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dr.jsmlm

Dr JS Moroka Local Municipality
Adaptation Action Plan

JUNE 2024

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forestry, fisheries & the environment
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Contents

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
PHSHDA	Priority Human Settlement and Housing Development Area
PHS	Priority Human Settlement
PHDA	Priority Housing Development Area
PLM	Polokwane Local Municipality
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, organisations 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 Dr JS Moroka Local Municipality 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 Dr JS Moroka 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 Dr JS Moroka 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 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, i.e., Act No. 16 of 2013 (SPLUMA), 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 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 (PLM, 2021). 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 (PLM, 2021). 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 (See Figure 2).

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.

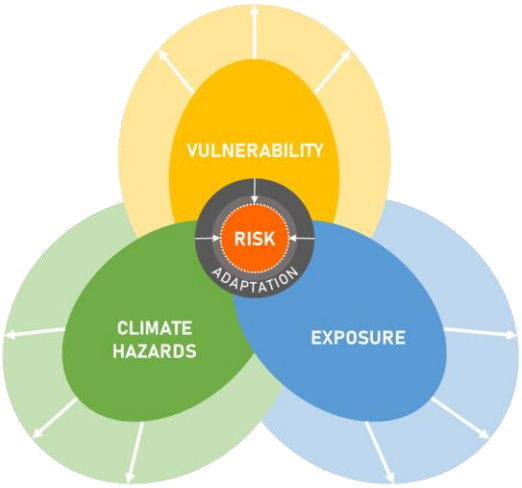

Figure 1 – The interplay between climate hazards, vulnerability and exposure that determines risk (based on IPCC, 2014 and IPCC, 2021)

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 aimed at local governments 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 Dr JS Moroka 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 Dr JS Moroka Local Municipality, 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 Dr JS Moroka Local Municipality is a Category B municipality situated within the Nkangala District in the north-western part of the Mpumalanga Province. It is the smallest of six municipalities in the district, making up 8% of its geographical area. The municipalities average annual temperature range between 18°C and 20°C. Under a high emissions scenario (RCP8.5), climate change projections indicate an increase in the average annual temperature by 2.8°C to 3.1°C by 2050 for the area. his also translates into an increase in heat stress, including an increase in both very hot days and heat wave days in the municipality.

Current annual average rainfall for the area ranges between 650mm and 870mm. There are mixed signals regarding climate change projections for rainfall over the region, indicating uncertainty around changes in future rainfall patterns. Rainfall projections indicate both the equal but contrasting possibility of increases or decrease in rainfall by up 15mm annually. The municipality and the region at large is therefore likely to experience greater variability in rainfall and will almost certainly witness an increase in evaporation rates due to increasing temperatures.

High levels of socio-economic vulnerability further compound the potential effects of climate change in the municipality. The LM is characterised by low-intensity development, with scattered, relatively low-density towns and settlements throughout the area. Most villages in the municipality are under traditional leadership. The municipality includes approximately 60 villages and settlements, with significant clustering in the eastern corner near Siyabuswa, and which also serves as the capital town. This area is predominantly residential, with local communities relying on the City of Tshwane, City of Johannesburg, Emalahleni, and Steve Tshwete Municipalities, which provide employment opportunities and higher-order services for a significant portion of the municipality's population.

4.2. Priority climate-related hazards

The climate projections indicate that Dr JS Moroka Local Municipality will become hotter towards 2050. The greatest likelihood of hazards occurring in the municipality are increases in wildfires and temperatures, with the risk of heat extremes becoming greater and wildfires more likely. Of secondary concern, the municipality also has a moderate risk of flood hazard. These elevated climate risks are compounded by the high socio-economic vulnerabilities faced by communities in the area, making them more susceptible to adverse outcomes arising from climate change. The area is however projected to have declining population growth pressure, which may reduce the number of people exposed in the future.

The high risk of heat and wildfires have cascading effects of which poses severe health risks to people and animals. Higher temperatures over extended periods contribute to the urban heat island effect and increases the demand for cooling and water, which in turn increase overall electricity demand. Moreover, higher temperatures are associated with health hazards such as heat stress and the spread of vector borne diseases in both humans and livestock. 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.

5. Adaptation Goals, Programmes and Actions

The section outlines the adaptation plan using goals and measures designed to help Dr JS Moroka 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 Dr JS Moroka 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 water security and good water quality for human consumption under a changing climate
- Goal 2: To protect biodiversity and improve sustainable use of natural resources
- Goal 3: To reduce the vulnerability and exposure of human and natural systems to wildfires
- Goal 4: To build capacity of the public health sector and protect human health
- Goal 5: To protect and increase the resilience of critical municipal infrastructure

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 water security and good water quality for human consumption and irrigation under a changing climate.

Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. These could include prioritising water infrastructure maintenance; investing in efficient water supply infrastructure to meet future demand; promoting water conservation practices by implementing strategies and interventions such as public awareness campaigns, leak detection and repairs, and water metering as well as exploring measures to secure alternative water sources such as rainwater (harvesting), groundwater (recharge and extraction) and wastewater (reuse).

Programme 1.1: Adopt an integrated approach to water augmentation, water use and water management. This programme is a strategic response to the municipalities dynamic and multifaceted water-related challenges in the context of climate change, and it embodies a comprehensive and collaborative approach to water resource management. The rationale for this programme arises from the interrelated climate projections, environmental challenges, and socio-economic factors within the municipality that shape water availability and quality. The following actions would contribute to this programme:

- Adopt Water-sensitive urban design (WSUD): Given the escalating climate extremes, including temperate increases and increased potential for flooding, implementing WSUD is crucial to enhance the municipalities resilience. WSUD principles promote the sustainable use and management of water in urban design and planning, treating water as an integral part of the urban

ecosystem. This approach involves creating urban landscapes and infrastructures that mimic natural water cycles, managing stormwater, conserving water, and reducing runoffs. WSUD can also help alleviate water pollution issues by filtering runoffs before they reach water bodies, contributing to improved water quality.

- Address human resources constraints for effective water management: Climate change adaptation requires effective water management, which in turn necessitates a competent and robust human resources pool. Addressing any human resources constraints within the municipality is vital for implementing and managing the various initiatives under this programme. Training and capacity building in water management, conservation, and climate change adaptation are crucial for enhancing the municipality 's ability to adapt to future climate-related water challenges.
- Review bulk water master plan: This review should consider the expected increase in water demand due to urbanisation and population growth, the projections of climate change, and the need to ensure water security. Such a review will help identify any necessary upgrades or replacements for ageing infrastructure and plan for potential expansions to meet growing demand.
- Develop a water safety plan (WSP): A WSP is a comprehensive risk assessment and risk management approach that encompasses all steps in the water supply from catchment to consumer. Considering the threats to water quality and availability in the municipality, including pollution and climate change impacts, a WSP will provide a systematic framework for ensuring safe drinking water. This will involve identifying potential risks, implementing control measures, and establishing monitoring systems and management procedures to ensure ongoing water safety.

Programme 1.2: Water conservation and demand management

The programme aims to promote efficient water use and decrease wastage to ensure long-term water security. Water Conservation and Demand Management calls for a holistic and concerted effort to manage water demand and promote sustainable practices to ensure water security. The following actions would contribute to this programme:

- Implement monitoring mechanisms and protecting water sources by reducing pollution: Effective water management necessitates continuous and accurate monitoring of water sources. This involves not only keeping track of water levels and usage but also monitoring water quality. Monitoring can help detect any pollution that could compromise water safety and lead to violations of South African National Standards (SANS 241). Further, mechanisms need to be put in place to prevent pollution, including policies and regulations aimed at industries and other potential sources of contamination.
- Implement water conservation measures: This involves developing and promoting practices and technologies to reduce water use and waste. This could include public awareness campaigns to encourage water-saving behaviours, leak detection and repair programmes to reduce losses from the ageing water infrastructure, and the promotion of water-efficient appliances and fixtures in both residential and commercial settings.
- Implement alien invasive species clearing initiatives in catchment areas: Alien invasive species often consume more water than native species and can disrupt local ecosystems. Their presence can lead to significant water losses in catchment areas, reducing the amount of water available

for human use. Initiatives to clear these species can improve water availability and also benefit local biodiversity.

- Enforce 'green' approaches in residential areas and developments: 'Green' approaches incorporate environmentally-friendly practices into everyday living and urban planning. In terms of water, this could involve rainwater harvesting, greywater recycling, and sustainable landscaping practices that reduce water demand. For new developments, this could mean ensuring that buildings are designed to be water-efficient and that water-sensitive urban design principles are followed.
- Implement public awareness campaigns to encourage water-saving practices at home and in businesses: Educate and raise awareness among stakeholders about the importance of reducing water demand as a climate change adaptation strategy. This includes providing information and resources to the public, businesses, and policymakers about the benefits of water conservation, as well as offering training and outreach programs to promote water-saving behaviours and practices.

Programme 1.3: Protect, maintain and improve water services infrastructure

The programme aims to increase the resilience of water services to climate change, by improving infrastructure reliability, reducing downtime, and minimising service interruptions, thereby ensuring sustainable water supply for municipalities. The following actions would contribute to this programme:

- Undertake regular maintenance and inspection: Implement regular maintenance schedules for water infrastructure, including pipelines, treatment plants, reservoirs, and pumping stations. Conduct routine inspections to identify and address potential issues before they escalate into larger problems. All water provision infrastructure should be maintained to ensure that it will be able to deal with extreme events such as flooding and drought, and remain in functioning condition.
- Prioritise repairs and upgrades based on the condition and criticality of infrastructure components: This includes the installation of technology that can detect leaks in water supply reticulation and send notifications and alarms to relevant personnel. Retrofit existing infrastructure to withstand extreme weather events, such as floods, fires, storms, and droughts.
- Upgrade existing infrastructure: Invest in upgrading aging infrastructure to improve reliability, efficiency, and resilience to climate change impacts.
- Adopt climate-resilient design: Incorporate climate-resilient design principles into new infrastructure projects to future-proof against climate risks.

Programme 1.4: Water quality monitoring and management

The programme aims to addresses the pressing need for careful stewardship of the municipality's water resources and seeks to strengthen institutional and community capacity to manage its resource sustainably in the face of climate change, ensuring the quality of water resources, which is vital to the municipality's sustainable development trajectory. The following actions would contribute to this programme:

- Monitor water quality: Conducting regular water quality monitoring to track the levels of various pollutants, including pathogens, nutrients, and chemicals, in water bodies.

- Implement pollution prevention measures: 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.
- Implement water reuse projects: Developing and implementing water treatment technologies to remove pollutants from wastewater before discharge or reuse.
- Enforce water resource regulations and policies: 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.
- Collaborate around shared water resources: Collaborating with neighbouring municipalities and stakeholders to manage shared water resources and prevent transboundary pollution.

5.3. Adaptation programme: Goal 2

Goal 2: To protect biodiversity and improve sustainable use of natural resources.

Nationally, biodiversity is increasingly under pressure from rapid urbanisation, agricultural expansion and land use change. Moreover, the impacts of climate change further threaten the ability of ecosystems and ecological assets to maintain their essential functions. Therefore, protecting and restoring natural ecosystems such as high priority biomes, wetlands, river ecosystems and riparian areas – i.e., to perform critical ecosystem services, enhance biodiversity, support water resource management, and provide natural buffers against climate-related hazards such as wildfires – will have to become a priority. Some of the actions that the Municipality could take to realise this goal include establishing or expanding protected areas, enforcing regulations against harmful practices in such areas, and promoting the sustainable use of natural resources.

Programme 2.1: Conserve, Protect and Restore Natural Open Spaces and Ecosystems with Climate Change Adaptation Benefits

The programme aims to conserve, protect and restore natural open spaces, ecosystems and natural resources. The programme is a comprehensive effort to protect the municipality's natural heritage and use it as a means to adapt to climate change. Preserving and restoring healthy ecosystems is essential for effective flood management, drought resilience, and sustainable water provision. Conservation efforts and integrated watershed management approaches are critical for ensuring the continued functioning of these ecosystems and the services they provide. The following actions would contribute to this programme:

- Enforce environmental regulations: Effectively enforce existing environmental regulations to prevent illegal activities like deforestation, pollution, and overexploitation of natural resources.
- Implement a natural resource management training programme: Provide training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines.
- Establish protected areas: Designate and manage protected areas to conserve critical habitats and species.
- Identify and map valuable ecosystems: Conduct comprehensive surveys to identify and map critical natural areas, biodiversity hotspots, and ecosystem service providers within the municipality.

- Develop conservation plans: Create and implement local conservation plans that prioritise the protection of sensitive ecosystems and endangered species.
- Promote sustainable land management: Encourage practices that minimise soil erosion, promote water infiltration, and maintain healthy ecosystems. This could involve promoting responsible grazing, restoring degraded lands, and combating invasive alien species.
- Develop restoration strategies: Develop comprehensive plans for the restoration of degraded natural areas, focusing on restoring ecological functions and native biodiversity.
- Monitor and prevent soil erosion: 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.
- Harness the potential of open spaces to absorb and mitigate the impacts of climate change: This action involves the strategic management of open spaces to maximise their carbon sequestration potential to aid in air quality management, as well as their ability to act as buffers against extreme weather events. This could include initiatives like reforestation, the creation of urban green spaces, and the restoration of wetlands and riparian zones, which not only absorb carbon but also serve to regulate water flow and minimise flood risk.
- Identify areas that should be maintained in a natural state: These areas should be identified by the municipality and community and protected from land invasions. Keeping these areas in a natural or near-natural state will allow ecosystems and species to adapt naturally to climate change, thus supporting ecologically healthy landscapes and the ability of ecosystems to continue to provide a range of ecosystem services to surrounding residents of the area.
- Improve the environmental management capacity of Traditional Leaders: Introduction of interventions to improve the environmental management capacity of Traditional Leaders and the development of environmental planning standards that are aimed at creating ecological resilience.

5.4.Adaptation programme: Goal 3

Goal 3: To reduce the vulnerability and exposure and increase the adaptive capacity of human settlements to wildfires.

To minimise the damage and loss stemming from the unavoidable impacts of wildfires, it is essential to reduce the exposure and vulnerability of elements found in both human and natural systems present in the municipality. Reducing exposure and vulnerability will involve a combination of infrastructural, behavioural, and institutional changes. For human systems, this might involve building climate-resilient infrastructure, adopting or improving existing disaster risk reduction strategies, and enhancing social safety nets for the most vulnerable. For natural systems, this can involve protecting and restoring ecosystems that provide natural buffers against climate impacts, such as wetlands that absorb flood waters.

Programme 3.1: Integrated Fire Management for Climate Resilience

The integrated fire management for climate resilience programme is crucial for the municipalit considering both its current state and future projections of wildfire risk. This programme aims to minimise the occurrence and impact of wildfires, protect communities, ecosystems, and infrastructure, and enhance resilience to increasing fire risk. The following actions would contribute to this programme:

- Conduct comprehensive risk assessments to identify areas prone to wildfires: Consider factors such as climate conditions, vegetation types, topography, and human activities. Develop wildfire risk maps to prioritise areas for mitigation measures and emergency preparedness planning.
- Implement measures to prevent wildfires: This includes enforcing fire bans during periods of high fire danger, regulating land-use practices, and conducting prescribed burns to reduce fuel loads. Implement fuel management strategies, such as creating firebreaks, thinning dense vegetation, and removing flammable debris, to reduce the intensity and spread of wildfires.
- Enhance early detection and monitoring of wildfires: Use fire detection systems, remote sensing technologies, and community reporting mechanisms to detect and monitor wildfires. Invest in fire surveillance and monitoring infrastructure, including lookout towers, aerial surveillance, and satellite imagery analysis, to detect and respond to wildfires quickly.
- Develop and implement wildfire response plans: Uutline roles and responsibilities, communication protocols, evacuation procedures, and coordination mechanisms among relevant stakeholders. Conduct training exercises and drills for emergency responders, community members, and other stakeholders to ensure effective wildfire response and evacuation procedures.
- Engage with communities to raise awareness about wildfire risks, prevention measures, and evacuation procedures: Provide training and educational programs on fire safety, including safe burning practices, home fire prevention, and wildfire preparedness, targeting vulnerable populations and high-risk areas.
- Design and retrofit infrastructure to withstand wildfires:, This could include using fire-resistant building materials, ember-resistant roofing, and defensible space around structures. Implement land-use planning measures to avoid locating critical infrastructure and residential developments in high-risk wildfire areas.
- Restore and manage ecosystems to reduce wildfire risk and enhance ecological resilience: This could include controlled burns, forest thinning, and invasive species management. Promote biodiversity conservation and habitat restoration to improve ecosystem health and reduce the spread of wildfires.
- Develop and implement land use planning and zoning regulations that consider the potential impacts of wildfires: Land use planning can help reduce vulnerability to climate change, for example by preventing development in fire-prone areas or protecting areas that provide crucial ecosystem services.

5.5. Adaptation programme: Goal 4

Goal 4: To build capacity of the public health sector and protect human health.

Climate change hazards such as heat extremes pose serious risks to public health. Heat-related illnesses such as heatstroke is one of the health risks associated with this hazard. It is therefore necessary to ensure that adequate systems are in place to mitigate (or respond to) the adverse consequences of such impacts. Implementing early warning systems for extreme weather events, ensuring access to climate-sensitive health services (such as heat illness prevention), and improving emergency response capacity,

are some of the measures that the municipality could look into. Furthermore, public education about the risks of climate change to health and safety is also crucial.

Programme 4.1: Human health and heat stress management

According to the climate risk assessment, Dr JS Moroka will become increasingly susceptible to extreme heat events into the future. These events can cause heat stress, leading to severe health issues such as heat strokes and dehydration, making heat stress management a critical priority. Implementing heat health action plans is essential to prepare the community for heat stress. This includes establishing early warning systems, developing response plans, and effectively communicating heatwave warnings and safety measures. Proactive measures like cooling infrastructure, heat-reducing city planning, and community education on heat risks are also crucial. Improving access to healthcare during extreme heat events is equally important. Healthcare facilities must be equipped to handle heat-related illnesses, and healthcare providers need the capability to identify and treat these conditions swiftly. Ensuring healthcare access for vulnerable populations, such as the elderly, children, and those with chronic diseases, is vital as they are most at risk. The human health and heat stress management programme is thus pivotal for protecting community health in the municipality from the increasing threat of heat stress due to climate change. By addressing heat stress proactively and systematically, the municipality can significantly reduce heat-related illnesses and deaths, enhancing community resilience. The following actions would contribute to this programme:

- Conduct climate vulnerability assessments for the municipalities population to identify those most at risk from heat stress: Perform detailed assessments that consider various factors such as age, health status, socioeconomic conditions, and geographic location to identify vulnerable groups, such as the elderly, children, outdoor workers, and low-income residents.
- Develop and implement public awareness campaigns on heat-related illnesses, their prevention, and the use of personal protective equipment (PPE) to prevent heat stress: Design multilingual and culturally sensitive campaigns using various media platforms to reach a wide audience. Create informative materials, including brochures, posters, and videos, detailing symptoms of heat-related illnesses, preventive measures, and the importance of staying hydrated and using PPE like hats and light clothing. Collaborate with schools, workplaces, and community organisations to disseminate information.
- Implement heat-health warning systems in collaboration with local meteorological agencies: Develop an early warning system that provides timely alerts about upcoming heatwaves and high-temperature days, using SMS, email, and public announcements
- Train and appoint community representatives in first aid to respond effectively to heat stress incidents: Conduct regular first aid training sessions focused on recognising and treating heat-related illnesses, such as heat exhaustion and heat stroke.
- Train healthcare workers on identifying and treating heat-related illnesses: Provide specialized training for healthcare workers, including doctors, nurses, and paramedics, on the symptoms, diagnosis, and treatment of heat-related conditions.
- Expand emergency healthcare services during heatwaves, ensuring quick and efficient response to heat stress incidents: Increase staffing and resources in emergency departments during peak heat periods to handle the anticipated rise in heat-related cases. Set up temporary emergency clinics in high-risk areas to provide quick and localised medical care and ensure that ambulances and emergency response teams are adequately equipped to handle heat stress emergencies.

- Establish hydration and cool-down facilities in public spaces to provide immediate relief during high temperatures: Install water stations and shaded areas in public spaces to help people stay cool and hydrated. Encourage businesses and public institutions to create cool-down zones where people can rest and cool off during extreme heat. Promote the availability and location of these facilities through public awareness campaigns.

5.6. Adaptation programme: Goal 5

Goal 5: To protect and increase the resilience of critical municipal infrastructure.

Critical infrastructure is the backbone of the economy and functionality of the built environment. Protecting and increasing the resilience of critical municipal infrastructure ensures the continuous provision of essential services, such as water supply, energy, transportation, and communication systems. It helps to minimise disruptions during emergencies, supports economic stability, and enhances public safety. By investing in resilient infrastructure, municipalities can better withstand and recover from natural disasters, climate change impacts, and other threats, thereby maintaining the well-being and quality of life for their communities.

Programme 5.1: Infrastructure Resilience Programme

The Infrastructure Resilience Programme is vital for the municipality, particularly in the face of climate change projections that indicate an increase in extreme rainfall events. Flooding can have devastating impacts on the community, not just in terms of immediate physical damage, but also by disrupting essential services such as electricity, water supply, and transportation. By strengthening key infrastructure to withstand these events, the municipality can ensure the continuity of these services, mitigate potential damage, and increase the resilience of the community to weather-related hazards. The following actions would contribute to this programme:

- Assess the vulnerability of existing infrastructure: Carry out a thorough vulnerability assessment of existing infrastructure to identify areas most at risk during flood events and extreme rainfall. This will involve examining the structural integrity of buildings, bridges, roads, and other infrastructure, as well as their proximity to flood-prone areas.
- Upgrade and retrofit infrastructure: Based on the vulnerability assessment, upgrade or retrofit the infrastructure identified as high-risk. This could involve improving the design of buildings to make them more flood-resistant, reinforcing roads and bridges, and enhancing drainage systems to manage stormwater effectively.
- Integrate climate resilience in future infrastructure development: Integrate climate resilience into the planning, design, and construction of all new infrastructure projects. This means ensuring that any new infrastructure is designed to withstand predicted future climate conditions, including increased flooding.
- Conduct regular inspection and maintenance: Conduct regular inspections and maintenance to ensure the structural integrity of key infrastructure, and to identify and fix potential issues before they lead to more serious problems.
- Conduct infrastructure resilience training for engineers and planners: Provide training for engineers and urban planners on the latest techniques and technologies for building resilient infrastructure. This can help to ensure that the municipality's infrastructure is able to withstand future climate challenges.

6. Implementation Framework

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

Commented [AP1]: Update to reflect changes made above

6.1. Implementation framework: Goal 1

Goal 1: To ensure water security and good water quality for human consumption and irrigation under a changing climate.

Adaptation programme 1.1: Adopt an Integrated Approach to Water Augmentation, Water Use and Water Management				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Adopt Water-sensitive urban design (WSUD)	Water supply vulnerability, Urban flooding	Planning	Short Term (<5 years)	High
ii. Address human resources constraints for effective water management	Water supply vulnerability, Urban flooding	Human Resources/ Water and Sanitation	Short Term (<5 years)	High
iii. Review bulk water master plan	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
iv. Develop a water safety plan (WSP)	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High

Adaptation programme 1.2: Water Conservation and Demand Management				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Implement monitoring mechanisms and protecting water sources by reducing pollution	Water supply vulnerability	Environmental Services/ Water and Sanitation	Short Term (<5 years)	High
ii. Implement water conservation measures	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
iii. Implement alien invasive species clearing initiatives in catchment areas	Water supply vulnerability, urban flooding	Environmental Services/ Water and Sanitation	Short Term (<5 years)	High

iv. Enforce 'green' approaches in residential areas and developments	Water supply vulnerability, urban flooding	Planning/ Environmental Services	Medium Term (5-10 years)	Medium
v. Implement public awareness campaigns to encourage water-saving practices at home and in businesses	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	Medium

Adaptation programme 1.3: Protect, Maintain and Improve Water Services Infrastructure				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Undertake regular maintenance and inspection	Water supply vulnerability, Urban flooding	Water and Sanitation	Short Term (<5 years)	High
ii. Prioritise repairs and upgrades based on the condition and criticality of infrastructure components	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
iii. Upgrade existing infrastructure	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
iv. Adopt climate-resilient design	Water supply vulnerability, Urban flooding	Water and Sanitation	Short Term (<5 years)	High

Adaptation programme 1.4: Water Quality Monitoring and Management				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Monitor water quality	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
ii. Implement pollution prevention measures	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
iii. Implement water reuse projects	Water supply vulnerability	Water and Sanitation/ Environmental Services	Short Term (<5 years)	High

iv. Enforce water resource regulations and policies	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High
v. Collaborate around shared water resources	Water supply vulnerability	Water and Sanitation	Short Term (<5 years)	High

6.2. Implementation framework: Goal 2

Goal 2: To protect biodiversity and improve sustainable use of natural resources

Adaptation programme 2.1: Conserve, protect and restore natural open spaces, ecosystems and natural resources				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Enforce environmental regulations	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services/ Land Use Management	Short Term (<5 years)	High
ii. Implement a natural resource management training programme	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Short Term (<5 years)	Medium
iii. Establish protected areas	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services/ Land Use Management	Medium Term (5-10 years)	Medium
iv. Identify and map valuable ecosystems	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Short Term (<5 years)	High
v. Develop conservation plans	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Short Term (<5 years)	Medium

vi. Promote sustainable land management	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services/ Land Use Management	Short Term (<5 years)	Medium
vii. Develop restoration strategies	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Medium Term (5-10 years)	Medium
viii. Monitor and prevent soil erosion	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Medium Term (5-10 years)	Medium
ix. Harness the potential of open spaces to absorb and mitigate the impacts of climate change	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Medium Term (5-10 years)	Medium
x. Identify areas that should be maintained in a natural state	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Short Term (<5 years)	High
xi. Improve the environmental management capacity of Traditional Leaders	Environmental vulnerability Flooding, Wildfire Population exposure	Environmental Services	Short Term (<5 years)	High

6.3. Implementation framework: Goal 3

Goal 3: To reduce the vulnerability and exposure and increase the adaptive capacity of human settlements to wildfires.

Adaptation programme 3.1: Integrated Fire Management for Climate Resilience				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level

i. Conduct comprehensive risk assessments to identify areas prone to wildfires	Wildfire	Fire Services/ Disaster Management	Short Term (<5 years)	High
ii. Implement measures to prevent wildfires	Wildfire	Fire Services/ Disaster Management	Short Term (<5 years)	High
iii. Enhance early detection and monitoring of wildfires	Wildfire	Fire Services/ Disaster Management	Short Term (<5 years)	High
iv. Develop and implement wildfire response plans	Wildfire	Fire Services/ Disaster Management	Short Term (<5 years)	Medium
v. Engage with communities to raise awareness about wildfire risks, prevention measures, and evacuation procedures	Wildfire	Fire Services/ Infrastructure Planning & Management	Medium Term (5-10 years)	Medium
vi. Design and retrofit infrastructure to withstand wildfires	Wildfire	Fire Services/ Environmental Services	Short Term (<5 years)	Medium
vii. Restore and manage ecosystems to reduce wildfire risk and enhance ecological resilience	Wildfire	Fire Services/ Land Use Management	Short Term (<5 years)	Medium
viii. Develop and implement land use planning and zoning regulations that consider the potential impacts of wildfires	Wildfire	Fire Services/ Land Use Management	Short Term (<5 years)	Medium

6.4. Implementation framework: Goal 4

Goal 4: To build capacity of the public health sector and protect human health

Adaptation programme 4.1: Human Health and Heat Stress Management				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level

i. Conduct climate vulnerability assessments for the municipalities population to identify those most at risk from heat stress	Heat stress	Health services	Short Term (<5 years)	High
ii. Develop and implement public awareness campaigns on heat-related illnesses, their prevention, and the use of personal protective equipment (PPE) to prevent heat stress	Heat stress	Health services	Short Term (<5 years)	High
iii. Implement heat-health warning systems in collaboration with local meteorological agencies	Heat stress	Health services	Short Term (<5 years)	High
iv. Train and appoint community representatives in first aid to respond effectively to heat stress incidents	Heat stress	Health services	Short Term (<5 years)	High
v. Train healthcare workers on identifying and treating heat-related illnesses	Heat stress	Health services	Short Term (<5 years)	High
vi. Expand emergency healthcare services during heatwaves, ensuring quick and efficient response to heat stress incidents	Heat stress	Health services	Short Term (<5 years)	High
vii. Establish hydration and cool-down facilities in public spaces to provide immediate relief during high temperatures	Heat stress	Health services	Short Term (<5 years)	High

6.5. Implementation framework: Goal 5

Goal 5: To protect and increase the resilience of critical municipal infrastructure.

Adaptation programme 5.1: Infrastructure Resilience Programme				
Adaptation Actions	Key risk or vulnerability addressed	Responsible entity	Timeframe	Priority level
i. Assess the vulnerability of existing infrastructure	Flooding Extreme weather events	Infrastructure Planning & Management	Short Term (<5 years)	High
ii. Upgrade and retrofit infrastructure	Flooding Extreme weather events	Infrastructure Planning & Management	Short Term (<5 years)	High
iii. Integrate climate resilience in future infrastructure development	Flooding Extreme weather events	Infrastructure Planning & Management	Short Term (<5 years)	High
iv. Conduct regular inspection and maintenance	Flooding Extreme weather events	Infrastructure Planning & Management	Short Term (<5 years)	High
v. Conduct infrastructure resilience training for engineers and planners	Flooding Extreme weather events	Infrastructure Planning & Management	Short Term (<5 years)	Medium

7. Implications for the PHSHDA's

Based on the provided climate risk information and the proposed adaptation plan for the Dr JS Moroka Local Municipality, there are several implications and recommendations for the planning and development of the Siyabuswa PHSHDA. The settlement will face increased temperatures and heat stress, which will impact public health, energy demand, and infrastructure. The urban heat island effect will exacerbate the impact of heat in densely populated areas. Additionally, variable rainfall patterns could affect water availability and quality, with increased evaporation rates further reducing water supply and affecting agriculture, households, and ecosystems. The greater risk of wildfires will threaten lives, property, and natural ecosystems, while smoke pollution from wildfires may pose additional health risks. Potential flooding risk requires robust infrastructure planning and development. High levels of socio-economic vulnerability compound the adverse effects of climate change, making it challenging to provide services and emergency responses in low-density, scattered settlements.

To address these challenges, integrated water management is crucial. Adopting Integrated Water Resource Management strategies that combine efficient water use and sustainable management of water resources will help ensure water security in the PHSHDA. Promoting water conservation practices may also reduce water wastage. Improving water infrastructure to ensure reliable supply and reduce service interruptions, focusing on resilience to climate impacts like increased evaporation and uncertain rainfall, is essential.

Urban planning and infrastructure development projects in the Siyabuswa PHSHDA must prioritise heat-resilient measures. Implementing cooling measures such as green roofs, urban greening, and reflective building materials can mitigate the urban heat island effect. Strengthening flood resilience by enhancing drainage systems, constructing flood barriers, and ensuring new housing and infrastructure developments in the Siyabuswa PHSHDA are resilient to flooding is necessary. Integrated fire management practices, such as developing firebreaks, implementing controlled burns, and maintaining vegetation fuel loads on the urban-wildland interface of the PHSHDA, can also assist in reducing wildfire risk.

Public health initiatives are also critical. Establishing early warning systems for heatwaves, creating public cooling centres, and ensuring healthcare facilities are equipped to handle heat-related illnesses will help manage heat stress. Community education on heat risks, wildfire safety, and water conservation practices is vital for preparedness and resilience of vulnerable groups.

Ecosystem and biodiversity protection should balance sustainability and development demands within the Siyabuswa PHSHDA, where there is a need to focus on conserving and restoring natural spaces which provide natural flood control, water purification, and climate regulation. Promoting biodiversity-friendly practices in agriculture and urban development will help maintain essential ecosystem services.

Enhancing socio-economic resilience will need to involve developing programs to reduce poverty and improve living conditions, particularly in vulnerable communities. Engaging local communities in planning and decision-making processes ensures that adaptation measures are more widely accepted. Developing and enforcing climate-smart policies that incorporate climate change projections into all aspects of planning and development projections planned for the PHSHDA is crucial. Fostering partnerships with neighbouring municipalities and government agencies can aid in leveraging resources and expertise.

By integrating these recommendations into planning and development, Dr JS Moroka Local Municipality and the Siyabuswa PHSHDA can enhance its resilience to climate change, protect its communities, and ensure sustainable growth.

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 or 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. 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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