the implementation of sustainable agricultural and land management practices.

The third key action involves providing training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines. This is a vital step towards ensuring compliance with these regulations and building capacity within UMDM and the broader community to manage natural resources sustainably and adaptively, especially in areas with high biodiversity loss and threatened ecosystems. Training sessions could cover topics such as biodiversity conservation, watershed management, soil conservation, and climate change adaptation, and could empower participants with the skills to interpret and apply regulations and guidelines effectively.

Lastly, the establishment of a District Municipal Environmental Management Forum (DEMF) forms the fourth key action of this programme. The MEMF will serve as a platform for improved collaboration and coordination between various sectors, organizations, and agencies involved in natural resource management. The MEMF could facilitate the sharing of knowledge and resources, the harmonization of strategies and plans, and the resolution of conflicts over resource use.

Through these interconnected activities, this programme underscores the critical role of responsible natural resource management in navigating UMDM's climate future. It seeks to empower UMDM and its communities to protect and enhance their natural resources, not just

as an end in itself, but as a means to secure the district's resilience and sustainability in the face of climate change.

Table 14: Programme 7 - Enhanced natural resource management and use of ecosystem services.

Programme 7: Enhanced Natural Resource Management and Use of Ecosystem Services	
ACTIONS	ACTIVITIES
Ensuring the quality of water resources is critical to the sustainable development of UMDM, 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*	• 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.

strategies that protect natural resources).	
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 Municipal 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 8: Integration of Ecological Support Areas and Ecosystem Services into SDFs

The programme, "*integration of ecological support areas and ecosystem services into spatial development frameworks (SDFs)*" underscores the critical importance of recognizing the inherent and instrumental value of natural spaces and ecosystems in UMDM planning and development agenda. The climate change projections we've discussed, such as the impacts of habitat transformation, invasive species, and overexploitation, further underscore the necessity of this initiative. Here's how each of these key actions might function within the context of this programme:

- Ensuring critical biodiversity and ecological support areas are integrated into municipal spatial plans at all scales: This action mandates the identification of those areas within UMDM that are particularly significant for biodiversity and ecosystem services, such as those parts of the district that fall within the Maputaland-Pondoland-Albany hotspot. Given the district's diverse corridors and numerous FEPAs critical for ecosystem functioning, these ecologically vital areas should be incorporated into the municipal spatial planning process to guarantee their preservation and sustainable use. With impending risks like habitat loss and degradation, the conservation of these areas could also provide valuable climate change mitigation and adaptation benefits.
- Identifying and mapping natural open spaces, ecosystems, and natural resources, and integrating inventories in the Spatial Development Framework and the open space framework: This involves conducting a comprehensive assessment of UMDM's natural assets, which should encompass not only areas of significant biodiversity but also other open spaces, ecosystems, and natural resources. These findings should then be woven into UMDM's Spatial Development Framework and Open Space Framework, providing a blueprint for sustainable development that respects and upholds the value of these natural resources.
- Identifying undeveloped open space with potential for green infrastructure: This action is about recognizing those undeveloped areas within UMDM that hold potential for the development of green infrastructure. Given the current rates of habitat transformation and the spread of invasive species, such spaces can provide vital climate adaptation benefits, such as improved water security, increased habitat for indigenous biodiversity, and resilience against climate change, contributing to the overall resilience of the municipality.
- Assessing the value of open spaces and ecosystem services: This action speaks to the need to quantify and appreciate the ecological, economic, and socio-cultural value offered by UMDM's open spaces and the services its ecosystems provide. Recognizing the tangible and intangible benefits these spaces offer can strengthen the case for their protection and management, particularly in light of the escalating impacts of climate change.

Table 15: Programme 8 - Integrate critical biodiversity areas and ecological support areas into the spatial framework.

Programme 8: 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.

1.5.5. Programme 9: Develop and Implement Conservation and Management Plan For Vulnerable Species.

The UMDM is home to an impressive range of biodiversity, capturing a multitude of species and ecosystems. Society draws benefits from this biodiversity through the provision of ecological infrastructure such as water, air, and plants. The ongoing supply of these ecosystem services is dependent on the protection and maintenance of ecological processes and natural ecosystems. Notably, UMDM is situated within the Maputaland-Pondoland-Albany hotspot and forms a significant part of the KZN Midlands, one of the most diverse corridors in the Maputaland region.

However, these valuable ecosystems are under threat. The National Biodiversity Assessment (2011) reported a high rate of natural habitat loss in KZN, predicting minimal natural habitat outside protected areas by 2050 if current rates of loss continue. Key factors contributing to this biodiversity loss include habitat transformation driven by the expanding residential and commercial facilities, overexploitation of species, and the spread of invasive alien species such as Wattle, American Bramble, Lantana, and Triffid Weed. Agricultural and forestry activities have transformed approximately 45% of UMDM, and degraded land due to communal grazing is another issue, particularly in rural areas.

Therefore, the programme to safeguard and preserve natural resources, particularly vulnerable species, is paramount in UMDM. This programme encompasses the evaluation of natural resources, the identification of species needing protection, and the development and implementation of a conservation and management plan.

The assessment process considers potential climate change effects on species, such as changes in habitats, food sources, and migration patterns, and the impacts of severe weather and other climate-related risks. The conservation plan will focus on protecting and restoring natural habitats, minimising human impacts, and creating safe zones for species as their habitats come under threat or degrade.

Successful execution of this plan calls for partnerships with stakeholders, including landowners, conservation groups, and government agencies. Through this programme, UMDM can play a pivotal role in mitigating the impacts of climate change and preserving its rich biodiversity. In essence, the protection and preservation of vulnerable species and natural resources are critical components of climate change adaptation, strengthening the ecosystem's resilience to evolving environmental conditions.

Table 16: Programme 9 - Develop and implement a conservation and management plan for vulnerable species.

Programme 9: Develop and Implement Conservation and Management Plan For Vulnerable Species.	
ACTIONS	KEY ACTIVITIES
Develop and implement a conservation and management plan for vulnerable species.	• Conduct a thorough assessment of vulnerable and endangered species within the municipality. • Identify and prioritize species in need of protection and management based on their level of vulnerability, ecological importance, and cultural significance. • Develop and implement conservation and management plans that include strategies to protect and restore habitats, manage threats, and monitor populations. • Partner with local organizations, experts, and communities to implement conservation and management plans and ensure their long-term sustainability.

	• Provide education and outreach to raise awareness of the importance of protecting vulnerable species and their habitats and engage the public in conservation efforts. • Integrate conservation and management plans into municipal policies and planning documents, and ensure that they are regularly reviewed and updated to reflect changing ecological conditions and new information.

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

Table 17: Climate change goal 3, desired outcome and linkage to UMDM's development priorities.

Goal:	• Climate Change Goal 3 strives for reduced vulnerability and exposure of UMDM's human and natural systems to climate change and extreme events. Through risk management, resilient infrastructure, and community empowerment, this goal seeks to protect the district's people, economy, and natural environment. By 2030, significant reductions in vulnerability are anticipated, reinforcing commitments to universal service access, community partnerships, special programs, and sustainable development in a climate-resilient context.
Outcome:	• By 2030, UMDM will have implemented comprehensive risk management and adaptation strategies to significantly decrease the vulnerability and exposure of human and natural systems to climate change and extreme weather events. This includes an integrated early warning system, climate-resilient infrastructure, and community training programs for disaster preparedness and risk reduction.
Linkage to UMDM's Strategic Objectives	1. Universal access to basic services: As climate change can disrupt essential services like clean water, sanitation, electricity, and waste management, the climate goal aligns with the district's pledge to ensure 100% access to these fundamental services. Climate adaptation measures will ensure these services remain reliable and resilient under changing climate conditions. 2. Maintenance plan: Developing a maintenance plan that factors in climate change risks and extreme weather events will ensure the sustainable and reliable provision of essential services across all sectors, minimizing the vulnerability of the district's infrastructure and the communities that depend on it. 3. Community partnerships: The vulnerability of communities to climate change impacts can be greatly reduced by equipping them with knowledge and skills on disaster risk reduction, climate adaptation, and resilient livelihoods. Leveraging the Expanded Public Works Programme (EPWP) and co-operatives can facilitate these training and capacity-building initiatives.

	4. Special programmes: Climate change often exacerbates the vulnerabilities of already marginalized and disadvantaged communities. Special programs aimed at enhancing their resilience to climate change impacts, such as heatwaves, floods, and droughts, align with the district's commitment to promoting social equity and inclusivity. 5. Achieving sustainable development and climate change mitigation: Reducing vulnerability to climate change impacts is a critical part of achieving sustainable development. The measures taken under this climate goal will also contribute to preserving the natural environment and mitigating the district's contribution to climate change.

4.6.1. Rationale/Context

The climate change projections for UMDM illustrate a dramatic shift in regional climate dynamics, marked by increased instances of extreme heat, drought tendencies, wildfires, and heightened flood risks. Such transformations are liable to put substantial pressure on both human and natural systems, potentially jeopardizing socio-economic stability and ecosystem health. Therefore, the strategic priority, "*to reduce the vulnerability and exposure of human and natural systems to climate change and extreme events*" is essential to protect life, livelihoods, and biodiversity in the district.

The trend towards rising temperatures, with a projected increase of up to 20 more very hot days per annum, indicates a heightened risk of heat waves and associated public health issues such as heat stress and exacerbated chronic illnesses. The incidence of wildfires also appears set to increase in various settlements. These events not only pose direct physical risks but also lead to significant economic damages and affect air quality, aggravating respiratory conditions. Hence, protecting communities from these challenges becomes crucial, requiring robust disaster management strategies and public health interventions.

Moreover, the shifts in precipitation patterns, with variable flood and drought tendencies across the district, could strain water resources and agricultural systems. The projected decrease in rainfall in the eastern parts of the district and increased drought tendencies could exacerbate water scarcity, while the anticipated rise in extreme rainfall days in the western regions could heighten flood risks, leading to potential damage to infrastructure, loss of property, and disruption of livelihoods. Natural ecosystems too, face the threat of disruption, altering habitats, and affecting biodiversity. Given these circumstances, reducing vulnerability and exposure to these extreme events is fundamental to securing water resources, ensuring food security, and maintaining ecosystem health, making it a top strategic priority in the climate adaptation report.

- Programme 15: Integrated Fire Management for Climate Resilience: This programme focuses on reducing wildfire risks and impacts through comprehensive management strategies,

directly contributing to reducing human and natural systems' vulnerability and exposure to climate-induced fire events.

- Programme 16: Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements: By identifying key climate risks and creating specific response plans, this programme aims to enhance the resilience of settlements and reduce exposure to extreme climate events, in line with the strategic priority of reducing vulnerability and exposure.
- Programme 17: Climate-Smart Waste Management Promotion: This programme not only promotes climate-smart waste practices to lower greenhouse gas emissions and prevent contamination, but it also combats issues of illegal dumping and pollution. By advocating for responsible waste disposal and pollution management, it aims to reduce the vulnerability of natural systems to environmental degradation and human exposure to health hazards associated with unsanitary conditions and polluted environments. This approach significantly contributes to reducing the vulnerability and exposure of both human and natural systems to climate change impacts and other environmental threats.
- Programme 18: Community-Based Adaptation in Communities Most at Risk of Climate-Related Hazards: This programme centres on empowering vulnerable communities to adapt to climate changes, thus directly aligning with the strategic priority of reducing human vulnerability and exposure to extreme climatic events.
- Programme 19: Climate-Resilient Spatial Planning: By integrating climate change considerations into spatial planning, this programme aims to shape a built environment that can withstand and recover from climate disturbances, thereby reducing the vulnerability and exposure of both human and natural systems to climate change impacts.

4.6.2. Programme 10: Integrated Fire Management for Climate Resilience

The "*integrated fire management for climate resilienc*e" programme is pivotal for UMDM, given its present condition and forecasted wildfire risk. With a considerable proportion of settlements nestled at the wildland-urban interface, including vast areas of Pietermaritzburg within the Msunduzi Municipality, all habitations in the uMngeni Municipality like Howick, Hilton, Lidgetton, and Nottingham Road, major centres in the uMshwathi Municipality, including Albert Falls, New Hanover, Wartburg, and Dalton, as well as the Hopewell area within the Richmond municipality, the district is markedly susceptible to wildfires. Moreover, Richmond and Mooirivier settlements present a potential, albeit uncertain, wildfire threat. Predictions for the future point towards an increasing threat level for these areas, exacerbated by anticipated higher temperatures due to climate change.

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 uMgungundlovu District's resilience against wildfires in a thorough and integrated way, taking into account the projected impacts of climate change.

Table 18: Programme 10: Integrated fire management for climate resilience.

Programme 10: 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 behavior modeling: Use fire behavior 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 behavior, 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.

4.6.3. Programme 11: Comprehensive Stormwater and Flood Management Programme

The Comprehensive Stormwater and Flood Management Programme, designed to be implemented within the UMDM, 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 UMDM 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 19: Programme 11 - Comprehensive stormwater and flood management programme.

Programme 11: Comprehensive Stormwater and Flood Management Programme.	
Actions	Activities
Infrastructure assessment and network mapping.	• Conduct a comprehensive evaluation of current stormwater drainage systems, identifying flood-prone areas needing upgrade, repair, or new infrastructure. • Chart the existing drainage network, evaluating capacity and conditions and identifying bottlenecks, blockages, or flood-prone areas. • Utilize Geographic Information Systems (GIS) and hydraulic modelling tools to simulate stormwater flow and identify areas at risk of flooding.
Infrastructure development and green infrastructure integration.	• Design and construct new stormwater drainage and flood management infrastructure, integrating future climate scenarios, urban growth trends, and land use changes into planning and design. • Promote and integrate green infrastructure like rain gardens, bioswales, and permeable pavements to supplement traditional drainage systems.
Monitoring, maintenance, and management plan.	• Establish a detailed monitoring, maintenance, and management plan for stormwater drainage and flood management infrastructure, including routine inspections and debris removal.
Stakeholder engagement and field surveys.	• Engage with engineers, architects, urban planners, landscape architects, local communities, and stakeholders in the design and management of drainage infrastructure, floodplains, and retention basins. • Conduct field surveys and data collection on existing infrastructure, water levels, biodiversity, and usage of flood management areas.
Early warning system.	• Create an early warning system, including the installation of monitoring equipment for real-time data collection and analysis, and develop efficient communication channels for disseminating information.

Education, awareness campaigns, and training.	• Implement public awareness campaigns and educational programmes on stormwater management, flood risk awareness, responsible waste management, and emergency preparedness, emphasizing the importance of maintaining clean stormwater drains. • Provide 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.	• Regularly monitor and evaluate the program, assessing the effectiveness of flood risk reduction measures and identifying necessary system upgrades.

4.6.4. Programme 12: Infrastructure Resilience and Public Health Education Programme

The Infrastructure Resilience and Public Health Education Programme, designed for the UMDM, is a comprehensive initiative aimed at bolstering the region's infrastructure to withstand the impacts of climate change, while simultaneously enhancing public understanding of health and safety measures in extreme weather events. This forward-looking programme employs an integrated approach that encompasses detailed vulnerability assessments, infrastructure enhancements, training initiatives, and public education drives to foster a community that is well-equipped to deal with the challenges posed by a changing climate.

The programme begins with an in-depth infrastructure vulnerability assessment to identify the weak spots in the existing infrastructure that could be most affected by climate change. Once these vulnerable areas have been identified, the programme moves into the infrastructure retrofitting and upgrading phase. This phase ensures that critical structures are sufficiently resilient to withstand extreme weather events and other climate-related impacts. The programme also seeks to integrate climate resilience into all facets of infrastructure planning and development. Additionally, emergency systems, such as early warning systems, will be installed to provide timely alerts in the face of impending hazards. To ensure the long-term viability of these efforts, regular inspections and maintenance of the upgraded infrastructure will be carried out.

The programme also places great emphasis on capacity building and public education. It includes training sessions for local authorities and other key stakeholders to ensure they have the knowledge and skills to manage and maintain resilient infrastructure effectively. At the same time, the programme seeks to educate the public about the importance of infrastructure resilience and its direct correlation with health. This initiative will be complemented by an anti-littering and responsible waste management campaign to mitigate the potential impact of waste on local infrastructure and the environment. Community training on flood preparedness is another critical component of the programme, aimed at enhancing the community's capacity to respond effectively during flood events. Lastly, the programme will incorporate ongoing

monitoring, evaluation, and adaptive management strategies to ensure its ongoing relevance and effectiveness in the face of changing climate scenarios.

Table 20: Programme 12 - Infrastructure resilience and public health education programme.

Programme 12: Infrastructure Resilience and Public Health Education Programme.	
Actions	Activities
Comprehensive infrastructure assessment and enhancement.	• Conduct a comprehensive vulnerability assessment of existing infrastructure, identifying high-risk areas during flood events and extreme rainfall. • Based on the assessment, retrofit and upgrade high-risk infrastructure, including improving design for flood resistance, reinforcing structures, and optimizing drainage systems. • Undertake regular inspections and maintenance to preserve structural integrity and proactively address potential issues. • Review and update flood lines periodically.
Climate resilience and emergency preparedness.	• Incorporate climate resilience into the planning, design, and construction of all new infrastructure projects. • Install emergency power and communication systems to ensure the continuity of essential services during extreme events. • Deliver community training on flood preparedness, providing guidance on actions during and after a flood event, as well as evacuation procedures.
Education, training, and advocacy.	• Develop a comprehensive public education programme focusing on flood risk awareness, emergency preparedness, and responsible waste management. • Launch an anti-littering campaign and conduct educational sessions highlighting the environmental health problems caused by indiscriminate waste dumping. • Provide training for engineers and urban planners on contemporary techniques and technologies for building resilient infrastructure.
Monitoring, evaluation, and adaptive management.	• Regularly monitor and evaluate the effectiveness of the programs. • Adjust strategies based on feedback and evolving needs to ensure continuous improvement.

4.6.5. Programme 13: Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements.

The programme, "Identify and Prioritise Climate Change Risks and Develop Response Measures for Settlements," is fundamental in confronting the multifaceted climate change issues experienced by the UMDM. The district's susceptibility to a wide range of natural, technological, and environmental threats, including severe storms, floods, fires in informal settlements, and veld fires, underscores the importance of this programme.

One of the key actions under this programme is the execution of a vulnerability assessment to identify the populations and locations in UMDM most susceptible to the repercussions of climate change. This information is crucial in a district regularly faced with diverse threats, assisting in prioritising areas for intervention and formulating precise, effective climate adaptation strategies.

In terms of early warning systems, UMDM, like other districts, relies heavily on the South African Weather Service (SAWS). However, the district's vulnerability to severe weather conditions necessitates a more effective, responsive system for early warnings. Achieving this involves a comprehensive strategy that includes securing increased funding, enhancing local capacity, and integrating local knowledge. This may involve lobbying for additional support from the national government, obtaining international climate resilience grants, developing public-private partnerships, training local volunteers, and improving infrastructure for alert dissemination.

To establish long-lasting climate resilience, the programme underscores the importance of nurturing partnerships with local stakeholders, including community groups and NGOs. These partnerships are instrumental in strengthening local capacity, making communities more adept at managing climate change-related challenges - a critical need in a district that frequently faces a myriad of environmental threats.

Lastly, the programme integrates climate change considerations into land use planning and zoning regulations. Given UMDM's susceptibility to environmental hazards, it's paramount to adopt planning practices that factor in potential climate impacts. These strategies ensure the enduring resilience of human settlements, thereby reducing their vulnerability to the escalating impacts of climate change.

Table 21: Programme 13 - Identity and prioritise climate change risks and develop response measures for settlements.

Programme 13: 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	• Analysing climate data to determine the frequency and severity of extreme weather events. • Assessing the vulnerability of infrastructure to flooding and wildfire. • Mapping areas with high concentrations of vulnerable populations.

of climate change impacts.	
Enhancing and tailoring an early warning system to help communities in the uMgungundlovu District prepare for and respond to climate change risks promptly and effectively.	• Collaborating with the South African Weather Service (SAWS) and leveraging additional funding to improve existing weather monitoring systems, providing more accurate and localised real-time data on extreme weather events. • Developing and implementing protocols for disseminating early warnings to the public efficiently, using a variety of communication channels and ensuring clear, actionable information is provided. • Strengthening local capacity through training of community volunteers in weather monitoring and disaster response, ensuring an immediate and effective local reaction to warnings. • Formulating community response plans tailored to different types of extreme weather events specific to the district, incorporating local knowledge and experience for a more accurate and effective response. • Building public-private partnerships and applying for international grants to bolster resources for enhancing the early warning system. • Integrating local knowledge into the early warning system, utilising the unique understanding communities have of their local environment to complement formal monitoring and response systems.
Establishing partnerships with local stakeholders, such as community groups and NGOs, to build local capacity for climate change adaptation and resilience.	• 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.
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.

4.6.6. Programme 14: Advancing Towards a Climate-Smart Circular Economy

Advancing towards a climate-smart circular economy is crucial for mitigating climate change impacts while providing economic and social benefits for the UMDM. This shift, from linear

economic models of "take-make-dispose", focuses on maximising the utilisation of materials and resources, reducing waste, and curbing emissions.

Table 22: Programme 14 - Advancing towards a climate-smart circular economy.

Programme 14: Advancing Towards a Climate-Smart Circular Economy.	
ACTIONS	KEY ACTIVITIES
Shift towards a circular economy.	• Develop and implement a circular economy policy and action plan, involving stakeholder engagement and public consultation. • Conduct a comprehensive waste audit to pinpoint opportunities for materials recovery and recycling. • Develop and implement circular economy strategies like waste reduction targets, recycling programs, and product stewardship initiatives. • Support local businesses and industries to adopt circular economy practices, such as resource sharing and reuse, and closed-loop supply chain development. • Promote green procurement policies, purchasing products made from recycled materials to support the growth of circular markets. • Collaborate with local research institutions for innovative circular economy solutions and technology development. • Develop education and outreach programs to raise awareness and engage the community in the shift towards a circular economy. • The inclusion of informal waste collectors and formalizing the trade through support and business development. • Developing a proper EPR plan that will address the management and incentive program for sanitary waste. • Review the impact and contribution of waste on infrastructural damage and degradation. • Standardize the phenomena of street sweeping and all major towns. • The inclusion of informal waste collectors and formalizing the trade through support and business development. • Developing a proper EPR plan that will address the management and incentive program for sanitary waste. • Review the impact and contribution of waste on infrastructural damage and degradation. • Standardize the phenomena of street sweeping in all major towns.
Climate-smart waste management.	• Conduct a feasibility study to identify innovative waste processing technologies. • Develop recycling programs that incentivise households and businesses to recycle, such as offering discounts or rebates based on the amount of waste recycled.

	• Establish dedicated recycling centres across UMDM to facilitate easier access for residents and businesses. • Monitor and evaluate the impact of these innovations on waste reduction and recycling rates, adjusting the program for maximum effectiveness.
Staff training and capacity building.	• Identify key areas of knowledge and skills required for effective waste management, such as waste collection, separation, and processing procedures. • Develop and implement a comprehensive training program for waste management staff. • Provide ongoing support and resources for staff to continue learning and improving their skills • Regularly review and update the training program to ensure its relevance and effectiveness.
Improved waste collection and transportation.	• Carry out an assessment of the existing waste collection and transportation infrastructure to identify areas for improvement. • Develop a plan for upgrading this infrastructure, such as purchasing new, more efficient compactor trucks • Implement the plan, monitor its effectiveness, and make necessary adjustments over time. • Conduct routine maintenance on the infrastructure to ensure it remains in good condition and operates efficiently.
Public awareness and illegal dumping reduction.	• Develop a public awareness campaign to educate residents about the importance of responsible waste disposal and the dangers of illegal dumping. • Organise community clean-up events in areas affected by illegal dumping to foster a sense of community pride and responsibility. • Work with law enforcement to increase patrols in areas known for illegal dumping and impose penalties for those caught in the act. • Monitor and evaluate the impact of these activities on rates of illegal dumping, adjusting the strategy as necessary to achieve maximum effectiveness.

This comprehensive programme aims to stimulate UMDM's transition towards a more sustainable, resilient, and inclusive economy, responding proactively to the challenges posed by climate change.

4.7.3. Programme 15: Community-Based Adaptation in Communities Most at Risk of Climate-Related Hazards

The "*community-based adaptation in communities most at risk of climate-related hazards*" programme is crucial in building resilience and mitigating the impacts of climate change in

UMDM. It's built around the understanding that local communities, often the first to feel the impacts of climate change, need tailored, place-based adaptation measures.
The programme emphasizes empowering local communities and leveraging their knowledge in creating and implementing climate adaptation strategies.

Key actions under this programme include:

- Conducting granular risk and vulnerability assessments in communities to identify drivers of risk and develop appropriate adaptation measures: This activity involves a detailed examination of specific climate risks that local communities face. By identifying these risks at a granular level, the municipality can develop adaptation measures that are specific, targeted, and effective.
- Developing and implementing community-based adaptation measures to reduce risks and build resilience: This involves local departments like the Department of Forestry, Fisheries, and the Environment (DFFE) that play a crucial role in promoting climate-smart agricultural practices, enhancing food security, and building community resilience. The goal is to reduce climate-related risks and strengthen the capacity of the communities to withstand and bounce back from adverse climate impacts.
- Providing training and education to build community capacity and promote sustainability: Through training and education, the programme aims to equip community members with the knowledge and skills needed to adapt to climate change. This can help to promote sustainable practices at the local level, fostering a more resilient community.
- Comprehensive Community Engagement and Public Awareness Initiative on Climate Change: This initiative is designed to raise awareness about climate change and involve the community in addressing it. By engaging local organisations, schools, and community groups, the programme ensures that the awareness campaign is inclusive, accessible, and relevant to all members of the community.

By focusing on community-level adaptation, the programme plays a crucial role in reducing the vulnerability of both human and natural systems to climate change and extreme events within the UMDM.

Table 23: Programme 15 - Community-based adaptation in communities most at risk of climate-related hazards.

Programme 15: Community-Based Adaptation in Communities Most at Risk Of Climateofelated 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 the 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*	• 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.

addressing climate change. By engaging local organisations, schools, and community groups, the programme will ensure that the campaign is inclusive, accessible, and relevant to all members of the community.	• 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. • Providing capacity-building sessions for local leaders and stakeholders on topics such as sustainable energy practices and eco-friendly behaviors. • 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.

4.7.4. Programme 16: Climate-Resilient Spatial Planning

The "Climate-Resilient Spatial Planning" programme is fundamental in the UMDM's endeavour to mitigate and adapt to the impacts of climate change. It acknowledges that traditional approaches to spatial planning may not be adequate in the face of climate change, which presents new and evolving challenges. The programme seeks to integrate climate change considerations into spatial planning, fostering resilience and ensuring the municipality's urban and rural spaces are better prepared for the future.

Key actions under this programme include:

- Ensure that spatial planning frameworks consider a long-term view of climate hazards and incorporate natural infrastructure: This action aims to integrate an understanding of future climate hazards into spatial planning and recognises the crucial role of natural infrastructure in climate adaptation, such as using wetlands for flood regulation.
- Develop local-level climate-resilient planning mechanisms - Precinct Plans: At the local level, these plans will guide development that's designed to withstand climate impacts and ensure the longevity and sustainability of UMDM's communities.

- Ensure collaborative strategic planning that incorporates all relevant departments: Recognising that climate change will affect all sectors of the municipality, this action promotes cross-departmental collaboration to ensure cohesive and comprehensive planning.
- Create mechanisms to strengthen public participation in planning and decision-making processes: Public involvement ensures plans reflect local needs and knowledge, improving the effectiveness and acceptance of climate-resilient plans.
- Resilient urban and township design and development to minimise the risk and impact of climate change on urban areas: This involves designing urban and township areas with climate resilience in mind, such as planning urban green spaces to mitigate heatwaves and floods.
- Identify climate risk zones and hotspots that affect vulnerable municipal infrastructure and assets: By identifying these risk zones, the municipality can prioritise where resilience needs to be built most urgently, and where infrastructure upgrades or changes may be necessary.

By integrating climate change resilience into spatial planning, UMDM can reduce the vulnerability of its human and natural systems to climate change and extreme events, thus enhancing the long-term sustainability of its communities.

Table 24: Programme 16 - Climate-smart spatial planning for climate-resilient growth and development.

Programme 16: Climate-Smart Spatial Planning For Climate-Resilient Growth and Development.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Ensure that spatial planning frameworks consider a long-term view of climate hazards and incorporate natural infrastructure.	• Conduct a review of current spatial planning frameworks, • Identify climate hazards and vulnerable areas in the municipality, • 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 District Spatial Development Framework (DSDF) 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. • 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, UMDM could undertake various activities.	• 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.

4.7. Climate Change Goal 4: To Increase the Resilience of the Agricultural Sector

Table 25: Climate change goal 4, desired outcome and linkage to UMDM's development priorities.

Goal:	• Reinforce the resilience of UMDM's Agricultural Sector, fortifying a critical economic contributor and provider of livelihoods against the adverse effects of climate change.
Outcome:	• By 2030, the agricultural sector in the UMDM is envisaged to withstand, adapt, and grow amidst climate change challenges. This resilience bolsters the district's economy, safeguards jobs, ensures food security, and supports sustainable development.
Linkage to UMDM's Strategic Objectives	1. Radical economic transformation: Enhancing the resilience of the agricultural sector contributes to overall economic stability and growth. 2. Community partnerships: Resilient agriculture can boost community partnerships through initiatives like the Expanded Public Works Programme (EPWP) and Co-operatives. 3. Maintenance plan: Adapting to climate change requires robust maintenance and management of agricultural resources and infrastructure. 4. Achieving sustainable development and climate change mitigation: Resilient agriculture is key to sustainable development and helps mitigate the impacts of climate change.

4.7.1. Rationale/Context

Given the Agricultural, Forestry, and Fisheries (AFF) sector's significant contribution to the uMgungundlovu District Municipalities' economy, accounting for a substantial 7% of the primary economic sector, *'Climate Change Goal 4: Increase the Resilience of the Agricultural Sector'* emerges as a critical strategic climate adaptation priority. This sector's diversity forms the backbone of the District's socioeconomic fabric, supporting various livelihoods. Ensuring its resilience amidst climate change is thus pivotal for sustaining economic stability, employment, and community welfare.

The uMgungundlovu District Municipalities, with agriculture and forestry at the heart of its primary sector and making up 7% of the economy, is a notable agricultural hub. It is home to a wide array of farming activities, including maize, sugarcane, fruit and vegetable cultivation, cattle and sheep rearing, horse breeding, and timber plantations. Consistent with the district's vision, the expansion of this sector is of utmost importance (CoGTA, 2020). Given the local climates and the District's overall agricultural land potential, significant parts of the area are conserved for commercial farming (CoGTA, 2020). The potential implications of climate change and climate-related hazards on agriculture bear considerable weight, especially considering the high dependence of many households on the sector for employment.

This priority becomes especially pertinent in light of the District's agricultural resources facing multifaceted threats from urbanisation, poor land use management, economic recession, and land reform. An investment into enhancing agricultural resilience would serve to counter these threats, ensuring the continued viability and profitability of the region's farming activities. The state, provincial, local government agencies, private sector, and traditional institutions need to recognise the value of these resources to safeguard their sustainability and ensure food security.

Moreover, the District's favourable agro-climatic conditions lend themselves to potential expansion opportunities within the Agricultural, Forestry, and Fisheries sector. Increasing this sector's resilience could further unlock these opportunities, leading to the development of value chains and stimulating job creation. This would contribute to both economic growth and social development in the District, making climate resilience in agriculture a significant strategic focus.

Lastly, the projected climatic changes for the uMgungundlovu District Municipalities paint a challenging picture for the Agricultural, Forestry, and Fisheries sector. Transitioning towards a hotter and wetter climate may present both opportunities and threats for crop and livestock management. Immediate strategic intervention is necessary to harness potential benefits, such as increased crop yields, while mitigating risks, such as heat stress, disease proliferation, and reduced livestock productivity. Given these projections, prioritising the resilience of the Agricultural, Forestry, and Fisheries sector in the climate adaptation report aligns with a proactive, strategic response to ensure the sector's sustainability amidst the changing climate.

4.7.2. Programme 17: Enhanced Climate-Resilient Agricultural Practices

As the impacts of climate change become increasingly evident, the necessity to adapt our agricultural practices to meet these changing environmental conditions has never been more urgent. The agricultural sector, a vital backbone of the economy, particularly in the uMgungundlovu District Municipalities, faces substantial risks due to fluctuating climatic patterns. This reality underscores the strategic need for the *'enhanced climate-resilient agricultural practices'* programme.

The first action, "promotion and implementation of sustainable farming techniques", is a response to the pressing need for agricultural practices that are not only environmentally friendly but also economically sustainable. It recognizes the potential of such techniques to improve soil health, conserve water, reduce the dependency on chemical inputs, and enhance biodiversity, all while maintaining or improving yields. Furthermore, sustainable farming techniques have the potential to increase the resilience of farming systems to climatic stresses and shocks, thus contributing to food security.

The second action, "implementation of drought and heat-resistant crop varieties", acknowledges the increased frequency and intensity of drought and heatwaves resulting from climate change.

Traditional crop varieties may not be able to withstand these conditions, potentially leading to crop failure and jeopardizing food security. The introduction and promotion of drought and heat-resistant varieties can mitigate these risks, potentially improving agricultural productivity under climate change scenarios.

Lastly, "strengthening livestock health and resilience" action is key to maintaining livestock productivity amidst changing climatic conditions. Climate change, through increases in temperature and alterations in rainfall patterns, could exacerbate the spread of diseases and reduce the availability of quality fodder and pasture. This activity aims to enhance livestock health and productivity by adopting improved management practices, disease surveillance and control measures, and heat stress mitigation strategies.

Collectively, these activities constitute a comprehensive response to the climate change challenges faced by the Agricultural, Forestry, and Fisheries sector in the uMgungundlovu District Municipalities, contributing to the overall climate resilience of the region.

Table 26: Programme 17 - Enhanced climate-resilient agricultural practices.

Programme 17: Enhanced Climate-Resilient Agricultural Practices.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Promotion and implementation of sustainable farming techniques.	• Conduct climate-smart agricultural training sessions to equip farmers with techniques such as crop rotation, agroforestry, and conservation farming. • Facilitate pilot projects demonstrating effective sustainable farming techniques in different local municipalities. • Establish and implement guidelines for soil and water conservation practices, such as building contour trenches and terraces.
Implementation of drought and heat-resistant crop varieties.	• Collaborate with agricultural research institutions to develop and distribute drought and heat-resistant crop varieties. • Encourage seed banks and exchange programs that preserve and distribute seeds of climate-resilient local crops. • Organise farmer field days to demonstrate the benefits of these climate-resilient crop varieties.
Strengthening livestock health and resilience.	• Promote livestock breed diversification for breeds that are resistant to heat stress and diseases. • Implement veterinary support programs to help manage and reduce the spread of diseases and parasites in livestock. • Enhance access to water for livestock during dry periods through initiatives such as borehole drilling or water harvesting systems.

4.7.3. Programme 18: Improved Infrastructure and Natural Resource Management

Given the UMDM's strategic positioning as a significant hub for Agricultural, Forestry, and Fisheries, the necessity for a programme focusing on 'Improved Infrastructure and Natural Resource Management' is undeniable. This programme recognises the interconnectedness of the agricultural sector, natural resources, and local infrastructure, aiming to fortify each area to improve the district's overall climate resilience.

The first action, "water resource management and conservation," underpins the importance of sustainable water use and conservation in an era of climate unpredictability. Water is a pivotal resource in agriculture, and with the increasing threat of climate change, the importance of managing water resources efficiently cannot be overemphasized. This includes initiatives like efficient irrigation, rainwater harvesting, and watershed management to ensure water availability for the agricultural sector even during periods of drought.
The "implementation of programs for agroforestry and rehabilitation of degraded agricultural lands" reflects the urgency to restore degraded land while creating more sustainable land-use systems. Agroforestry can enhance land productivity, biodiversity, and carbon sequestration, thus mitigating climate change impacts while also rehabilitating degraded lands.

"Conducting regular assessments of agricultural ecosystem health and biodiversity" recognises the essential role of biodiversity in supporting productive and resilient agricultural systems. Regular assessments would provide critical data on the impacts of climate change, helping to inform adaptive management strategies and safeguard the health of the district's agricultural ecosystems.

The need to "establish protected buffer zones around agricultural lands to safeguard critical ecosystems and promote biodiversity" serves to protect the district's vital natural resources and ecosystems, providing a shield against encroachment and ensuring the longevity and resilience of these ecological spaces. This action also fosters biodiversity, which can improve agricultural productivity and resilience to climate change.

Lastly, the "development of climate-resilient infrastructure" is fundamental to cope with changing climate conditions. This includes infrastructure such as water storage and irrigation systems, farm buildings, and transportation networks designed to withstand climate change impacts like increased storm intensity, higher temperatures, and more severe flooding. Building climate-resilient infrastructure ensures the continued operation of the agricultural sector and reduces the potential economic losses from climate change.

In summary, the 'improved infrastructure and natural resource management programme recognises that managing the district's natural resources sustainably and investing in climate-resilient infrastructure are crucial strategies to safeguard the region's agricultural productivity and resilience amidst climate change.

Table 27: Programme 18 - Improved infrastructure and natural resource management.

Programme 18: Improved Infrastructure and Natural Resource Management.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Water resource management and conservation.	• Develop and implement water conservation policies and measures such as rainwater harvesting, greywater recycling, and wastewater treatment for agricultural use. • Enhance the efficiency of irrigation systems, promoting techniques such as drip irrigation to reduce water wastage. • Undertake regular maintenance and upgrade of water infrastructure to prevent water loss.
Implement programs for agroforestry and rehabilitation of degraded agricultural lands.	• Promote the use of agroforestry practices, combining trees, crops, and/or livestock on the same plot of land, which can provide benefits such as improved soil fertility, increased biodiversity, and enhanced resilience against climate change. • Develop and implement strategies for the rehabilitation of degraded agricultural lands, which could involve soil conservation measures, crop rotation schedules, or the use of cover crops.
Conduct regular assessments of agricultural ecosystem health and biodiversity.	• Carry out regular health assessments of agricultural ecosystems, focusing on factors like soil health, biodiversity, and the presence of beneficial insects and pollinators. • Develop biodiversity indicators and monitoring systems specific to agricultural ecosystems to track and promote the diversity of crops, livestock, wild species, and microorganisms.
Establish protected buffer zones around agricultural lands to safeguard critical ecosystems and promote biodiversity.	• Implement land-use planning to establish protected buffer zones around agricultural areas. These zones, consisting of native vegetation, can protect fields from wind and water erosion, provide habitats for beneficial wildlife, and increase biodiversity. • Encourage farming practices that promote biodiversity both on and around farms, such as maintaining hedgerows or creating wildlife ponds, which can support a wide variety of plant and animal species and enhance ecosystem services.
Development of climate-resilient infrastructure.	• Establish guidelines and regulations for climate-resilient infrastructure design and construction. • Enhance existing infrastructure to withstand climate-related hazards, such as improving drainage systems to prevent flooding. • Incorporate green infrastructure solutions, such as permeable pavements and green roofs, to reduce urban heat islands and manage stormwater.

4.7.4. Programme 19: Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices

In the context of UMDM, where agriculture, forestry, and fisheries form a crucial part of the local economy and livelihoods, the necessity for a programme focused on 'Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices' is unmistakable. This initiative recognises that people are at the heart of any adaptation strategy, and their capacity to understand, respond, and adapt to climate change impacts is critical for building the district's agricultural resilience.

The first action, "climate change education and awareness campaigns - agricultural focus," acknowledges that understanding climate change, its impacts, and potential adaptation and mitigation strategies are foundational to climate resilience. Through targeted awareness campaigns, the district's agricultural community can be educated about the implications of climate change on their work and the methods they can employ to mitigate and adapt to these changes. This would foster a shared sense of responsibility and motivate proactive engagement with climate change adaptation strategies.

The "capacity building and training programs - agricultural focus" action recognizes the need for agricultural stakeholders, from farmers to extension officers, to have the skills and knowledge to adapt to changing climate conditions. These programs can focus on areas such as sustainable farming techniques, the use of climate-resilient crop varieties, and efficient water management. By bolstering the capacity of individuals within the sector, we can enhance the overall resilience of the district's agricultural system.

Lastly, "enhancing local knowledge and practices - agricultural focus" emphasizes the importance of harnessing local knowledge in adaptation efforts. Farmers and local communities have a wealth of knowledge about their environment and have been adapting to climatic changes for generations. These indigenous knowledge systems and traditional farming methods can provide valuable insights into local-level adaptation strategies and should be recognised and integrated into broader climate change response efforts.

In summary, the *'Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices*' programme understand that building agricultural resilience is not solely about technical solutions or policy interventions; it's also about empowering people. By educating the local community about climate change, building their capacity to respond, and integrating local knowledge into adaptive practices, the district can significantly enhance its agricultural resilience.

Table 28: Programme 19 - Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices.

Programme 19: Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices.	
ACTIONS	POSSIBLE KEY ACTIVITIES
Climate change education and awareness campaigns - agricultural focus.	• Conduct agricultural-focused climate change awareness campaigns to help farmers understand the impacts of climate change on their crops/livestock and learn about potential adaptive measures. • Collaborate with agricultural schools and institutes to incorporate climate change education into their curriculum, focusing on sustainable farming practices under changing climate conditions. • Use community radio stations, local newspapers, and social media to disseminate information on climate-smart agriculture and the potential impacts of climate change on UMDM's agricultural sector.
Capacity building and training programs - agricultural focus.	• Organise workshops and training sessions for farmers, agricultural cooperatives, and other stakeholders in the agricultural sector to enhance their knowledge of climate change adaptation strategies and resilient farming practices. Particular attention should be given to supporting subsistence farmers in accessing these extension services. • Develop training materials and toolkits focusing on climate change adaptation and mitigation in agriculture, including topics like precision farming, water conservation techniques, soil health management, and diversifying crop types. Use these materials to host farmer field schools to support knowledge sharing on climate-resilient practices. • Establish local agricultural climate change adaptation committees to coordinate and implement climate change actions at the farm level, including the integration of climate-smart practices in farming operations. • Promote the implementation and utilisation of community gardens for agriculture and food production. Provide support in the form of training, resources and infrastructure for these initiatives to boost local food security and resilience against climate change impacts.
Enhancing local knowledge and practices - agricultural focus.	• Document and promote traditional and local farming knowledge and practices that contribute to climate change adaptation, such as using indigenous crop varieties or implementing traditional water management systems. • Encourage farmer-led initiatives to tackle climate change, such as the creation of local farmer cooperatives focusing on sustainable farming practices and natural resource conservation.

	• Develop platforms for knowledge exchange among farmers and agricultural communities within the district, facilitating the sharing of successful adaptation practices and lessons learned.

5. 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: To ensure water security under a changing climate.								
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 reuse 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	Drought	Water and Sanitation	Year 0-2: Complete needs assessment, and assign funds to	Low	Advocate for and secure funding for a dedicated water resources	Recruit a qualified water resources manager.	Maintain	High

Management			implement WRM KPIs. Year 3-5: Recruit water resource manager and establish partnerships.		manager position.			
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	Review 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	Review Water Safety 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	Drought	Water and Sanitation	Year 0 – 2: Develop a monitoring schedule, establish a buffer zone and integrate in spatial	Medium	Implement a regular water quality monitoring schedule, create and manage municipal	Implement	Implement	High

reducing pollution.			frameworks. Year 3-5: Implement by-laws.		buffer zones and develop by-laws to regulate effluent discharge.			
Implementing water conservation measures.	Drought	Water and Sanitation	Year 0-2: Achieve a set number of awareness campaigns and loss reduction. Year 3-5: Implement greywater-based irrigation on municipal land. Year 6-10: Large-scale reuse systems operational.	Low to High	Establish targets for awareness campaigns and loss reduction. Feasibility Studies and pilot projects.	Water re-use systems installed on municipal property.	Large-scale water re-use systems implement for non-potable uses.	High
Alien Invasive Species Clearing Initiatives In Catchment Areas.	Flooding	Water and Sanitation	Year 0-2: Map alien invasive hotspots. Continue current operations and campaigns. Source funds. Year 3-5: Scale alien invasive clearing and establish green economy initiatives. Year 6-10: Self-	Medium	Identify, map and control areas containing alien invasive species.	Scale	Scale	

			sustaining operations in key areas.					
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 partnerships to establish incentive programmes.	Low	Developing and implementing guidelines and standards for sustainable residential and commercial development	Incentive programme. Enforcement	Enforcement.	
Adaptation Programme 3: Enhancing Water Conservation Awareness and Education for Sustainable Water Management in Response to Climate Change.								
Developing Water Conservation Education Programs.	Drought/Heat Stress/Wildfires	Water and Sanitation	Year 0-2: Completion of the needs assessment, development of educational materials, and initiation of partnerships. Year 3-5: Widespread education and outreach to the community,	Medium.	Conducting a needs assessment, developing educational materials, and initiating partnerships with community organizations.	Conducting education and outreach activities and maintaining partnerships with community organizations.	the effectiveness of the program could be evaluated while continuing to maintain partnerships and conduct outreach activities as necessary.	High

			strengthening of partnerships. Year 6 – 10: Evaluation of program effectiveness.					
Promoting Water Conservation in Households.	Flooding, heat stress, drought, and wildfires,	Water and Sanitation	0-2 years: Establish educational programs, initiate audits, organize workshops, and establish relationships with community leaders and stakeholders 3-5 years: Incentive programs are fully functional, significant increase in rainwater harvesting and water-efficient landscaping installations	High	Developing and distributing educational materials, conducting water audits, providing training and workshops, and engaging community leaders and stakeholders	Providing incentives for water conservation, encouraging the use of rainwater harvesting systems, and implementing water-efficient landscaping		High
Encouraging Businesses To Implement Water-Saving Measures.	Flooding, heat stress, drought, and wildfires.	Water and Sanitation	0-2 years: Establish partnerships with industry associations, launch outreach programs, and	High.	Developing and distributing guidance material, working with industry associations,	Conducting water audits, providing financial incentives, providing training and	Collaborating with large water users to develop customized plans and targets	High.

			develop guidance materials 3-5 years: Complete a majority of water audits, observe noticeable uptake in businesses implementing water-saving measures due to incentives and training 6-10 years: Achieve significant water savings through customized plans for large water users		conducting outreach and education programs	technical assistance		
Conducting Research On Water Conservation.	Flooding, heat stress, drought, and wildfires.	Water and Sanitation	0-2 years: Complete initial water usage studies, establish collaborations, and initiate public awareness campaigns 3-5 years: Implement new technologies in select areas for	High	Conducting studies on water usage patterns, initiating collaboration with stakeholders, and launching public outreach campaigns.	Developing and testing new technologies, analyzing the impacts of water conservation initiatives, and evaluating existing conservation programs.	Continued technology development and testing, program evaluation and refinement.	High

			testing, complete impact analyses, improve existing programs based on evaluations 6-10 years: Broad implementation of proven technologies, ongoing program refinement, continuous monitoring and impact evaluation					
Adaptation Programme 4: 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	Medium	Conduct a feasibility study to identify alternate water sources, and			High

			implemented.		undertake hydrological assessments to determine water availability and potential yield of alternative water sources.			
Investing in alternative water resources	Drought	Water and Sanitation	Year 3 – 5: Pilot Projects Year 6 – 10: Scaling	High		Implement	Implement	High
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 requirements, stakeholder engagement, and potential risks and mitigation strategies.	Implement	Implement	High
Adaptation Programme 5: Implementing Sustainable Groundwater Use and Development Strategy								
Conducting Groundwater Resource Assessments to Establish the	Drought	Water and Sanitation	Year 0-2: Completion of a groundwater management plan.	Medium	Develop a groundwater management plan	Implement	Implement	Medium

Availability and Quality of Groundwater in the SBDM Area.								
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 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 Potential Problems and Timely Intervention.	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 potential pollution sources.		High
Promoting Groundwater Conservati	Drought	Water and Sanitation	Year 0-2: Awarenes s	Medium	Develop and implement water	Establish a technical support structure.	Maintain	

on and Efficiency by Encouraging the Adoption of Water-Saving Technologies and Practices in all Sectors.			campaigns. Year 3 -5: Launch technical partnerships with spheres of government or private sector to promote water-efficient technologies.		conservation standards for new and existing municipal buildings and properties and encourage the adoption of water reuse/recycling technologies.			
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 Pollution	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	Implement and monitor.	Implement and monitor	

and Overuse.					regulations.			
Develop an 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 a 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.			
Climate Change Goal 2: Protect natural resources and ecosystems								
Programme 6: 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 Health	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 Health	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 projects.	Establish new protected areas.	High

Implementing programmes focused on mitigating the impact of climate change and severe weather, particularly in climate-risk zones.	Flooding	Environmental Health	Year 0-2: Develop an Ecosystem-Based Adaptation Plan. Year 3-5: Resource Plan and Implement	Medium	EBA Plan	Implement	Implement	High
Programme 7: Enhanced Natural Resource Management								
Ensuring the quality of water resources is critical to the sustainable development of UMDM, 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	Flooding	Environmental Health	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

maintain the quality of water resources.								
Provide training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines.	Flooding/ Drought/ Fire/ Heat Stress	Environmental Health	Year 0-2: Number of officials trained. Year 3-5: Number of officials trained. Monitoring and evaluation. Year 6-10: Number of officials trained. Monitoring and evaluation.	Low	Implement training programme.	Monitor	Monitor	Medium
Establish a District Environmental Management Forum (DEMF) to enhance collaboration and coordination between Sectoral Departments, Conversation Organisation and agencies related to natural resource management.	Flooding/ Drought/ Fire/ Heat Stress	Environmental Health	Year 0-2: Establish a 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
Programme 8: 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 Health	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 Health	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	Health	Water and Sanitation	Year 0-2: Develop policies and regulation	Low	Develop policies and regulations to	Implement	Implement	High

ecosystem services			s to assess the value of open spaces. Year 3-5: Implement		protect and manage these areas.			
Programme 9: Develop and Implement Conservation and Management Plan For Vulnerable Species.								
Develop and implement a conservation and management plan for vulnerable species.	Heat Stress, Drought, Environmental Health	Environmental Health	0-2 years: Complete species assessments, establish local partnerships, launch education and outreach programs 3-5 years: Prioritize species, implement conservation plans for prioritized species, integrate conservation plans into municipal policies 6-10 years: Continue implementation and updating of conservation plans, continue education and outreach programs	High	Conducting assessments of vulnerable species, initiating education and outreach programs, starting to form local partnerships	Identifying and prioritizing species, developing and beginning to implement conservation plans, integrating conservation plans into municipal policies	Ongoing implementation, monitoring and updating of conservation plans, continuous education and outreach programs	High
Climate Change Goal 3: Reduce the vulnerability and exposure of human and natural systems to climate change and extreme events								
Programme 10: 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 Ecosystem Rehabilitation	Fire	Disaster Management	0-2 years: Damage assessment and implementation of	Medium	Damage assessment and implementation of restoratio	Damage assessment and implementation of restoratio	Damage assessment and implementation of restoratio	

			restoration measures including erosion control, revegetation and wildlife management		n measures including erosion control, revegetation and wildlife management	n measures including erosion control, revegetation and wildlife management	n measures including erosion control, revegetation and wildlife management	
Policy and By-law Development	Fire	Disaster Management						
Programme 11: 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 3-5 years: Begin upgrades, repairs, and construction of new infrastructure based on the evaluation results 6-10 years: Complete large-scale infrastructure projects and start maintenan	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

			ce programs					
Mapping of Drainage Network	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	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, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	0-2 years: Design the new stormwater drainage and flood management infrastructure 3-5 years: Begin the construction of the designed	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

			infrastructure 6-10 years: Complete the construction and start maintenance, evaluation, and potential improvements					
Green Infrastructure Advocacy	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	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, Environmental Health, Heat Stress,		0-2 years: Acquire necessary GIS and	Medium	Acquire and implement GIS and	Completion of initial stormwater flow	Regular updates to models and	High

	Wildfires, Drought		hydraulic modelling tools, train staff in their use, and begin 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.		hydraulic modelling tools; staff trained and initial data collection started.	simulations and identification of high-risk areas	predictions based on new data; strategies are adjusted based on modelling outcomes.	
Implementation of Monitoring, Maintenance, and Management Plan	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	0-2 years: Establishment of a detailed maintenance and management plan. Begin regular inspections and maintenance tasks.	Medium	0-2 years: Develop a comprehensive maintenance and management plan. Begin implementing routine inspections and necessary system	3-5 years: Continue regular system maintenance. Refine and adjust management plans based on the outcomes of inspections and	6-10 years: Continue maintenance according to the management plan. Update the plan as necessary to adapt to changing conditions or new	High

			3-5 years: Maintenance tasks are being performed regularly, and the system's efficiency is improving. 6-10 years: Regular maintenance and inspections continue, and the system functions efficiently.		maintenance.	system performance.	infrastructure.	
Stakeholder Engagement	All	Infrastructure	0-2 Years; Engagement Occurred	Low	Engagement initiated	Ongoing	Ongoing	Medium
Field Surveys and Data Collection	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	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	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

			collection and analysis efforts, refine methodologies based on previous years' experience, and adjust strategies based on findings.					
Establishment of an Early Warning System	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Infrastructure	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	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

			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 channels as required.					
Public Awareness Campaigns and Education								
Training								
Monitoring and Evaluation								
Programme 12: Infrastructure Resilience and Public Health Education Programme.								
Comprehensive Infrastructure Assessment and Enhancement	Flooding, Extreme Rainfall, Heat Stress		0-2 years: Complete vulnerability assessment of existing infrastructure. Start retrofitting and upgrading high-risk	High	0-2 years: Conduct a comprehensive vulnerability assessment of existing infrastructure. Begin retrofitting and	3-5 years: Continue retrofitting and upgrading infrastructure as per assessment results. Maintain the regular inspection and	6-10 years: Ensure all identified infrastructure is retrofitted and upgraded. Continue with inspections and maintenan	High

			infrastructure identified. 3-5 years: All identified high-risk infrastructure retrofitted and upgraded. All flood lines reviewed and updated once. 6-10 years: Ongoing maintenance and inspections at set standards. Flood lines are reviewed and updated as necessary.		upgrading high-risk infrastructure. Initiate regular inspections and maintenance regime.	maintenance schedule. Undertake first review and update of flood lines.	ce. Conduct subsequent reviews and updates of flood lines as necessary.	
Climate Resilience and Emergency Preparedness	Flooding, Heat Stress, Extreme Weather Events		0-2 years: Incorporate climate resilience in all new infrastructure projects. Begin installation of emergency systems. Start community training on flood preparedness.	Medium to high	0-2 years: Begin incorporating climate resilience into all new infrastructure projects. Start the installation of emergency power and communication systems. Initiate	3-5 years: Complete installation of emergency systems across all high-risk areas. Continue the rollout of community training on flood preparedness.	6-10 years: Ensure all new infrastructure projects incorporate climate resilience. Ensure all communities have received flood preparedness training.	High

			3-5 years: Emergency systems installed in all high-risk areas. Majority of communities have received flood preparedness training. 6-10 years: All new infrastructure projects built with climate resilience. All communities trained in flood preparedness.		community training on flood preparedness.			
Education, Training, and Advocacy	Flooding, Heat Stress, Environmental Health, Wildfires, Drought		0-2 years: Development and initial implementation of public education programs and anti-littering campaigns. Begin training sessions for engineers and urban planners. 3-5 years: Public education programs	Medium	0-2 years: Begin development of public education programs and launch the anti-littering campaign. Start organizing training sessions for engineers and urban planners.	3-5 years: Complete the roll-out of public education programs and continue with the anti-littering campaign. Continue providing regular training for engineers and urban planners.	6-10 years: Sustain public education efforts and the anti-littering campaign. Keep the training of engineers and urban planners up-to-date with the latest resilience techniques and technologies.	High

			and anti-littering campaigns reach a majority of the population. Most engineers and urban planners have received training. 6-10 years: Public education programs and anti-littering campaigns are fully integrated into community practices. All engineers and urban planners are trained in resilient infrastructure techniques.					
Monitoring, Evaluation, and Adaptive Management	Flooding, Heat Stress, Environmental Health, Wildfires, Drought		0-2 years: Establish regular monitoring and evaluation processes for all programs. 3-5 years: Use feedback from monitoring and evaluation	Low to Medium	0-2 years: Develop and implement a monitoring and evaluation plan for each program. Begin regular monitoring and initial	3-5 years: Continue regular monitoring and evaluation, making adjustments as needed to improve program effectiveness.	6-10 years: Continue monitoring and evaluation, making further refinements and adaptations to improve performance and address	High

			to make meaningful adjustments to improve program effectiveness. 6-10 years: Ensure all programs are responsive to evolving needs and demonstrate continuous improvement through regular adjustments.		evaluations.		changing needs.	
Programme 13: 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.	All	Environmental Management	Year 0-2: Assess the vulnerability of infrastructure to climate change. Year 3-5: Implement	Medium	Assess the vulnerability of infrastructure to sea-level rise and coastal flooding.	Develop and implement climate-resilient infrastructure.	Implement and maintain.	Medium
Developing and implementing an early warning system to help communities prepare	All	Disaster Management	Year 0-2: Install weather monitoring systems. Year 3-5: Enforce an early	Medium	Install weather monitoring systems to provide real-time data on extreme weather	Enforce an early warning system	Enforce an early warning system	High

for and respond to climate change risks.			warning system.		events and develop warning protocols.			
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 and flooding.	Flooding	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 14: Advancing Towards a Climate-Smart Circular Economy								
Shift Towards a Circular Economy	All	Waste Management	0-2 years: Develop and implement a circular economy policy and action plan, conduct a waste audit, develop	Medium to High	Circular economy policy and action plan established, comprehensive waste audit completed, initial	Waste reduction targets met, recycling programs operational, product stewardship initiatives in place, local	Ongoing achievement of targets and further refinement of strategies based on evidence and experience	High

			initial circular economy strategies, initiate collaborations with research institutions 3-5 years: Implementation of waste reduction targets, initiation of recycling programs and product stewardship initiatives, education and outreach programs, promotion of green procurement policies, support to local businesses 6-10 years: Monitor and update circular economy policies and action plans, continue supporting local businesses, expand and refine recycling programs,		strategies developed	businesses adopting circular economy practices, green procurement policies implemented	, with an established and robust circular economy in place	

			and continue research collaboration and education programs.					
Climate-Smart Waste Management	Flooding, Heat Stress, Wildfires, Drought.	Waste Management	0-2 years: Conduct feasibility study, develop initial recycling programs 3-5 years: Establish recycling centres, fully implement recycling programs, start monitoring and evaluation 6-10 years: Continue to monitor and adjust recycling programs for maximum effectiveness, expand as necessary	Medium to High	Complete feasibility study, design and initiate recycling programs	Recycling centres are established and operational, recycling programs are fully functional, and monitoring systems are in place.	Achieve targeted recycling rates, and show evidence of reduced waste through continued monitoring and evaluation.	High
Staff Training and Capacity Building	Flooding, Environmental Health, Heat Stress, Wildfires, Drought.	Waste Management	0-2 years: Identify key areas of knowledge, develop and start implementing the training program 3-5 years: Fully	Low to Medium	Key knowledge areas identified, an initial version of the training program developed, the start of implementation	Training program fully operational, ongoing support provided, regular review process established	Continued implementation, review, and updating of the training program, demonstrated improvement in staff	High

			implement the training program, provide ongoing support, start regular reviews and updates 6-10 years: Continue providing ongoing support, regular reviews, and updates, assess the overall impact and adjust as necessary				skills and effectiveness	
Improved Waste Collection and Transportation	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Waste Management	0-2 years: Assessment completed, upgrade plan developed 3-5 years: Commence the implementation of the upgrade plan 6-10 years: Continued implementation, maintenance, and effectiveness monitoring, demonstra	High	Conduct the assessment, develop the upgrade plan	Begin implementation of the upgrade plan, and monitor its effectiveness	Continue implementation, routine maintenance, monitoring, and adjustments	High

			ting improved efficiency and reliability					
Public Awareness and Illegal Dumping Reduction	Flooding, Environmental Health, Heat Stress, Wildfires, Drought	Environmental Health	0-2 years: Develop and launch a public awareness campaign, begin organizing community clean-up events, collaborate with law enforcement 3-5 years: Continue with these activities while beginning to monitor and evaluate effectiveness, adjust strategies as necessary 6-10 years: Ongoing activities, monitoring and evaluation, and continuous adjustments as necessary	Medium	Successful launch of the public awareness campaign and community clean-up events, agreements with law enforcement in place	Observable reduction in illegal dumping incidents, higher public awareness levels	Sustainable reduction in illegal dumping incidents, maintenance of high public awareness, ongoing effectiveness of law enforcement	High
Programme 15: Community-Based Adaptation in Communities Most at risk of climate-related hazards								
Conducting granular risk and	All	Environmental Health	Year 0-2: Develop	Low	Develop adaptation measures	Implement	Implement	

vulnerability assessments in communities to identify drivers of risk and develop appropriate adaptation measures.			adaptation measures. Year 3-5: Implement		for populations most at risk.			
Developing and implementing community-based adaptation measures to reduce risks and build resilience falls under the purview of relevant departments.	Flooding/ Drought	Environmental Health	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 Health	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	All	Environmental Health	Year 0-2: Climate change awareness raising.	Low	Raise climate change awareness for	Implement training and education programm	Continue awareness raising, developing partnershi	

Public Awareness Initiative on Climate Change.			Year 3-5: Implement training and education programmes		communities.	es for community members.	ps and capacity building.	
Adaptation Programme 16: Climate Resilient Spatial Planning for Climate Resilient Growth and Development								
Ensure that spatial planning frameworks consider a long-term view of climate hazards and incorporate natural infrastructure.	All	Planning and Local Economic Development	Year 0-2: Develop guidelines for climate-resilient spatial planning. Year 3-5: Implement guidelines	Low	Develop guidelines for climate-resilient spatial planning.	Implement guidelines	Implement and monitor	
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		Medium	Develop strategies to manage risks and protect infrastructure and assets from climate change impacts.	Implement strategies.	Implement and monitor strategies.	

Programme 17: Enhanced Climate-Resilient Agricultural Practices.								
Promotion and Implementation of Sustainable Farming Techniques.	Drought and Heat Stress		0-2 years: Initiate climate-smart agricultural training sessions and establish guidelines for soil and water conservation practices. 3-5 years: Continue and expand training sessions, and begin facilitating pilot projects in local municipalities. 6-10 years: Full implementation of soil and water conservation guidelines and practices, evaluate and iterate on pilot projects.	Medium	0-2 years: Train a targeted number of farmers in climate-smart agriculture, and establish conservation guidelines. 6-	3-5 years: Achieve significant farmer participation in pilot projects, and observe initial improvements in soil and water conservation.	10 years: Demonstrate noticeable improvement in agricultural resilience, and widespread adoption of sustainable farming techniques.	High
Implementation of Drought and Heat-Resistant Crop Varieties	Drought and Heat Stress		0-2 years: Partnerships with agricultural research institutions establishe	Medium	0-2 years: Establish partnerships with agricultural research institutions, initiate	3-5 years: Start distributing developed seeds, increase the scale	6-10 years: Widespread adoption of climate-resilient crop varieties, regular	High

			d, research on drought and heat-resistant crops initiated, initial seed bank programs set up. 3-5 years: Developed seeds distributed to a significant number of farmers, increased participation in seed bank programs, regular farmer field days attended by a considerable percentage of local farmers. 6-10 years: High adoption rate of climate-resilient crops, established and fully operational seed banks and exchange programs, farmer field days are a regular		research and development of heat and drought-resistant crops, and start seed bank programs.	of seed bank programs, and organize regular farmer field days.	operation of seed banks and exchange programs, regular organization of farmer field days.	

			and well-attended event.					
Strengthening Livestock Health and Resilience	Drought, Heat Stress, Disease Spread		0-2 years: Begin promotion of heat and disease-resistant livestock breeds, initiate veterinary support programs, and start implementing water access initiatives. 3-5 years: Scale up veterinary support programs and water access initiatives, and continue promoting livestock breed diversification. 6-10 years: Achieve widespread adoption of resilient livestock breeds and regular operation of veterinary support programs, fully implemented water	Medium	0-2 years: Initiation of programs and promotion campaigns, increased number of heat and disease-resistant livestock breeds in the area, initial implementation of water access initiatives	. 3-5 years: Veterinary support programs helping a significant number of farmers, increasing use of water access initiatives, growing adoption of resilient livestock breeds.	6-10 years: High adoption rate of resilient livestock breeds, veterinary support programs and water access initiatives benefitting a majority of livestock farmers.	High

			access initiatives.					
Programme 18: Improved Infrastructure and Natural Resource Management.								
Water resource management and conservation.	Drought, Heat Stress		0-2 years: Develop and begin implementing water conservation policies, start enhancing irrigation system efficiency, and initiate water infrastructure maintenance. 3-5 years: Continue implementation and enforcement of water conservation policies, further enhancement of irrigation systems, ongoing maintenance, and upgrade of	Medium	0-2 years: Initial implementation of water conservation policies, begin improvements in irrigation systems, start of water infrastructure maintenance and upgrades.	3-5 years: Increasing adoption of water conservation policies and efficient irrigation, continued improvement in water infrastructure.	6-10 years: Significant improvement in water usage efficiency in the agricultural sector, complete integration of water conservation policies, substantial upgrades in water infrastructure.	High

			water infrastructure. 6-10 years: Widespread adoption of water conservation policies and efficient irrigation techniques, completion of significant water infrastructure upgrades.					
Implement programs for agroforestry and rehabilitation of degraded agricultural lands.	Drought, Heat Stress, Flooding		0-2 years: Initiate promotion of agroforestry practices, and begin development of rehabilitation strategies. 3-5 years: Widespread implementation of agroforestry practices, ongoing development and start of implementation for rehabilitation strategies.	Medium	0-2 years: Start of agroforestry promotion, initiation of rehabilitation strategy development.	3-5 years: Significant uptake of agroforestry practices, commencement of rehabilitation strategy implementation.	6-10 years: Extensive use of agroforestry practices, significant progress in rehabilitating degraded lands.	High

			6-10 years: Full adoption of agroforestry practices in suitable areas, comprehensive implementation of land rehabilitation strategies.					
Conduct regular assessments of agricultural ecosystem health and biodiversity.	Flooding, Heat Stress, Drought		0-2 years: Initiate regular agricultural ecosystem health assessments, start developing biodiversity indicators, and monitor systems. 3-5 years: Consolidate regular health assessments, complete development and start implementing biodiversity monitoring systems. 6-10 years: Routine ecosystem health	Medium	0-2 years: Initiate regular health assessments, and commence the development of biodiversity indicators and monitoring systems.	3-5 years: Consolidated ecosystem health assessments, and operational biodiversity monitoring systems.	6-10 years: Comprehensive ecosystem health reports, full application of biodiversity monitoring systems.	High

			assessments in place, fully operational biodiversity monitoring systems.					
Establish protected buffer zones around agricultural lands to safeguard critical ecosystems and promote biodiversity.	Flooding, Wildfires, Drought		0-2 years: Begin the land-use planning process and start educating farmers about biodiversity-friendly farming practices. 3-5 years: Establish protected buffer zones around key agricultural areas and see widespread adoption of biodiversity-friendly practices on farms. 6-10 years: In all major agricultural areas surrounded by buffer zones, biodiversity-friendly farming practices are the norm.	Medium	0-2 years: Initiate land-use planning, commence farmer education.	3-5 years: Protected buffer zones established, majority of farmers practicing biodiversity-friendly farming.	6-10 years: Complete buffer zone establishment, all farmers practising biodiversity-friendly farming.	High

Development of climate-resilient infrastructure.	Flooding, Heat Stress, Wildfires		0-2 years: Develop and implement guidelines and regulations for climate-resilient infrastructure. 3-5 years: Begin major upgrades of existing infrastructure; start implementing green infrastructure solutions. 6-10 years: Complete all major upgrades; green infrastructure solutions fully integrated.	High	0-2 years: Finalize guidelines for climate-resilient infrastructure; begin training programs.	3-5 years: 50% of existing infrastructure upgraded; 25% of green infrastructure solutions integrated.	6-10 years: 100% of existing infrastructure upgraded; 100% green infrastructure solutions integrated.	High
Programme 19: Building Agricultural Resilience through Climate Change Education, Capacity Building, and Enhancement of Local Practices.								
Climate change education and awareness campaigns - agricultural focus	Flooding, Heat Stress, Wildfires, Drought		0-2 years: Launch climate change awareness campaigns, start collaborations with schools and institutes, and initiate communication through	Low	0-2 years: Initial campaign launch and educational curriculum integration, establish regular communication through media.	3-5 years: Reach at least 50% of farmers and agricultural stakeholders with awareness campaigns, 75% of agricultural schools incorporating climate	6-10 years: Reach over 90% of the farming community with awareness campaigns, and 100% agricultural schools with integrated climate	High

			media outlets. 3-5 years: Establish ongoing and seasonal campaigns, fully integrate climate change education into the curriculum, and maintain regular updates via media. 6-10 years: Evaluate, refine and expand education and awareness initiatives as necessary based on evolving climate change impacts and agricultural advances.			change education.	change education.	
Capacity building and training programs - agricultural focus	Flooding, Heat Stress, Wildfires, Drought		0-2 years: Conduct initial training sessions for farmers and agricultural stakeholders, form adaptation committee	Medium	0-2 years: Begin organizing workshops and developing training materials, establish initial adaptation committees, start promoting	3-5 years: Regularly update training programs with latest climate adaptation knowledge, strengthen and expand adaptation	6-10 years: Assess and refine training programs and materials, consolidate role of adaptation committees in local governance	High

			s, establish a certain number of community gardens. 3-5 years: Reach 50% of the farming community with training and capacity building programs, have functioning adaptation committees across the district, see community gardens becoming integral part of local food security strategies. 6-10 years: Achieve broad coverage of training programs across the farming community, see adaptation committees playing a significant role in shaping local policies,		community gardens.	committees, increase support for community gardens.	structures, evaluate the impact and benefits of community gardens.	

			and observe clear benefits from community garden initiatives.					
Enhancing local knowledge and practices - agricultural focus			0-2 years: Complete the documentation of a significant number of traditional practices, have a certain number of farmer-led initiatives underway, and the knowledge-sharing platform is live. 3-5 years: See the use of traditional practices and engagement in farmer-led initiatives increasing, and the knowledge-sharing platform is actively used by a significant portion of the farming community.	Low	0-2 years: Begin documentation of traditional practices and promoting farmer-led initiatives, and start the development of a knowledge-sharing platform.	3-5 years: Continue to support farmer-led initiatives, and further develop and refine the knowledge-sharing platform.	6-10 years: Regular review and updates of documented practices, see the farmer-led initiatives and knowledge-sharing platform becoming a self-sustaining part of the agricultural community.	High

			6-10 years: Traditional practices widely integrated into modern farming techniques, farmer-led initiatives playing a key role in the agricultural community, the knowledge-sharing platform serving as a vital resource for the farming community.					

5.1. Enabling Mechanisms for Implementation

5.1.1. Institutional Arrangements

In the UMDM, South Africa, the development of a Climate Change Response Strategy marks a critical milestone towards combating the effects of climate change. The efficiency of this strategy is anchored in the optimal arrangement of institutional structures within the municipality, echoing the commitment demonstrated in successful endeavours such as the uMngeni Resilience Project (URP).

An integral first step for UMDM could involve a comprehensive appraisal of the Climate Change Response Strategy to discern specific climate mitigation actions that require implementation. From this analysis, the municipality can delegate roles and responsibilities to relevant departments, leveraging their distinctive abilities, resources, and capacities to execute the actions efficiently. The uMngeni Resilience Project, initiated in UMDM with substantial support from the United Nations Adaptation Fund, serves as an illustration of effective action and delegation. The UMDM was the primary project partner and executing agency, collaborating with the University of KwaZulu-Natal's School for Agriculture, Earth and Environmental Sciences (UKZN SAEES) and the South African National Biodiversity Institute (SANBI).

Similarly, UMDM could assign the lead role for each climate action to a department possessing the appropriate expertise, resources, and capacity. Identifying departments that can contribute to the realisation of these climate actions would also be beneficial. The departments' synergistic strengths and capacities should guide the assignment of supporting roles. Consulting with departmental heads could facilitate consensus on the designated roles and also identify potential hurdles and strategies for efficient implementation.

However, it's important to note that while the function of Climate Change falls under the "Economic Development and Planning" portfolio within the Department of Local Economic Development of the District, the position responsible for this function is currently vacant. This absence highlights the need for immediate action to ensure that climate change mitigation remains at the forefront of economic and strategic planning within the municipality, as demonstrated by the URP and other initiatives.
Moreover, aligning the Climate Change Response Strategy with each department's specific plans and policies is critical for integrating climate mitigation efforts into all municipal operations. For instance, the Department of Economic Development and Strategic Services' Integrated Development Plan, Spatial Development Framework, and Local Economic Development Strategy can integrate specific targets and actions related to climate change.

By adopting these strategies, UMDM can reflect the integrated approach as demonstrated by the URP in its Climate Change Response Strategy, fostering an institutional ethos that recognises

climate change as a central consideration in every aspect of municipal operations, despite the current vacancy of the position overseeing this vital function.

5.1.2. Governance Considerations

In the context of the UMDM, it is recommended that each department within the municipality be given specific responsibilities related to climate change. These responsibilities should be coupled with key performance indicators (KPIs) that monitor and evaluate progress towards defined climate objectives. This can be achieved by aligning existing plans and strategies with climate change targets and subsequently tracking the progression towards these targets using dedicated KPIs.

The sectoral departments within uMDM could synchronize their key plans—such as the Integrated Development Plan (IDP), Spatial Development Framework, and Local Economic Development Strategy—with climate change objectives. This synchronisation can serve as a powerful driving force guiding the region towards a climate-resilient future.

Moreover, each department can establish and monitor KPIs tailored to these climate change goals. These KPIs could cover a range of parameters, from measuring the number of local businesses implementing sustainable practices to monitoring the amount of renewable energy harnessed within the municipality.

The municipality should be prepared to confront and manage natural disasters—like floods and wildfires—that are predicted to increase in frequency and severity due to climate change. By integrating climate change objectives with existing plans and strategies, and monitoring progress through KPIs, UMDM can ensure that climate change responses are integrated into all areas of municipal operations. This comprehensive integration will serve as a strong confirmation of the municipality's advancement towards a sustainable future. It will also verify the municipality's readiness to handle the challenges and impacts associated with climate change, thereby protecting its communities and natural assets.

5.1.3. Information Management

Nurturing a culture that emphasizes risk avoidance is crucial for the successful execution of the climate change response plan within the UMDM. This involves enabling all stakeholders—including officials, policymakers, and residents—through comprehensive education, extensive training, and vigorous public awareness initiatives, all founded on scientific research. This strategic course of action will promote a more profound understanding of climate change implications and the necessary responses, and foster a collective sense of responsibility and stewardship among all involved parties.

To achieve this goal, UMDM could undertake the following measures:

- Education and Training: The municipality can plan and implement a comprehensive educational and training programme focused on climate change and its impacts on the municipality. By targeting officials, policymakers, traditional authorities and residents, this programme will ensure a universally shared understanding of climate change and underscore the urgency of responsive action.
- Scientific Research and Data Utilisation: The Municipality can use scientific research and data to guide the development of educational and training content, ensuring that stakeholders are equipped with the most accurate and current information. This can also assist in identifying key risk areas and zones requiring immediate attention.
- Public Awareness Initiatives: uMDM can organise public awareness campaigns centred around climate change and its effects. These initiatives could be communicated through various channels, including social media, community workshops, and public gatherings. The aim of such campaigns is to raise public understanding of climate change, highlight the need for action, and provide practical advice on individual steps to mitigate the impact.
- Stakeholder Engagement: The municipality can promote active participation in climate change mitigation and adaptation efforts by residents, traditional authorities, civil society organisations, and the private sector. This could involve providing platforms for engagement and collaboration, forming partnerships with relevant stakeholders to design and implement joint initiatives, and offering resources and support to individuals and organisations actively responding to climate change.

Lastly, UMDM can foster partnerships with academic institutions and research organizations to ensure ongoing access to the latest research and expertise in the field of climate change. This will ensure that the municipality stays updated with the most recent developments in the field and can utilize the latest knowledge and tools to inform its decision-making and strategies.

5.1.4. Funding Mechanisms

Climate change poses an escalating challenge for local municipalities in South Africa, necessitating substantial funding allocations to mount an effective response. Several funding mechanisms are available to propel these climate change response initiatives, ranging from national and international grants to public-private partnerships and municipal budgets. Nonetheless, municipalities might grapple with issues such as insufficient funding, capacity constraints for effective fund management, and limited access to funding resources.

One such mechanism is the Municipal Infrastructure Grant (MIG), offering fiscal support to municipalities for the development of fundamental infrastructure, including water, sanitation, and solid waste management. The MIG can also be utilized to fund climate change response projects tethered to these infrastructure needs. However, the MIG's limited scope could present challenges for municipalities striving to finance all necessary climate change initiatives solely via this conduit.

An alternate source of funding available to municipalities is the Green Fund, a national financial mechanism proffering financing for environmentally responsible initiatives. Projects aligned with renewable energy, energy efficiency, climate change adaptation, and mitigation can tap into the Green Fund. Yet, the fund's finite resources and substantial competition from other municipalities and organizations make it a challenging source to access.

Municipalities can also seek funding from international entities such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF). These institutions extend financing to climate change response programmes in developing nations. However, satisfying the stringent eligibility criteria to access these funds can be demanding for municipalities.

Public-Private Partnerships (PPPs) offer an additional route to financing climate change response initiatives. These partnerships represent collaborative efforts between the public and private sectors to fund and execute infrastructure projects. PPPs can furnish municipalities with alternative funding sources and the advantage of private sector expertise in project management and implementation. Nevertheless, municipalities must ensure equitable terms within the partnership and a shared commitment towards the project's objectives.

Municipalities may confront several challenges in sourcing funding for climate change response initiatives. The lack of in-house technical expertise to develop and implement climate change projects can be a formidable barrier to accessing funds from entities like the Green Fund, which typically demand comprehensive project proposals and technical competence.

Furthermore, the limited resources earmarked for climate change response in municipalities already experiencing financial constraints can pose a significant challenge. In many South African municipalities, financing climate change response initiatives might be deprioritized against other basic service delivery needs, making resource allocation to climate change response programs challenging.

To surmount these hurdles, municipalities should emphasize building internal technical capacities and forging partnerships with private sector organizations to unlock additional funding sources. Municipalities should also explore novel financing mechanisms, such as green bonds and crowdfunding, which have proven successful in other jurisdictions.

In conclusion, while funding mechanisms exist for South African local municipalities to finance climate change response initiatives, municipalities must navigate a complex labyrinth of funding sources and ensure they possess the technical proficiency and capacity to develop and implement successful projects. By investigating innovative financing mechanisms and building partnerships with private sector organizations, municipalities can marshal the resources required to create more resilient and sustainable communities.

5.2. Recommendations for mainstreaming

Mainstreaming climate adaptation within the UMDM requires a multidimensional approach that considers the existing institutional structures, processes, and instruments within the district. The overall strategy should focus on integrating climate-responsive thinking into every aspect of the municipality's operations, making it a standard consideration rather than an isolated concern.

1. Opportunities for mainstreaming: Multiple opportunities for mainstreaming exist within UMDM. For example, the District Development Model (DDM) offers an integrated planning and delivery framework across different government spheres, making it an ideal platform for incorporating climate adaptation into existing strategies. Climate adaptation considerations can be integrated into the unified "One Plan" approach of the DDM.
2. Leveraging existing decision-making structures: Existing decision-making structures, such as the Project Management Unit (PMU), can be utilized to advance climate adaptation. For instance, the PMU's project assessment and approval framework can be revised to include climate responsiveness/adaptation/sustainability, ensuring all new initiatives are climate-friendly.
3. Targeting planning instruments for mainstreaming: Crucial planning instruments like the Integrated Development Plan (IDP), Spatial Development Framework, and Local Economic Development Strategy can be targeted for integrating climate adaptation. These documents can be updated to include climate evidence and adaptation measures.

Some specific mainstreaming recommendations include:

- Key Performance Indicators (KPIs): Climate response/adaptation/sustainability outcomes should be incorporated into the KPIs of all departments, enabling the tracking and measurement of progress towards climate goals.
- Raising Awareness: Awareness training can be conducted for groups such as the Project Management Unit, Strategic Procurement, Councillors, and other relevant entities to facilitate mainstreaming. Improved understanding of climate change and adaptation needs will enable these groups to better integrate climate considerations into their activities.
- Policy and Plan Updates: Existing policies and plans should be revised to reflect the climate risk profile and adaptation measures. This could involve integrating climate change considerations into land use plans, infrastructure development strategies, and emergency management plans.
- Funding: uMDM should explore existing and new revenue sources to support climate adaptation/response efforts. This could involve applying for grants from government agencies, participating in public-private partnerships, and integrating climate adaptation into budget planning processes.
- Capacity Building: Ongoing training and capacity building of officials in all departments is required to enhance their understanding of climate change and their capability to incorporate climate considerations into their work.

- Establishing Networks or Partnerships: UMDM should consider establishing networks or partnerships with civil society organizations, the private sector, government, and other relevant entities to bolster climate adaptation efforts.

At the heart of these strategies is the DDM, which can serve as the foundation of these efforts. By adopting a "One District, One Plan, One Budget" approach, uMDM can ensure that all development initiatives within the district are climate-friendly. The DDM's objectives of breaking down silos, maximising impact, narrowing the distance between people and government, and ensuring sustainable development align well with the goal of mainstreaming climate adaptation. In conclusion, mainstreaming climate adaptation in uMDM necessitates a comprehensive, integrated approach that leverages existing structures and processes, builds capacity, and engages all stakeholders. By taking these steps, uMDM can ensure a more sustainable and resilient future for its communities and the environment.

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