GREENBOOK
adapting settlements for the future

Madibeng Local Municipality Adaptation Action Plan

JULY 2024

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List of Acronyms and Abbreviations

CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DFFE	Department of Forestry, Fisheries and the Environment
DHS	Department of Human Settlements
DRR	Disaster risk reduction
HDA	Housing Development Agency
IPCC	Intergovernmental Panel on Climate Change
LRT	Let's Respond Toolkit
MLM	Madibeng Local Municipality
PHDA	Priority Housing Development Area
PHS	Priority Human Settlement
PHSHDA	Priority Human Settlement and Housing Development Area
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No.16 of 2013)

Glossary of Terms

Adaptation actions	A range of planning and design actions that can be taken by local government to adapt to the impacts of climate change, reduce exposure to hazards, and exploit opportunities for sustainable development (CSIR, 2019).
Adaptation planning	The process of using the basis of spatial planning to shape built-up and natural areas to be resilient to the impacts of climate change, to realise co-benefits for long-term sustainable development, and to address the root causes of vulnerability and exposure to risk. Adaptation planning assumes climate change as an important factor while addressing developmental concerns, such as the complexity of rapidly growing urban areas, and considers the uncertainty associated with the impacts of climate change in such areas – thereby contributing to the transformational adaptation of urban spaces. Adaptation planning also provides opportunities to climate proof urban infrastructure, reduce vulnerability and exploit opportunities for sustainable development (National Treasury, 2018; Pieterse, 2020).
Adaptive capacity	"The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2022, p. 2899).
Climate change adaptation	"In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2022, p. 2898).
Climate change mitigation	"A human intervention to reduce emissions, or enhance the sinks, of greenhouse gases (GHGs)" (IPCC, 2022, p. 2915). The goal of climate change mitigation is to achieve a reduction of emissions that will limit global warming to between 1.5°C and 2°C above preindustrial levels (Behsudi, A, 2021).
Climate hazards	Climate hazards are a sub-set of natural hazards and a grouping of hydrological, climatological, and meteorological hazards. This includes the spatial extent and frequency of, among others, floods, fires, and extreme weather events such as extreme rainfall and extreme heat. Sometimes referred to as hydrometeorological hazards. The potential occurrence of a climate hazard may cause loss of life, injury, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2022). Climate hazards can increase in intensity and frequency with climate change (Pieterse et al., 2023).
Climate risk	Risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and a hazard. Relevant adverse consequences include those on "lives and livelihoods, health and well-being, economic and sociocultural assets, infrastructure and ecosystems" (IPCC,

	2022, p. 144). In the IPCC's 6th Assessment Report, it is confirmed that risks may result from "dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system" (IPCC, 2022, p. 132).
Coping capacity	"The ability of people, institutions, organizations and systems, using available skills, values, beliefs, resources and opportunities, to address, manage, and overcome adverse conditions in the short to medium term" (IPCC, 2022, p. 2904).
Disaster risk reduction	"Denotes both a policy goal or objective, as well as the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard or vulnerability; and improving resilience" (IPCC, 2022, p. 2906).
Exposure	Exposure implies the physical exposure of elements to a climate hazard. It is defined as the "presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected [by climate hazards]" (IPCC, 2022, p. 2908).
Mainstreaming	The process of integrating climate change adaptation strategies and measures into existing planning instruments and processes as opposed to developing dedicated adaptation policies and plans (Pieterse et al., 2021).
Resilience	"The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation" (IPCC, 2022, pp. 2920–2921).
Sensitivity	"The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)" (IPCC, 2022, p. 2922).
Vulnerability	Vulnerability is defined as the "propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including, sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2022, p. 2927). Vulnerability refers to the characteristics or attributes of exposed elements, i.e., elements that are exposed to potential climate-related hazards. Vulnerability is a function of sensitivity and (coping or adaptive) capacity (Pieterse et al., 2023).

1. Introduction

Climate change impacts vary widely from region to region in South Africa, and are reflected by floods, droughts, heatwaves, and coastal erosion, among others. These impacts directly threaten life, economic well-being, property, infrastructure, and ecosystems as well as the ability of local government to provide public services. It is local government's responsibility and duty to provide leadership in planning and preparing to manage these risks for the sake of the well-being, safety, and security of individuals within their jurisdiction (SABS, 2023). The purpose of this document is to strengthen the capability of local government to prepare for climate change threats and associated risks.

The Climate Change Adaptation Plan and its accompanying Risk Profile report have been specifically drafted for the Madibeng Local Municipality (MLM) with the aim of strengthening its strategic response to climate change. These documents derive their insights from the GreenBook (www.greenbook.co.za), a freely accessible online planning support system. The GreenBook is a unique and invaluable resource, providing quantitative scientific evidence to assist local governments in comprehending their climate risks. It plays a pivotal role in guiding the adaptation of settlements to withstand the impacts of both current and future climate challenges.

Designed as an information-rich tool, the GreenBook caters to South African local governments, offering insights into risks and vulnerabilities associated with population growth, climate change, exposure to hazards, and the vulnerability of critical resources. Moreover, the GreenBook not only diagnoses these challenges but also provides practical adaptation measures. These measures are essential for cities, towns, and settlements, empowering local government to mitigate the impacts of climate hazards on communities, the environment, the economy, and municipal assets and infrastructure, while aligning with broader developmental goals (refer to Green Book | Adapting settlements for the future).

The Climate Risk Profile and the Climate Change Adaptation Plan serve distinct yet interlinked purposes and strategic objectives. They aim to:

1. Drive and advance the local climate change response agenda.
2. Provide a foundational framework for strategy and planning within the Local Municipality, with a specific focus on Priority Human Settlements or Priority Housing Development Areas (PHSDAs).
3. Systematically identify and prioritise risks and vulnerabilities.
4. Pinpoint and prioritise targeted interventions and responses.
5. Facilitate the integration of climate change response, particularly adaptation, into mainstream policies and practices.

In essence, these documents are instrumental in equipping Madibeng Local Municipality with a comprehensive strategy to navigate the complexities of climate change, reduce vulnerability and exposure, and champion sustainable development.

The Adaptation Action Plan briefly outlines the policies constituting the framework for adaptation in South Africa. It then goes on to describe generic adaptation principles, approaches, pathways, and various categories of actions. Subsequently, the plan suggests a specific adaptation strategy for Madibeng LM by aligning it with adaptation goals, programmes, and actions designed to address priority risks. Finally, the document concludes with recommendations aimed at facilitating the integration of the proposed actions into broader initiatives, ensuring their effective mainstreaming.

2. Policy Framework

South Africa's institutional policy and legislative framework makes provision for climate change adaptation at all levels of government, with local government increasingly identified as the primary driver 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, i.e., Act No. 16 of 2015, the Spatial Planning and Land Use Management Act (SPLUMA), i.e., Act No. 16 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 involves accommodating "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) amongst the key principles intended to guide municipal planning and development. The Climate Change Bill (DEA, 2018) 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 risk assessments, as well as climate change response and -implementation plans.

Moreover, 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 (DEA, 2019) outlines several actions that are applicable at local government level, including the development and implementation of adaptation strategies and vulnerability reduction programmes for communities and individuals that are most at risk to the impacts of climate change; the development of municipal early warning systems; as well as the integration of climate change adaptation into municipal development plans and relevant sector plans.

In response to the national call to advance spatial transformation and consolidation in human settlement development, the National Department of Human Settlements (DHS) has identified and gazetted a total of 136 Priority Human Settlements and Housing Development Areas (PHSHDAs). The PHSHDAs were declared to ensure that housing delivery is used to restructure and revitalise towns and cities, strengthen the livelihood prospects of households, and overcome apartheid spatial patterns by fostering integrated urban forms (DHS, 2020). PHSHDAs were designated using national criteria which includes an area or settlement's potential to support sustainable environmental management (which plays a critical role in mitigating the negative impacts of climate change, particularly through nature-based adaptation

solutions), as well as its potential to accommodate the integration of land uses and amenities, i.e., in addition to other criteria.

The DHS has identified two key objectives for PHSHDAs, including (1) targeting and prioritising areas for integrated housing and human settlements development to ensure the delivery of housing for a diverse range of income groups within an integrated mixed-use development, as well as (2) transforming spatial patterns which have historically exacerbated social inequality and economic inefficiency (DHS, 2020). As part of the second objective, this initiative aims to develop post-apartheid cities and city patterns that ensure urban access, as well as achieve a balance between spatial equity, economic competitiveness and environment sustainability (DHS, 2020). As the impacts of climate change become more severe, the latter outcome (i.e., ensuring and maintaining environmental sustainability) will become increasingly important.

Furthermore, as part of the implementation approach for housing and human settlement development in PHSHDAs, the DHS has identified the provision and maintenance of ecological infrastructure to support development in priority areas as a key avenue for integrating climate considerations and mainstreaming climate responses, including climate change adaptation.

3. Adaptation Principles, Approach, Programmes & Actions

Climate change mitigation and adaptation refer to the two primary strategies aimed at addressing the adverse effects of climate change, i.e., by either delaying, reducing, redistributing, or avoiding the impacts. 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.

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, 2022, p. 2898) that may derive from unavoidable impacts of climate change such as extreme hazards. The climate change adaptation agenda is concerned with adapting species, people, places, assets, and systems, to the impacts of actual or anticipated climate-related risks and implements various measures or actions to achieve this (Behsudi, 2021; C40, 2020).

This section of the report outlines adaptation principles, drawing from the recommendations by the South African Bureau of Standards. It also presents a structured approach to selecting adaptation options, categorises adaptation actions, and explains the concept of an adaptation pathway.

3.1 Adaptation principles

The Bureau for Standards recently proposed the following principles that apply to local government when adapting to climate change (SABS, 2023):

i. Accountability: Local governments not only acknowledge but also assume responsibility for their climate change adaptation efforts. They willingly subject themselves to appropriate scrutiny and accept the duty to respond to this scrutiny.
ii. Continual learning and improvement: Recognising the uncertainties in knowledge and the dynamic nature of drivers of change, available knowledge and evidence, and the contextual factors, continual learning and improvement are essential for effective climate change adaptation.

iii. Mainstreaming and embedding: The effectiveness of climate change adaptation is maximised when integrated into local government operations, encompassing policies, plans, procedures, risk management, and implementation strategies.
iv. Flexibility: Embrace a flexible approach that considers technical, social, administrative, political, legal, environmental, and economic circumstances. This allows for the accommodation of a diverse range of data availabilities and technical and institutional capacities to meet goals and objectives.
v. Practicality: Set practical and achievable goals and objectives. Impractical targets may hinder the successful realisation of climate change adaptation benefits. Focus on easily measurable indicators/metrics with available underlying data and compare them across scales to avoid imposing additional burdens.
vi. Prioritisation: During the identification of adaptation plans and measures, prioritise areas based on the relative characteristics of climate change impacts (magnitude, likelihood, and urgency). Consider the capacities of stakeholders and the local government and community's ability to act.
vii. Proportionality: Undertake actions that are most effective under the current circumstances, including economic, social, cultural, and political contexts, capabilities, knowledge, and evidence base. Aspire for continual improvement in identifying and assessing adaptation measures.
viii. Relevance: Facilitate assessments that provide decision-makers and practitioners with meaningful information for adaptation planning, considering appropriate spatial scales and relevant time durations.
ix. Transparency: Ensure that reports and communications on climate change adaptation are openly, comprehensively, and understandably presented, providing accessible information for all interested parties (SABS, 2023).

These principles should be considered when formulating adaptation goals, programmes, and measures.

3.2 Adaptation approach

The approach that was followed to develop this adaptation plan revolves around comprehending the climate-related risks and implementing adaptive measures in response to these risks. Climate-related risk encompasses the potential for adverse consequences arising from the interplay of vulnerability, exposure, and the occurrence of climate hazards (IPCC, 2022). The components of risk are dynamic, with the occurrence of climate hazards influenced by both natural climate variability and anthropogenic climate change. The exposure of individuals, the built environment, and the natural surroundings to climate hazards is driven by both planned and unplanned development and growth. Vulnerability is the inherent characteristics that make systems sensitive to the effects and impacts of climate hazards.

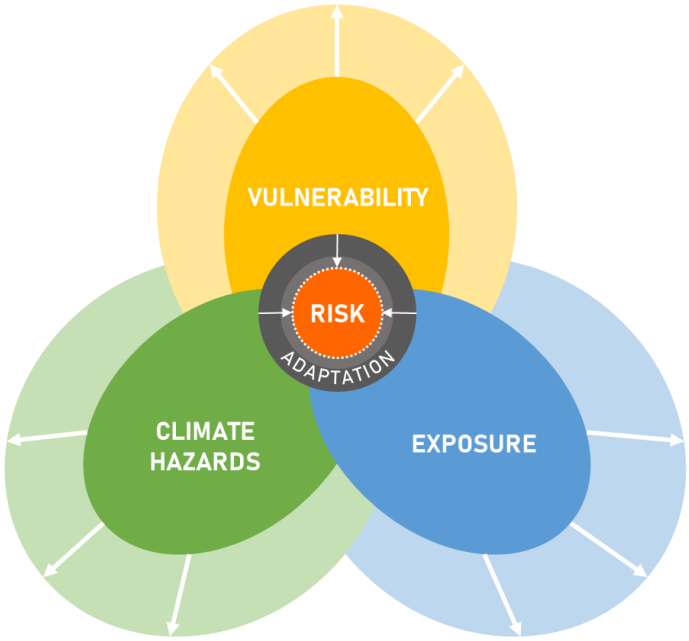

Figure 1 – The interplay between climate hazards, vulnerability and exposure that determines risk (based on IPCC, 2014 and IPCC, 2021)

The inherent uncertainty in future climate trends underscores the necessity for a flexible response and the formulation of adaptable, medium to long-term adaptation strategies.

The approach followed in this plan involves the following steps:

i. Gain an understanding of climate risk in a specific geographic area.
ii. Identify priority climate hazards/zones based on the risk profile.
iii. Establish adaptation goals to mitigate the risk associated with priority hazards/zones.
iv. Develop adaptation programmes with measures/actions to achieve these goals.
v. Integrate climate considerations into other sector plans/instruments/strategies.

Refer to Table 1 for a more detailed description of this approach.

Table 1: The adaptation approach

Understand climate risk for a specific geographic area	A climate risk profile assesses risk by determining – in a specific geographic area and at a specific scale – the likelihood of a hazard to occur, the inherent vulnerability of various systems, and exposure of these systems to specific climate hazards. To be able to develop an appropriate adaptation plan, it is important to understand what contributes to risk and vulnerability.
Identify priority climate-related risks/zones	Identify the climate hazards and impacts that pose the greatest risk at present and in the future within a geographic area. If possible, also identify climate risk zones that need to be prioritised for intervention.

Establish adaptation goals	Identify adaptation goals to address priority risks/zones that speak to policy goals.
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 hazard/vulnerability/exposure. • Suggest a target or an indicator to measure progress. • Be assignable to a primary implementer. • Consider co-benefits and other possible implications. • Include mitigation as far as it builds resilience or reduces exposure and vulnerability.
Mainstream climate considerations into planning	Integrate evidence of climate risk, adaptation goals, programmes, and actions into existing instruments and processes. The aim is to ensure that climate change considerations are an integral part of all that local government is doing.

The primary aim of an adaptation plan is to address both current and anticipated future risks and vulnerabilities while also leveraging opportunities for long-term transformation and sustainable development.

3.3 Adaptation programmes and actions

An adaptation programme is a structured and systematic set of actions, initiatives, and interventions that can be used to adapt to the impacts of climate change. It involves the practical implementation of specific goals identified in the plan.

Broadly, adaptation actions include anticipatory and reactive measures. Anticipatory adaptation involves proactive measures taken in preparation for anticipated climate change impacts, while reactive adaptation entails responding to climate change effects as they are experienced. Furthermore, it facilitates the integration and prioritisation of climate change adaptation and resilience measures into various planning mechanisms and processes (CSIR, 2019).

A spectrum of adaptation actions is at the disposal of local municipalities to enhance resilience and mitigate risks posed by changing climatic patterns and extreme weather events. Some of the categories of actions include:

- Infrastructure development, encompassing the construction of, for example, seawalls, levees, and storm surge barriers to protect against rising sea levels and extreme weather events. These engineered solutions provide immediate protection and buy time for longer-term adaptation efforts but are mostly very expensive to build.
- Green infrastructure initiatives offer sustainable and nature-based solutions. Municipalities can implement urban green spaces, green roofs, and permeable pavements to absorb excess water, reduce flooding, and mitigate the urban heat island effect. Such approaches not only enhance climate resilience but also contribute to improved air quality and overall urban liveability.

- Environmental protection such as restoring ecosystems like mangroves, dunes, and wetlands, not only provides natural buffers but also supports biodiversity.
- Integrated urban planning is essential to create climate-resilient municipalities. Land-use regulations should be adapted to consider climate risks, prioritising construction practices that enhance resilience. Elevating structures above projected flood- and sea levels and using climate-resilient materials in building design can minimise the impacts of flooding and storm damage.
- Early warning systems and emergency preparedness plans are critical tools to ensure swift responses to extreme weather events, minimising the impact on vulnerable communities.
- Innovative water management strategies are essential for municipalities facing changing precipitation patterns and increasing water scarcity. Diversifying water sources, implementing water efficiency measures, and investing in advanced stormwater management systems contribute to water security and sustainable resource use.
- Engagement and education are pivotal components of successful adaptation strategies. Empowering officials, and residents, to understand and respond to climate risks through awareness campaigns, education programmes, and participatory planning initiatives can enhance local adaptive capacity (CSIR, 2019).

Local governments must embrace a combination of structural, natural, and community-based approaches to build resilience and adaptive capacity, protect vulnerable communities, while ensuring long-term sustainability in the face of evolving climate challenges.

4. Summary of Climate Risk Profile

A Climate Risk Profile Report was prepared by the team, designed to complement this Plan. The comprehensive Climate Risk Profile serves as an essential resource for understanding the risks associated with climate change in Madibeng Local Municipality. Presented to representatives of the Municipality during a series of nationwide stakeholder engagements in late 2023, these workshops served as forums to not only validate the risks outlined in the report but also to confirm the adaptation goals proposed.

This section of the Plan summarises the climate risk profile for Madibeng, drawing from the GreenBook Risk Profile Tool at https://riskprofiles.greenbook.co.za/. Consult the accompanying Climate Risk Profile Report for more detailed information.

4.1 Climate projections, vulnerabilities and impacts

The average annual temperature for Madibeng, under baseline conditions, ranges between 18°C and 20°C. These temperatures are expected to increase by between 2.8°C and 3.2°C in future. Under baseline conditions, MLM experience 11 to 20 very hot days. The projected change in average annual number of very hot days by 2050 is an increase of between 15 and 52 days. The current average number of heatwave days are five or less days per year which, in future, may increase by between 13 and 16 heatwave days under the RCP 8.5 scenario.

Current rainfall is between 800 and 1200 mm per annum, which is expected to increase by 17.7mm to 61.4mm in the future under the RCP 8.5 scenario. Extreme rainfall day projections for 2050 range between a decrease of 0.14 days to an increase of 1.34 days.

Based on the projections for drought tendencies, MLM is not projected to have a change in drought tendency up to 2024 (current period). However, a moderate increase in drought tendency is expected for the future period in settlements such as Mooinooi, Brits and Elandskloof Chrome Mine with the risk being low in the other settlements.

Madibeng LM's socio-economic vulnerability (SEVI) has decreased (improved) between 1996 and 2011 – thus indicating that the number of vulnerable households has decreased, particularly in terms of their lack of access to basic and social services, and essential resources that influence their ability to withstand adverse shocks from the external environment, including those induced by climate change. However, the LM's economic vulnerability (EV) has increased (worsened) within the same period, therefore indicating the municipality's high susceptibility to being adversely affected by external shocks due to economic sector diversification, the size of economy, labour force, GDP growth/decline pressure and the inequality present in the municipality. MLM has a very high physical vulnerability (PVI) score, i.e., the seventh highest in the country and the highest in the province; this alludes to areas of remoteness and high structural vulnerabilities in the LM, particularly when considering the municipality's buildings and infrastructure.

Madibeng's township development struggles to keep pace with population growth, prompting people to relocate to rural areas that are close to the CBD or town (DEDECT, 2021). The population in the MLM is projected to increase by 83.1% between 2011 and 2050 (medium growth scenario) with most of the growth occurring between 2011 and 2030. Brits is likely to experience the highest projected growth pressure in MLM. Some other towns and settlements in the area are projected to experience high to extreme population growth pressures, which may increase the number of people exposed to climate hazards in the future.

Approximately 62% of households in the MLM earn less than R3,500 per month, which is the RDP Housing Subsidy Level (HDA, 2022a). In 2016, 67 450 people within the LM lived in informal settlements (SACN, 2020). Madibeng has a high number of informal settlements. Currently there are over 48 informal settlements which are home to about 36 499 households. It is highly rural, with 57% of its population residing in rural areas (tribal or traditional areas), about 28% residing in urban areas and about 15% residing in farming areas.

All the towns and settlements in the both the Oukasie and Mothotlung and the Mooinooi N4 Corridor and Sonop Priority Housing Development Areas are surface water dependent. Water quality is severely impacted by poor quality wastewater effluent return flows from municipal wastewater treatment works. The growth in water requirements is mainly driven by urban and rural municipal demand, as well as mining, and agriculture (HDA, 2022). Madibeng LM's water demand is currently lower than supply. However, the LM's water supply vulnerability is projected to increase to between 0.92 and 1.42 due to the projected decrease in mean annual precipitation, as well as projected increases in mean annual evaporation, and population growth.

The risks identified in the Risk Profile report were validated by stakeholders during the workshops.

4.2 Priority climate-related hazards

The climate hazards that pose the biggest threats to the LM include:

- Extreme heat
- Poor air quality
- Fire, veldfires
- Waste and sewage infiltration (insufficient sewerage systems)
- Drought (affecting water supply, stormwater)
- Flash floods

The greatest likelihood of hazards occurring in Madibeng are floods and wildfires due to significant projected increases in extreme rainfall as well as increases in average temperatures. This elevated risk is compounded by the socio-economic vulnerabilities faced by some communities in the area, making them more susceptible to adverse outcomes arising from climate change.

The current water demand in the municipality is lower than supply. However, despite an increase in rainfall, water supply vulnerability is projected to increase due to several factors, including population growth and the fact that urban water supply is only expected to increase by 0.06%.

Wildfires under current climatic conditions across the MLM are likely in most settlements. The likelihood of increases in wildfires under 2050 projected change is high in all settlements. The number of fire danger days under the RCP8.5 scenario is projected to increase by up to 60 per annum in the north and central parts of the LM, which includes Wonderkoppies, Elandskraal Chrome Mine and part of Mooinooi. The high risk of wildfires may contribute to health risks to people and animals. Wildfires pose a threat of smoke pollution. It is therefore necessary to ensure that systems are in place to maintain and ensure the public's health, should the need arise.

Hail and tornadoes have also been flagged as a potential hazard (MLM, 2022).

5. Adaptation Goals, Programmes and Actions

The section outlines the adaptation plan using goals and measures designed to help Madibeng LM to adapt to the impacts of climate change. Based on the assessment of the potential risks and vulnerabilities posed by climate change, this plan was developed as a proactive strategy to mitigate these risks and enhance resilience.

5.1 Adaptation goals

Drawing upon the assessment of the current and projected climate-related risks and vulnerabilities outlined in the preceding section, the following adaptation goals for Madibeng LM were identified, prioritising those risks with the highest potential impact. These goals were validated by stakeholders during the nationwide engagements:

- Goal 1: To ensure the protection and maximise the sustainable use of water sources such as the Crocodile River for human and agricultural consumption.

- Goal 2: To implement effective flood management strategies to mitigate the risks associated with heavy rainfall events.
- Goal 3: To climate-proof informal settlements.
- Goal 4: To improve infrastructure for responding to fire events.

The adaptation programmes below identify the overarching programmes and their actions, necessary to achieve each one of the goals. Specific timeframes and responsibilities are allocated in the subsequent implementation framework.

5.2 Adaptation programme: Goal 1

Goal 1: To ensure the protection and maximise the sustainable use of water sources such as the Crocodile River for agricultural and human consumption.

Programme 1.1: Ensure the protection of water sources (including water quality) throughout the Madibeng Municipal Area
The purpose of this programme is to protect critical water sources and downstream water bodies from contamination, whether from stormwater or from potential pollution sources.

Actions:

i. Develop and implement projects to support catchment management activities in upstream municipalities in which the Madibeng Municipal Area's water source areas are located.
ii. Implement measures to protect the quality of water sources through watershed management, pollution control, and regulations on activities near water sources.
iii. Monitor water quality regularly to ensure water safety, including groundwater quality as approximately 16% of household relies on groundwater only.
iv. Raise awareness in different community sectors including schools about the importance of protecting water sources.
v. Provide a platform that support citizen science initiatives to assist with reporting of water quality issues.

Programme 1.2: Maximise sustainable use of water sources for human and agricultural consumption
The purpose of this programme is to implement water conservation measures throughout the municipality to increase supply and reduce demand and water losses in the reticulation system.

Actions:

vi. Develop an overarching water conservation and water demand plan for the Madibeng Municipal Area.
vii. Increase supply by investing in leak detection and repair infrastructure to minimise the loss of treated water during distribution.
viii. Implement projects to reduce non-revenue water loses in the Madibeng Municipal Area such as the establishment of zonal bulk water meters.
ix. Identify farmers or other co-workers to measure rainfall regularly and to gather it at a central point that could form part of the national network (MLM, 2022).
x. Add at least two automatic weather stations in the area to benefit irrigation scheduling to optimise water use but also to serve for crop estimates (MLM, 2022).

xi. Establish a project to identify suitable crops for the area in terms of production as well as marketing risk (MLM, 2022).
xii. Distribute regular information like crop estimates, best planting dates, rainfall outlooks, frost dates, flood warnings, drought warnings, etc (MLM, 2022).
xiii. Do a more detailed soil survey to identify suitable areas for production, including soil depth and clay content (MLM, 2022).
xiv. Do a project to educate and introduce irrigation scheduling to optimise water use and production (MLM, 2022).
xv. Investigate the possibility of introducing new developed water harvesting/conservation technology by the ARC in rural areas (MLM, 2022).
xvi. Complete feasibility studies on the development of infrastructure to enable the treatment of raw water from the Klipvoor Dam, including a cost-benefit analysis of developing the proposed scheme.
xvii. Identify agricultural projects such as hydroponics production that will assist with water use management (MLM, 2022 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).
xviii. Explore alternative sources like rainwater harvesting, treated wastewater reuse for irrigation, to reduce dependence on strained sources.
xix. Raise awareness about water conservation through public campaigns, educational programs in schools, and community workshops.

Programme 1.3: Establish a special infrastructure provision programme for the investment priority areas, such as water safety.
The purpose of the programme is to ensure the provision of a sustainable and holistic value-chain of water supply and sanitation infrastructure This will facilitate and coordinate the immediate delivery of bulk services and infrastructure on the request of investors. This will also ensure a phased approach to service delivery. Outsource delivery services to capable local contractors as far as possible.

Actions:
i. Implement the Department of Water and Sanitation's Regional Bulk Infrastructure Programme (RBIG).
ii. Increase the capacity of the Brits Water Purification Plant by 20 Ml/d.
iii. Establish or recommission boreholes to augment bulk water supply, especially in rural areas.
iv. Establish a special infrastructure provision programme for the investment priority areas, such as water safety. This will facilitate and coordinate the immediate delivery of bulk services and infrastructure on the request of investors. This will also ensure a phased approach to service delivery. Outsource delivery services to capable local contractors as far as possible (MLM, 2022 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).

5.3 Adaptation programme: Goal 2

Goal 2: To implement effective flood management strategies to mitigate the risks associated with heavy rainfall events.

Programme 2.1: Develop and implement preventative actions that respond to potentially amplified flood risks due to climate change
The purpose of the programme is to foresee and plan for preventing floods to minimise damage.

Actions:

i. Develop master drainage plans for all river catchments in Madibeng – ensuring that the consultancy responsible for the plan also takes cognises of the integration of water demand and supply management principles and not only look at demand management principles (MLM, 2022).
ii. Implement green solutions like rain gardens, bioswales, and permeable pavements where practical to increase water infiltration and reduce runoff.
iii. Do regular maintenance of existing drainage systems, canals, and levees – including clearing of debris and ensuring proper flow capacity.
iv. Update research to include the latest rainfall and runoff projections and climate system models for the Madibeng Municipal Area.
v. Identify suitable sites for infiltration of rainwater runoff.
vi. Implement a project to identify and manage public open spaces in the Madibeng Municipal Area that can play strategic roles in flood attenuation and cooling services.
vii. Implement public awareness campaigns in the Madibeng Municipal Area to raise awareness of the benefits of stormwater-runoff reduction techniques and other flood-protection measures. Educate residents about flood risks, evacuation plans, and personal preparedness measures to minimise loss of life and property.
viii. Update and enforce Municipal legislation and by-laws to control urban drainage and to limit stormwater runoff in the Madibeng Municipal Area; enact regulations that restrict development in floodplains and encourage flood resilient building practices in at-risk areas.
ix. Identify at-risk communities with a high potential chance of exposure (MLM, 2002 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).

Programme 2.2: Develop and implement early warning programmes to prevent or minimise impacts of actual flooding events

The purpose of this programme is to prevent or minimise human impacts and infrastructure damage or loss due to flooding events.

Actions:

i. Identify critically vulnerable communities (MLM, 2002 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation.
ii. Put in place reliable flood warning systems with clear and appropriate communication channels to alert residents and emergency services timeously.
iii. Develop and regularly update comprehensive emergency response plans including evacuation procedures, search and rescue protocols, and resource allocation – in collaboration with communities.
iv. Infill development should be encouraged, especially between the settlements of Modderspruit and Elandsdrift, with development planned outside 1:100 flood line areas.

Programme 2.3 Develop and implement programmes to respond effectively and timeously after a flood event

The purpose of this programme is to put systems in place that assist with post-flood recover and enable building back better.

i. Conduct rapid damage assessments to identify the most impacted areas and prioritise recovery efforts.

ii. Put financial assistance programmes in place to secure funding and help with post-flood rebuilding and recovery.
iii. Analyse flood management strategies during the event to identify gaps and areas for improvement.
iv. Facilitate seamless collaboration between government agencies, emergency services, NGOs, and the community.
v. Integrate climate change projections into flood management plans.

5.4 Adaptation programme: Goal 3

Goal 3: To prepare settlements for higher temperatures.

Programme 3.1: Develop and/or rehabilitate parks in each area
The purpose of the programme is to provide cool outdoor spaces where people can exercise and socialise.

Actions:
i. Identify suitable areas for an outdoor gym park and recreational parks with play equipment with shading in each township, especially in Madibeng and rural townships.
ii. Develop a maintenance plan for parks to ensure that parks provide shade and cool areas and do not become fire and flood hazards.
iii. Involve surrounding community organisations in the planning and implementation process.
iv. Allocate sufficient budget for park development in the municipal plan (MLM, 2002 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).

Programme 3.2: Promote and empower communities on climate change issues through environmental education and awareness
The purpose of the programme is to empower and inspire the public to adopt behaviours and practices that will contribute to climate change adaptation, integrating actions into existing programmes where relevant.

Actions:
i. Incorporate climate change issues into programmes that are already available in the LM (MLM, 2022), including in the training of identified Community Development Workers (as per IDP, 2022-2027). For examples, programmes in the workplace, at the 11 libraries within the MLM, arts and cultural programs that aims to build unity and social cohesion amongst Madibeng cultural groups, programmes that support NGO's, environmental clubs and schools to attend environmental education training, camps and events. Identify projects that are eligible for funding through the Innovation Promotion Programme such as developing a school-support programme through which scholars and students can be introduced to the industrial and innovation environment.
ii. Use existing communication channels (social media, community groups, community radio, libraries etc) to ensure regular interactive climate communication and engagement with communities. Ensure that at-risk communities such as the blind and disabled are considered.
iii. Continually monitor and evaluation community resilience/readiness to climate disasters.
iv. Collaborate with the Department of Public Safety and Social Development and local NGOs to identify initiatives with co-benefits that can empower vulnerable groups (e.g. gardening, recycling, greening). Use existing strategies such as the HIV/AIDS policy and formulation

strategy to ensure that all multi-sectoral social upliftment programmes within the Municipality are properly planned, implemented, monitored and evaluated.

v. Identify manufacturing projects such as the use of recycling material product manufacturing for potential funding through the Industrial Cluster Development Programme.
vi. Implement a minimum of one clean-up per quarter with a focus on areas that do not receive regular waste removal and incorporate education on issues of illegal dumping and the impact of waste on stormwater and flooding.
vii. Encourage communities to start recycling project as a form of sustainable development and provide an enabling environment for reusing and recycling Incentivise recycling at source.
viii. Promote the alternative building material project (e.g. polystyrene) and educate and train communities.
ix. Construct recycling facilities at transfer stations.
x. Establish a permitting process that ensures sustainable recycling.
xi. Develop/obtain learning resources that contributes to climate awareness and climate proofing and can be integrated into the school curriculum.
xii. Develop and/or maintain an interactive database on the service providers in the local areas and their nature, known funding sources and skills.
xiii. Involve employees with the Learnership Programme managed by THETA to enable the development and promotion of locally-produced tourism-related arts and crafts (MLM, 2022 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).

Programme 3.3: Invest in renewable energy

The purpose of this programme is to create community understanding of the benefits of renewable energy so that they will be receptive to and take ownership of these technologies.

Actions:

i. Create awareness and understanding of the benefits of renewable energy in different communities, using programmes such as the housing consumer education programmes that are planned with support from the Northwest Department of Development Local Government and Housing and the capacity building programme that is planned to be implemented at community level (as per IDP, 2022-2027). (MLM, 2022).
ii. Identify projects that can be funded through Government programmes that focus on the micro enterprise sector and provide shared business services and infrastructure, information on service providers through training in basic business management and financial mentoring, micro finance assistance institutions and product advice institutions, as well as programmes to 1) link micro suppliers with larger companies and 2) formalise the informal sector.
iii. Collaborate with different departments to develop plans for switching to renewable energy, e.g. transport, agriculture, health (MLM, 2022 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation).

Programme 3.4: Ensure effective air quality management

The purpose of this programme is to identify areas with poor air quality, the sources of the poor air quality, and to put actions in place to improve air quality.

Actions:

i. Identify areas within the LM with poor air quality to ensure that air quality stations in the monitoring network represents problem areas in the LM.
ii. Monitor compliance and enforcement of the AQMP (MLM, 2022 https://ethekwini-climateactions.greenbook.co.za/theme/water-and-sanitation). Improve implementation of the AQMP.
iii. Develop and enforce regulations to limit emissions from stationary sources such as industrial facilities and domestic sources, and implement vehicle emission reduction programmes that include emission testing, promoting cleaner fuels, and encouraging alternative transport options.
iv. Improve public transport, cycling and pedestrian infrastructure, including safety measures
v. Reduce emissions by implement by-laws that stipulates reasonable measures to prevent air pollution, designated air quality officer roles, and emission licensing procedures.
vi. Make data publicly available in an understandable format.
vii. Invest in research and development of cleaner technologies and air pollution control methods.
viii. Collaborate with other municipalities and regions to share best practices and access technical expertise - link to Programme 4.1.
ix. Monitor compliance and enforcement of the AQMP

5.5 Adaptation programme: Goal 4

Goal 4: To improve the ability to respond effectively to fire events.

Programme 4.1: Develop a collaboration culture

The purpose of this programme is to improve communication and effective collaboration between different agencies responsible for responding to fire events.

Actions:

i. Develop and/or maintain service level agreement (in line with the Municipal Finance Management Act) between Madibeng Disaster Management Centre, other local government departments and local agents such as NECSA, Western Platinum Mines, to ensure sustainability of collaboration.
ii. Develop and/or maintain a professional services and contractors database and implement a grading system to promote good governance and effective institutional support (MLM, 2022).
iii. Develop and /or continually evaluate high risk areas to ensure that early warning mechanisms, appropriate to these different risk areas, are put in place.
iv. Monitor and evaluate the successes and failures of responses to such events, including loss and damage associate with disasters to assist with future planning.

Programme 4.2: Maintain infrastructure for continuous fire-response readiness

The purpose of this programme is to upgrade and maintain vehicles and road infrastructure and ensure water availability in the event of a fire.

Actions:

i. Do a fire risk assessment for different settlements in collaboration with appropriate stakeholders – to identify obstacles associated with access routes, water availability etc.
ii. Keep a current asset register, accessible to stakeholders, that tracks the state and readiness of infrastructure such as maintenance, availability etc.

iii. Meet regularly with other stakeholders about the state of infrastructure under their responsibility, e.g. Transport with regards the state of roads and access routes, Human Settlements with regards to high-risk settlements and accessibility, the SAPS with regards to safety issues during fire events, etc.
iv. Establish (if necessary) and maintain fire stations in high-risk areas.
v. Ensure that fire engines are maintained and accessible to these areas.
vi. Upgrade community centres where necessary to be able to function as emergency centres.
vii. Do regular assessments of response-readiness of infrastructure to identify gaps.

Programme 4.3: Fire and disaster awareness campaigns

The purpose of the programme is to empower and inspire the public to adopt behaviours and practices that will contribute to climate change adaptation.

Actions:

i. Incorporate fire and disaster awareness and readiness into other awareness campaigns such as those in Programme 3.2.
ii. Develop a fire response plan for each settlement - in collaboration with stakeholders in the settlement which identifies in high-risk areas and appropriate actions, outlines roles and responsibilities, places of safety, etc.
iii. Build capacity at ward level, which include training community fire fighters and first responders and training different community groups on related disaster management skills.
iv. Do education and awareness in different community settings such as schools, retirement centres, informal areas on issues such as the identification of fire hazards and how to report incidents.

6. Implementation Framework

The implementation framework summarises the adaptation plan and indicates responsibilities, timeframes, and priorities.

6.1 Implementation framework: Goal 1

Goal 1: To ensure the protection and maximise the sustainable use of water sources such as the Crocodile River for human and agricultural consumption.

Adaptation programme 1.1: Ensure the protection of water sources (including quality) throughout the Madibeng Municipal Area				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop and implement projects to support catchment management activities in upstream municipalities in which the Madibeng Municipal Area's water source areas are located.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Infrastructure and Technical Services Sanitation: Wastewater Management Water Economic Development	Medium-term	Medium
ii. Implement measures to protect the quality of water sources through watershed management, pollution control, and regulations on activities near water sources.	Waste and sewage infiltration	Sanitation: Wastewater Management Water	Long-term	High
iii. Monitor groundwater quality as approximately 16% of household relies on groundwater only.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Infrastructure and Technical Services Water	Long-term	High
iv. Establish a risk-defined water monitoring programme based on a full SANS analysis.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Infrastructure and Technical Services Water	Short-term	High
v. Identify potential water sources.	Heat Waste and sewage infiltration Drought	Infrastructure and Technical Services Water	Short-term	High
vi. Analyse the water.	Waste and sewage infiltration	Infrastructure and Technical Services	Short-term	High

Adaptation programme 1.1: Ensure the protection of water sources (including quality) throughout the Madibeng Municipal Area				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
		Water		
vii. Raise awareness in different community sectors including schools about the importance of protecting water sources.	Waste and sewage infiltration Drought	Infrastructure and Technical Services Water Education	Long-term	Medium
viii. Provide a platform that support citizen science initiatives to assist with reporting of water quality issues.	Waste and sewage infiltration	Economic Development & Planning Education	Medium-term	Medium

Adaptation programme 1.2: Maximise sustainable use of water sources for human and agricultural consumption				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop an overarching water conservation and water demand plan for the Madibeng Municipal Area.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Infrastructure and Technical Services Water	Short-term.	High
ii. Increase supply by investing in leak detection and repair infrastructure to minimise the loss of treated water during distribution.		Infrastructure and Technical Services Water	Short-term.	High
iii. Implement projects to reduce non-revenue water loses in the Madibeng Municipal Area such as the establishment of zonal bulk water meters.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Infrastructure and Technical Services Water Economic Development	Medium-term	High
iv. Identify agricultural projects such as hydroponics production that will assist with water use management.	Drought (affecting water supply, stormwater) Waste and sewage infiltration	Economic Development & Planning Agriculture Water	Long-term	Medium
v. Identify farmers or other co-workers to measure rainfall regularly and to gather it at a central point that could form part of the national network (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium

Adaptation programme 1.2: Maximise sustainable use of water sources for human and agricultural consumption				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
vi. Add at least two automatic weather stations in the area to benefit irrigation scheduling to optimise water use but also to serve for crop estimates (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
vii. Establish a project to identify suitable crops for the area in terms of production as well as marketing risk (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
viii. Regularly distribute updates of information such as crop estimates, best planting dates, rainfall outlooks, frost dates, flood warnings, drought warnings, etc (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
ix. Do a more detailed soil survey to identify suitable areas for production, including soil depth and clay content (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
x. Do a project to educate and introduce irrigation scheduling to optimise water use and production (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
xi. Investigate the possibility of introducing new developed water harvesting/ conservation technology by the ARC in rural areas (MLM, 2022).	Drought, flooding	Economic Development & Planning Agriculture Water	Long-term	Medium
xii. Complete feasibility: studies on the development of infrastructure to enable the treatment of raw water from the Klipvoor Dam, including a cost-benefit analysis of developing the proposed scheme.	Drought	Economic Development & Planning Infrastructure and Technical Services Water	Medium-term	Medium
xiii. Exploring alternative sources like rainwater harvesting, treated	Drought	Economic Development & Planning	Medium-term	Medium

Adaptation programme 1.2: Maximise sustainable use of water sources for human and agricultural consumption				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
wastewater reuse for irrigation, to reduce dependence on strained sources.		Infrastructure and Technical Services Water		
xiv. Raising awareness about water conservation through public campaigns, educational programs in schools, and community workshops.	Drought Heat	Economic Development & Planning Education	Medium-term	Medium
xv. Collect and analyse data on water use patterns, using citizen participation where possible.	Drought Heat	Economic Development & Planning Education	Medium-term	Medium

Adaptation programme 1.3: Establish a special infrastructure provision programme for the investment priority areas, such as water safety.				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Implement the Department of Water and Sanitation's Regional Bulk Infrastructure Programme (RBIG).	Waste and sewage infiltration	Infrastructure and Technical Services: Engineering Water and Sanitation	Medium -term	High
ii. Increase the capacity of the Brits Water Purification Plant by 20 Ml/d.	Waste and sewage infiltration Drought Heat	Infrastructure and Technical Services: Engineering Water and Sanitation	Medium-term	Medium
iii. Establish or recommission boreholes to augment bulk water supply, especially in rural areas.	Drought Heat	Infrastructure and Technical Services: Engineering Water	Medium-term	Medium
iv. Establish infrastructure provision programme for the investment in priority areas, such as water safety.	Waste and sewage infiltration Drought Heat	Infrastructure and Technical Services: Engineering Water	Long-term	Medium

6.2 Implementation framework: Goal 2

Goal 2: Developing effective flood management strategies to mitigate the risks associated with heavy rainfall events.

Adaptation programme 2.1: Develop and implement municipal climate change actions that respond to potentially amplified flood risks due to climate change				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop a Water Services Master Plan for all river catchments in the Madibeng Municipality.	Flash floods	Infrastructure and Technical Services: Engineering Water	Medium-term	High
ii. Implement green solutions like rain gardens, bioswales, and permeable pavements where practical.	Flooding, Drought	Infrastructure and Technical Services:	Medium-term	Medium
iii. Do regular maintenance of existing drainage systems, canals, and levees – including clearing of debris.	Flash floods	Infrastructure and Technical Services:	Long-term	High
iv. Update research to include the latest rainfall and runoff projections and climate system models for the MLM area.	Flash floods	Infrastructure and Technical Services: Water	Short-term	High
v. Identify suitable sites for infiltration of rainwater runoff.	Flash floods	Infrastructure and Technical Services Engineering	Short-term	High
vi. Implement a project to identify and manage public open spaces in the Madibeng Municipal Area that can play strategic roles in flood attenuation and cooling services.	Flash floods	Human Settlements and Planning Community Development	Medium-term	Medium
vii. Implement public awareness campaigns in the Madibeng Municipal Area.	Flash floods	Community Development Education	Short-term	Medium
viii. Update and enforce Municipal legislation and by-laws.	Flash floods	Infrastructure and Technical Services: Water	Long-term	High
ix. Identify at-risk communities.	Flash floods	Community Development	Short-term	High

Adaptation programme 2.2: Develop and implement early warning programmes to prevent or minimise impacts of actual flooding events				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Identify critically vulnerable communities.	Flash floods	Community Development Disaster Management	Short-term	High
ii. Implement reliable flood warning systems with clear and appropriate communication channels.	Flash floods	Community Development Disaster Management	Short-term	High
iii. Develop and regularly update comprehensive emergency response plans.	Flash floods	Community Development Disaster Management	Long-term	High

Adaptation programme 2.3 Develop and implement programmes to build back better after a flood event				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Conduct rapid damage assessments to identify the most impacted areas and prioritize recovery efforts.	Flash floods	Community Development Disaster Management	Long-term	High
ii. Put financial assistance programs in place to secure funding and help with post-flood rebuilding and recovery.	Flash floods	Community Development Economic Development & Planning Disaster Management	Long-term	High
iii. Analyse flood management strategies during the event to identify gaps and areas for improvement.	Flash floods	Community Development Economic Development & Planning Disaster Management	Short-term	High
iv. Facilitate seamless collaboration between government agencies, emergency services, NGOs, and the community.	Flash floods	Community Development Disaster Management	Long-term	High

Adaptation programme 2.3 Develop and implement programmes to build back better after a flood event				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
v. Integrate climate change projections into flood management plans.	Flash floods	Community Development Disaster Management	Long-term	High

6.3 Implementation framework: Goal 3

Goal 3: Prepare settlements for higher temperatures

Adaptation programme 3.1: Develop and/or rehabilitate parks in each area				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Identify suitable areas for an outdoor recreational park with play equipment with shading in each township, especially in Madibeng and rural townships.	Heat	Community Development	Short-term	High
ii. Develop a maintenance plan for parks to ensure that parks provide shade and cool areas and do not become fire and flood hazards.	Heat	Community Development	Medium-term	Medium
iii. Involve surrounding community organisations in the planning and implementation process.	Heat	Community Development WATEES Consortium	Short-term	High
iv. Allocate sufficient budget for park development and maintenance in the IDP.	Heat	Community Development Budget and Treasury	Long-term	High

Adaptation programme 3.2: Promote and empower communities on climate change issues through environmental education and awareness (Ensure continuous stakeholder engagement)				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Include climate issues in the training of identified Community Development	All risks Community vulnerability	Community Development	Medium-term	Medium

Adaptation programme 3.2: Promote and empower communities on climate change issues through environmental education and awareness (Ensure continuous stakeholder engagement)				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
Workers (as per IDP, 2022-2027, (MLM, 2022)).				
ii. Include climate change issues in programmes that are already available in the LM (MLM, 2022).	All risks Community vulnerability	Community Development WATEES Consortium	Medium-term	Medium
iii. Use existing communication channels to ensure regular interactive climate communication and engagement with communities.	All risks Community vulnerability	Community Development	Long-term	High
iv. Continually monitor and evaluation community resilience/readiness to climate disasters.	Community vulnerability	Community Development Public Safety, Fleet and Facilities Management	Long-term	High
v. Collaborate with the Department of Public Safety and Social Development and local NGOs to identify initiatives with co-benefits that can empower vulnerable groups.	Community vulnerability	Public Safety and Social Development	Long-term	Medium
vi. Promote the alternative building material project (e.g. using polystyrene) and educate and train communities.	Heat	Economic Development & Planning (Economic Generator Body (EGB))	Long-term	Medium
vii. Implement a minimum of one clean-up per quarter with a focus on areas that do not receive regular waste removal and incorporate education on issues of illegal dumping and the impact of waste on stormwater and flooding.	Flash floods	Community Development	Long-term	Medium
viii. Identify manufacturing projects such as recycling material product manufacturing through the Industrial Cluster Development Programme.	Community vulnerability	Economic Development & Planning (Economic Generator Body (EGB))	Long-term	Medium
ix. Encourage communities to start a recycling project as a form of sustainable development; provide an	Community vulnerability	Community Development	Long-term	Medium

Adaptation programme 3.2: Promote and empower communities on climate change issues through environmental education and awareness (Ensure continuous stakeholder engagement)				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
enabling environment for reusing and recycling and incentivise recycling at source.				
x. Construct (and maintain) recycling facilities at transfer stations.	Community vulnerability	Community Development	Long-term	Medium
xi. Establish a permitting process that ensures sustainable recycling.	Community vulnerability	Community Development	Long-term	Medium
xii. Develop/obtain learning resources that contributes to climate awareness and climate proofing and can be integrated into the school curriculum.	Community vulnerability	Community Development	Long-term	Medium
xiii. Develop and/or maintain an interactive database on the service providers in the local areas and their nature, known funding sources and skills.	Community vulnerability	Economic Development & Planning (Economic Generator Body (EGB))	Long-term	Medium
xiv. Involve employees with the Learnership Programme managed by THETA to enable the development and promotion of locally produced tourism-related arts and crafts.	Community vulnerability	Economic Development & Planning (Economic Generator Body (EGB))	Long-term	Medium

Adaptation programme.3.3: Invest in renewable energy to reduce the carbon footprint of the Municipality				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Create awareness and understanding of the benefits of renewable energy in different communities, using programmes such as the housing consumer education programmes.	Air quality Community vulnerability	Community Development Housing, Planning and Infrastructure Services	Medium-term	Medium
ii. Identify projects that can be funded through Government programmes that	Community vulnerability	Economic Development	Long-term	Medium

Adaptation programme.3.3: Invest in renewable energy to reduce the carbon footprint of the Municipality				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
focus on the micro enterprise sector and provide shared business services and infrastructure.				
iii. Collaborate with different departments to develop plans for switching to renewable energy.	Air quality Community vulnerability	Infrastructure and Technical Services – in collaboration with all departments in LM and DM	Medium-term Investigation of alternative energy sources during disasters: short-term	Medium High

Adaptation programme 3.4: Ensure air quality management to reduce emissions and improve implementation of the AQMP				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Identify areas within the LM with poor air quality.	Air quality	Infrastructure and Technical Services	Short-term	High
ii. Monitor compliance and enforcement of the AQMP.	Air quality	Infrastructure and Technical Services Community Development	Long-term	High
iii. Develop and enforce regulations to limit emissions from stationary sources domestic sources and implement vehicle emission reduction programmes.	Air quality	Infrastructure and Technical Services	Long-term	High
iv. Improve public transport, cycling and pedestrian infrastructure.	Air quality	Infrastructure and Technical Services	Medium-term	High
v. Reduce emissions by implement by-laws.	Air quality	Community Development	Short-term	High
vi. Make data publicly available in an understandable format.	Air quality	Community Development	Long-term	Medium
vii. Invest in research and development of cleaner technologies and air pollution control methods.	Air quality	Infrastructure and Technical Services	Long-term	Medium

Adaptation programme 3.4: Ensure air quality management to reduce emissions and improve implementation of the AQMP				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
viii. Collaborate with other municipalities and regions to share best practices and access technical expertise.	Air quality	Infrastructure and Technical Services	Long-term	High

6.4 Implementation framework: Goal 4

Goal 4: To improve the ability to respond effectively to fire events.

Adaptation programme 4.1: Develop a collaboration culture				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop and/or maintain service level agreement between Madibeng Disaster Management Centre and local agents.	Fires, veldfires	Public Safety, Fleet and Facilities Management – responsible for fire and disaster management	Medium-term	High
ii. Develop and/or maintain a professional services and contractors database and implement a grading system.	Fires, heat – but also other risks	Economic Development & Planning	Long-term	High
iii. Develop and /or continually evaluate high risk areas to ensure that early warning mechanisms, appropriate to these different risk areas, are put in place.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management – responsible for fire and disaster management Community Development	Long-term	High
iv. Monitor and evaluate the successes and failures of responses to such events, including loss and damage associate with disasters to assist with future planning.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management – responsible for fire and disaster management	Long-term	High

Adaptation programme 4.2: Maintain infrastructure for continuous fire-response readiness				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Do a fire risk assessment for different settlements in collaboration with appropriate stakeholders.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management Community Development	Short-term	High
ii. Develop a fire response plan for each settlement - in collaboration with stakeholders in the settlement.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management Community Development	Medium-term	High
iii. Keep a current asset register, accessible to stakeholders, that tracks the state and readiness of infrastructure.	Fires, heat – but also other risks	Infrastructure and Technical Services	Long-term	High
iv. Meet regularly with other stakeholders, e.g. Transport with Human Settlements, SAP, etc. about the state of infrastructure under their responsibility.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management	Long-term	High
v. Establish (if necessary) and maintain fire stations in high-risk areas.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management Infrastructure and Technical Services	Long-term	High
vi. Ensure that fire engines are maintained and accessible to these areas.	Fires, heat – but also other risks	Public Safety, Fleet and Facilities Management Infrastructure and Technical Services	Long-term	High
vii. Upgrade (and maintain) community centres where necessary to be able to function as emergency centres.	Fires, heat – but also other risks	Infrastructure and Technical Services Community Development	Medium-term	High
viii. Do regular assessments of response-readiness of infrastructure to identify gaps.	Fires, heat – but also other risks	Infrastructure and Technical Services Community Development	Long-term	High

Adaptation programme 4.3: Do regular fire and disaster awareness campaigns				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Incorporate Fire and Disaster awareness in other awareness campaigns.	Fires, heat – but also other risks	Disaster Management Community Development	Long-term	High
ii. Do education and awareness in different community settings such as schools, retirement centres, etc.	Fires, heat – but also other risks	Community Development	Long-term	High

7. Implications for the PHSHDA

Climate hazards of most concern in the Madibeng LM (MLM) are extreme heat, with associated increased risk of veldfires, and poor air quality. Significant projected increases in extreme rainfall also increase the risk of flooding. A moderate increase in drought tendency is expected for the future period in settlements such as Mooinooi, Brits and Elandskloof Chrome Mine with the risk being low in the other settlements. These elevated risks are compounded by the socio-economic vulnerabilities faced by some communities in the area, making them more susceptible to adverse outcomes arising from climate change.

All the towns and settlements in the both the Oukasie and Mothotlung and the Mooinooi N4 Corridor and Sonop Priority Housing Development Areas are surface water dependent. Although the current water demand in the municipality is lower than supply, water supply vulnerability is projected to increase due to several factors, including population growth, mining and agriculture, and the fact that urban water supply is only expected to increase by 0.06%. Water quality is also impacted due inadequate wastewater treatment.

Madibeng's township development struggles to keep pace with population growth, prompting people to relocate to rural areas that are close to the CBD or town (DEDECT, 2021). The population in the MLM is projected to increase by more than 83% between 2011 and 2050, with some towns and settlements in the area, including some in the PHSHDA, projected to experience high to extreme population growth pressures, which will the increase the number of people exposed to climate hazards in the future.

Higher temperatures and more flooding events increase the risk of water- and vector-borne diseases in the municipality. Appropriate adaptation actions that ensure water security in the PHSHDA will be crucial given the projected increases in temperature. This will include measures to conserve water, such as rainwater harvesting and efficient irrigation systems.

The planning and development of the PHDSDAs should include risk assessments to identify areas that are especially prone to wildfires and flooding and that are vulnerable to high temperatures due to housing and water infrastructure as well as the state of their natural environment. The identified climate risks and vulnerabilities emphasise the need for multi-stakeholder involvement in the development and implementation of adaptation plans to ensure that priority risks and vulnerabilities are addressed without creating unintended consequences. Where possible, integrate climate and hazard adaptation actions into existing community initiatives in these areas. A range of different responses is therefore necessary, requiring flexibility to address the challenges which vary from one settlement to another.

8. Recommendations for Mainstreaming

Mainstreaming is the process of integrating climate change considerations into existing sectoral plans, other instruments and decision-making processes across various sectors and levels of governance. It involves recognising that climate change impacts and risks cut across multiple sectors and require a holistic approach to address effectively.

Mainstreaming climate change involves several key elements:

- Policy integration: Embedding evidence of climate change, as well as climate change adaptation and mitigation considerations into sectoral policies and strategies, such as those related to disaster risk

management, energy, water resources, transportation, and urban planning. This ensures that climate change is not treated as a standalone issue but is instead integrated into broader development agendas.

- Institutional integration: Incorporating climate change responsibilities and expertise within departments. This may involve establishing a dedicated but decentralised climate change unit, as well as fostering collaboration and coordination among departments and relevant external stakeholders. Incorporating climate response outcomes in the KPIs of all relevant departments, will ensure that progress towards climate goals can be tracked and measured.
- Capacity building: Enhancing the knowledge, skills, and capacities of politicians, decision-makers, and practitioners to understand and address climate change effectively. This includes providing training, technical assistance, and access to relevant information and tools, such as the GreenBook. By improving their understanding of climate change and the need for adaptation, these groups can better integrate climate considerations into their work.
- Budgeting and financing: Allocating resources and funding to support climate change adaptation and mitigation activities within existing budgets and financing mechanisms. This may involve reallocating funds from other priorities, leveraging external sources of finance, or integrating climate considerations into budget planning processes.
- Establishing networks and partnerships: Establishing networks and partnerships with civil society organisations, research councils, the private sector, different spheres of government, and other relevant entities could bolster climate adaptation efforts.
- Monitoring and evaluation: Establishing systems for monitoring and evaluating the effectiveness of mainstreaming efforts and tracking progress towards climate-related goals and targets is essential. This helps ensure accountability and facilitates learning and adaptation over time.

Climate change mainstreaming is essential for building resilience and promoting sustainable development in the face of climate change. By integrating climate considerations into decision-making processes and actions across sectors, mainstreaming helps minimise future risks, maximise opportunities for adaptation and mitigation, and enhance overall resilience to climate change impacts.

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