GREENBOOK
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West Rand
District Municipality

West Rand District Municipality

Adaptation Plan

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List of Acronyms and Abbreviations

AMD	Acid Mine Drainage
CBA	Critical Biodiversity Area
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEMF	District Environmental Management Forum
DFFE	Department of Forestry, Fisheries, and the Environment
DDM	District Development Model
DRR	Disaster risk reduction
ESA	Ecological Support Areas
EcVI	Economic Vulnerability
EnVI	Environmental Vulnerability
GCM	General circulation model
GVA	Gross Value Added
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
KPIs	Key Performance Indicators
NGOs	Nongovernmental organisations
PVI	Physical Vulnerability Index
SEVI	Socioeconomic Vulnerability
SDF	Spatial Development Framework
SMMEs	Small, Micro and Medium-sized Enterprises
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No.16 of 2013)
WSUDP	Water Sensitive Urban Design and Planning

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, 2023).
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, [as well as] 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.

This Climate Change Adaptation Plan and its accompanying Risk Profile report have been specifically drafted for the West Rand District 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 l Adapting settlements for the future).

The Climate Risk Profile report 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 District Municipality.
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 the West Rands District Municipality with a comprehensive strategy to navigate the complexities of climate change, reduce vulnerability and exposure, and champion sustainable development.

The Adaptation Plan briefly outlines the policies constituting the framework for adaptation planning and implementation 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 West Rand District Municipality by aligning it with adaptation goals, programmes, and actions designed to address priority risks, as well as an implementation framework, designed to identify appropriate actors and enable the implementation of the strategy. Finally, the document concludes with recommendations aimed at

facilitating the integration of the proposed actions into broader initiatives, ensuring their effective mainstreaming.

1.1. 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, i.e. Act 16 of 2015, the Spatial Planning and Land Use Management Act (SPLUMA), i.e., Act No. 16 of 2013, the Climate Change Bill, i.e., 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 governments 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** sets out climate change response requirements for all organs of state across all levels of government, as well as the institutional arrangements necessary to meet those requirements. Amongst them is the requirement 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, as well as the requirement for every metropolitan and district 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** 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.

1.2. Outline of the Climate Change Adaptation Plan

Figure 1 below outlines the structure of the report, and includes a description of the development process, and components, of the Climate Change Adaptation Plan for the West Rand District Municipality. The first chapter introduces the district's Climate Change Adaptation Plan, and provides an overview of the national policy context for climate change adaptation planning and implementation, as well as an outline of the structure of the Adaptation Plan. Chapter 2 outlines the adaptation planning framework that forms the basis for the district's Climate Change Adaptation Plan, and consists of adaptation principles, an adaptation approach, as well as adaptation goals, programmes, and actions. Chapter 3 provides a summary of the district municipality's Climate Risk Profile report, which includes an overview of the climate projections, vulnerabilities and impacts identified for the district municipality, as well as the key climate-related risks that need to be prioritised when undertaking climate change response. Chapter 4 outlines the adaptations goals, programmes and actions identified for the district municipality, as informed by the key climate-related hazards facing the district. Chapter 5 provides a framework for the implementation of the adaptation programmes and actions identified for the West Rand District Municipality, and considers the local government functions and actors (including nongovernmental actors) responsible for the implementation of the identified actions, as well as the costs and level of priority associated with each adaptation action. Chapter 6 provides recommendations on how the district municipality can mainstream the identified programmes and actions into existing municipal processes and instruments, with the aim to ensure that climate change considerations are an integral part of all that local government is doing.

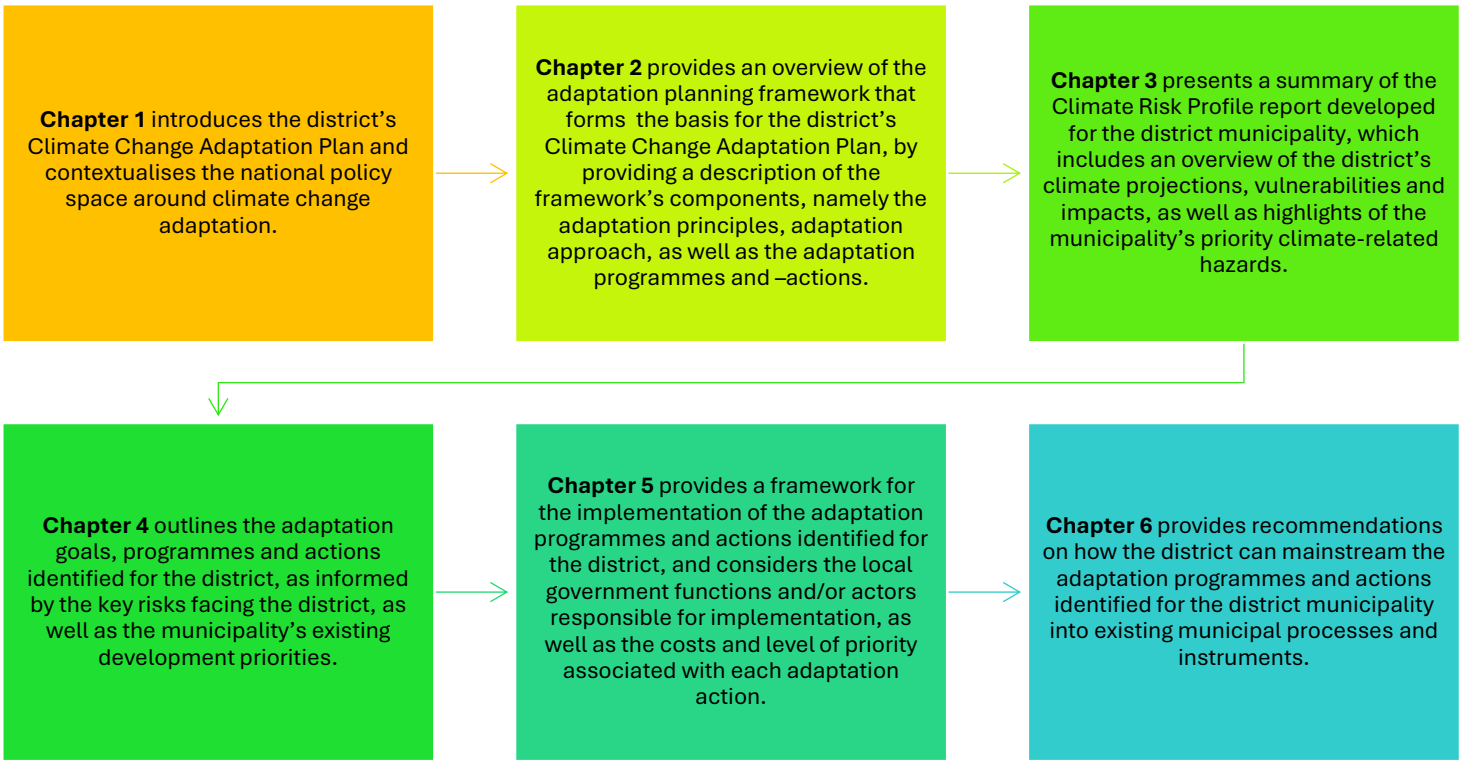

Figure 1: Outline of the Climate Change Adaptation Plan.

2. Adaptation Planning Framework

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).

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.

2.1. 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 (also referred to as 'actions').

2.2. 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.

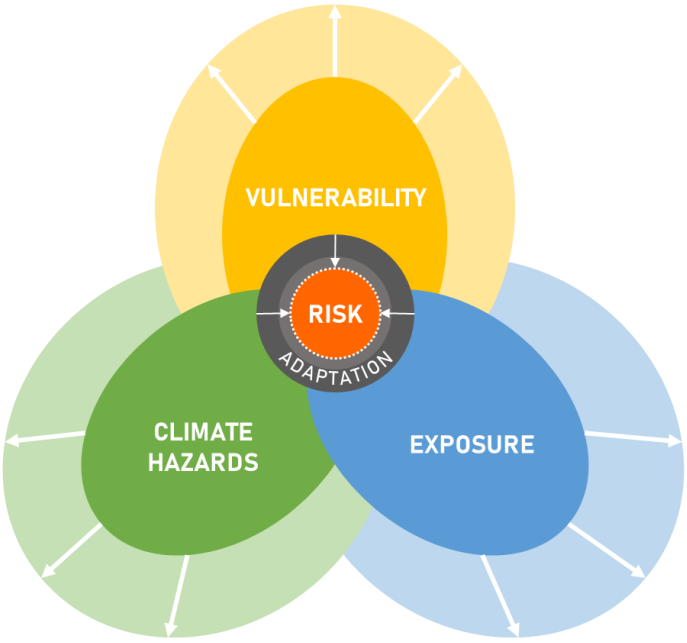

Figure 2: The interplay between hazards, vulnerability and exposure that determines risk (based in IPCC, 2014 and IPCC, 2021)

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.

2.3. Adaptation programmes and actions

An adaptation programme is a structured and systematic set of actions, initiatives, and interventions aimed at local governments to adapt their localities 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, 2023).

A spectrum of adaptation actions is at the disposal of 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, 2023).

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.

2.4. Stakeholder engagement process

To construct a Climate Change Adaptation Plan resonating with the specific requirements of the West Rand District Municipality, while appropriately addressing its significant risks – a stakeholder engagement component was factored into the adaptation planning process, which gave district municipal officials and practitioners a platform to provide meaningful input on both the Risk Profile report and Adaptation Plan. The first stakeholder engagement focused on the Climate Risk Profile report of the district municipality, with the aim of validating the climate-related risks identified for the district (as flagged in the Risk Profile report), while securing the district's confirmation of the adaptation goals proposed in response to the identified risks. The second engagement took place after a draft Climate Change Adaptation Plan was developed. As part of this engagement, each climate change adaptation programme identified under each goal, as well as each of the actions associated with the adaptation programmes, were intensely workshopped with the district and relevant local municipal officials/stakeholders, in an effort to gather comprehensive input that would help the project team finalise the document. Municipal officials and practitioners from various sectors – particularly those sectors that are either most vulnerable to climate change impacts, or those that are well-positioned to respond to climate change, particularly through adaptation, namely Environmental Management, Disaster Management, Public Safety, Emergency Services, Human Settlements and Land Use Planning, Spatial Planning and GIS – were present during these engagements. This was done in an effort to fulfil section 7.1 (a) of the Climate Change Bill, and to achieve a holistic response to climate change. All engagements took place virtually.

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

3. Summary of Climate Risk Profile

A Climate Risk Profile report was prepared by the project team, designed to complement this Plan. The Climate Risk Profile report serves as an essential resource for understanding the risks associated with climate change in the West Rand District Municipality.

This section of the Plan summarises the Climate Risk Profile for West Rand District Municipality, drawing from the GreenBook Risk Profile Tool (available at: https://riskprofiles.greenbook.co.za/). Please consult the accompanying Climate Risk Profile report for more detailed information.

3.1. Climate projections, vulnerabilities, and impacts

At the baseline, the West Rand District Municipality experiences average annual temperature of between 16 and 18 °C, with lower averages found along the lower south eastern parts of Mogale City and the upper north eastern parts of Rand West City. Projections show an average annual temperature increase of 2.5 °C across the district into the future, under an RCP8.5 low mitigation, "business as usual" emissions, scenario. The West Rand District Municipality also experienced *general circulation model* (GCM) derived average annual rainfall of between 800 and 1200 mm, with lower averages found along the central parts of the district, particularly in Rand West City's settlements of Azaadville, Randfontein and West Rand. Future projections show an average annual rainfall increase of between 100 and 200 mm, with most of the increase expected to occur in the southern parts of the district, assuming an RCP8.5 a low mitigation, "business as usual" emissions, scenario.

Socio-economic vulnerability (SEVI) has decreased (improved) across all local municipalities in West Rand between 1996 and 2011, except Merafong City, the SEVI score of which increased by 0.59 in the same period. However, all the local municipalities have a significantly below national average SEVI scores. Conversely, the economic vulnerability (EcVI) scores of all local municipalities in the district increased (worsened) in the same time period, and exceeded the national average, with Rand West City recording an EcVI score of 9.32 out of 10 (the highest in the province) in 2011. The high economic vulnerability is evident in the declining mining output, which has contributed to West Rand District being home to 9.55 % of the total number of unemployed people in Gauteng, while experiencing an average annual increase of 8.53 % in the number of unemployed people (CoGTA, 2020). All three municipalities in West Rand also recorded above national average physical vulnerability (PVI) scores, alluding to the structural vulnerabilities present in the district. Mogale City and Rand West City recorded high environmental vulnerability (EnVI) scores, alluding to the potential impacts of mining activities, e.g., Acid Mine Drainage (AMD), on the municipalities' environment (DEA, 2017). The district's EnVI score conveys a high conflict between the need to preserve the natural environment, and accommodate the growth pressures associated with population growth, urbanisation, and economic development.

The West Rand District Municipality recorded a total population of 889 731 in 2019 (about 6.1 % of the total population in Gauteng). This was a result of the 1.2 % annual population growth rate that the district experienced between 2017 and 2019 (CoGTA, 2020). The district's population is projected to increase by an additional 237 392 people between 2011 and 2050, under a high population growth scenario. According to the 2022 Census results, the West Rand District Municipality currently has a total population of 998 466.

3.2. Priority climate-related hazards

The greatest risks faced across the West Rand district are increased temperatures, drought and wildfire, with the risk of heat extremes and intense rainfall becoming greater towards 2050. The district currently has very high physical vulnerability (PVI), alluding to the structural vulnerabilities present within the district. District officials confirmed this during the first engagement when they made reference to the increasing burden of new mega-developments on the district's limited and aging infrastructure (the mega-development applications also allude to the increased exposure of people to the anticipated climate hazards). West Rand also has very high economic vulnerability (EcVI) due to its heavy reliance on one sector, i.e., mining, which has been on the decline for several years. This has major implications for those who rely on the sector for employment (bearing in mind that the majority of the district's labour force is employed in this sector) and revenue. Two thirds of district have above national average environmental vulnerability (EnVI) scores, pointing towards the conflict between preserving the natural environment and accommodating the growth pressures associated with urbanisation and economic development. In the case of West Rand, this conflict largely manifests in the form of decanting water in mines that are no longer in operation, as well as the resultant AMD that is threatening the survival and quality of some of the district's most critical natural resources, especially surface and groundwater resources.

In addition to these risks and vulnerabilities, several settlements in the Mogale City, including Krugersdorp and Azaadville, will likely experience high growth pressures up to 2050, while the West Rand Consolidated Gold Mine area (located north of Krugersdorp) will likely experience extreme growth pressures, also up to 2050 – thus alluding to an increase in the exposure of people and their assets to the anticipated climate hazards. This trend was also confirmed by the district during the first engagement, when representatives raised the importance of considering the implications of the multiple mega-developments planned in and around Mogale City, for infrastructure expansion and services provision, seeing that the district already struggles to meet

current demands. In an effort to diversify the economy, the district also indicated plans to expand and diversify the local economy by shifting its reliance from mining to agriculture and tourism. While both sectors emerge as key avenues for promoting economic growth, creating jobs, and reducing the district's economic vulnerability – it will become increasingly imperative to climate-proof and build the sectors' resilience to the impacts of climate change, in an effort to protect investments.

3.3. Additional impacts and vulnerabilities to consider for the West Rand District Municipality

In addition to the climate impacts flagged in the first draft of the Risk Profile report, representatives from the West Rand District Municipality expressed intentions to diversify the district's economy by shifting from a local economy that relies heavily on mining activity, to one that relies on agriculture and tourism, as well. It is with that revelation that during the first engagement with the district, municipal officials requested the project team to identify suitable responses for building the resilience of both sectors to the impacts of climate change. In terms of vulnerabilities, West Rand district representatives requested the project team to also consider (i) the impact of sinkholes on the district's physical vulnerability (which are primarily caused by the dolomitic bedrock present in the district municipal area, but exacerbated by mining activities such as groundwater extraction), as well as (ii) the impact of decanting mine water and the resultant water pollution and Acid Mine Drainage (AMD), on the district's environmental, physical and socio-economic vulnerability – considering that these factors have the potential to exacerbate climate risks.

4. Adaptation Goals, Programmes and Actions

The section outlines the adaptation plan using goals and actions designed to help the West Rand District Municipality to adapt to the impacts of climate change. Based on the assessment of the potential risks and vulnerabilities posed and/or exacerbated by climate change, this plan was developed as a proactive strategy to mitigate these risks and enhance resilience.

4.1. 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 West Rand District Municipality were identified, prioritising those risks with the highest potential impact. These goals were validated by stakeholders during the first engagement with the district:

- **Goal 1**: To ensure water security in the face of climate change.
- **Goal 2**: To protect natural resources and ecosystems.
- **Goal 3**: To reduce the exposure and vulnerability of human systems to climate change impacts and extreme weather events.
- **Goal 4**: To develop climate-resilient, low-carbon, diverse and inclusive local economies, particularly within the mining, tourism and agricultural sectors, that are socially responsible, environmentally sustainable and that provide job opportunities for unskilled, semi-skilled and skilled local residences.

4.2. Adaptation programmes and actions

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.

4.2.1. Goal 1: To ensure water security in the face of climate change

Given the water scarcity challenges in the country, as well as the effects that the projected increase in temperatures (which increase evaporation and reduce runoff, thus reducing the amount of water captured and stored for future consumption), drought tendencies, heat extremes and population growth will have on the West Rand district's future water supply (and demand) – developing comprehensive strategies for water resource management is crucial. As part of these strategies, the West Rand district and its local municipalities could therefore prioritize water infrastructure maintenance; invest in efficient water supply infrastructure to meet future demand; promote water conservation practices by implementing strategies such as public awareness campaigns, leak detection and repairs, water metering and billing; as well as explore measures to secure alternative water sources such as rainwater (harvesting), groundwater (recharge and extraction), and wastewater (reuse).

Programme 1.1: Integrated Water Supply Management

The programme aims to ensure a reliable and sustainable water supply by identifying, developing, and utilizing alternative sources of water. This programme's rationale is grounded in the belief that reducing reliance on a single water source and diversifying the water supply portfolio can increase resilience to climate change impacts, i.e., drought and increasing temperatures, which result in increased evaporation and reduce the amount of water stored in dams. The adaptation actions under this programme are outlined below.

i. **Address human resources constraints for effective water management:** Training and capacity building in water management, water conservation, and climate change could enhance municipal ability to adapt.
ii. **Undertake water resource management planning:** This action involves a comprehensive analysis of the water resources in the local municipality, determining the current and future demand, and assessing how this demand can be met through a mix of traditional and alternative water sources.
iii. **Diversify water supply and investigate alternative water sources:** Explore alternatives to freshwater resources (such as greywater re-use) to bolster resilience to climate change.
iv. **Review, or develop, and implement a treated wastewater reuse strategy:** Water reuse strategy should promote at-source greywater reuse, as well as the large-scale reuse of treated wastewater (effluent), for the purposes of conserving and augmenting available potable water resources, while meeting demand.
v. **Review, or develop, and implement a groundwater management strategy:** implementing a sustainable groundwater use and management strategy is essential for adapting the resource to climate change impacts, ensuring groundwater sustainability, and securing the continued supply of safe water in the municipality.
vi. **Review, or develop, and implement a stormwater management strategy:** Stormwater management strategy should promote the sustainable collection, storage, and use of stormwater (from household to catchment level), for the purposes of conserving and augmenting available potable water resources, while meeting demand.

vii. **Review the bulk water master plan:** This review should consider (i) the expected increase in water demand due to urbanisation, economic development, and population growth, (ii) the projected changes in climate conditions and climate change impacts, as well as (iii) the need to ensure water security.

viii. **Implement monitoring mechanisms and protect water sources by reducing pollution:** Monitoring mechanisms provide regular and reliable data on water quality, allowing for timely interventions.

Programme 1.2: Integrated Water Demand Management

The programme aims to promote efficient water use and decrease wastage to ensure long-term water security in the West Rand district. This approach is crucial given the ageing infrastructure, discrepancies in water access, over-reliance on groundwater (at least for the mining sector), the effects of climate change, and regulatory compliance demands in the district. The adaptation actions under this programme are outlined below.

i. **Implement water conservation measures:** Implementing water conservation measures can range from promoting water-efficient technologies and practices and enhancing public awareness about the importance of saving water, to implementing strict regulations on water use during periods of drought.

ii. **Implement alien invasive species clearing initiatives in catchment areas:** Alien invasive species, particularly those encroaching into river systems, often consume more water than native species, thus compromising water security. Their presence can lead to the degradation of water catchment areas. Therefore, enhancing water security should involve implementing the strategic clearing of these invasive species from catchment areas, which in turn protects these vital water sources.

iii. **Adopt a Water Sensitive Urban Design and Planning (WUSDP) approach for brownfield and greenfield developments:** A WSDP approach is intended to simultaneously promote development, as well as the sustainable use of resources, particularly water resources.

Programme 1.3: Education and Awareness Raising around Climate Change and Sustainable Water Use

As the climate projections suggest more frequent periods of water stress due to increased temperatures and drought tendencies, it is therefore of paramount importance that the West Rand district enhances water conservation awareness and education. This programme is aimed at improving the community's understanding of climate change impacts, particularly the importance of sustainable water management and its role in mitigating these impacts. This programme is grounded in the belief that an informed and engaged community is crucial to achieving long-term water security in the face of climate change. The adaptation actions identified under this programme are outlined below.

i. **Develop water conservation education programmes:** Workshops, community outreach, and public awareness campaigns can be used to disseminate information about the benefits of water conservation, water-saving techniques, and the long-term impact of these actions on water availability and quality.

ii. **Promote water conservation in households:** This can involve providing households with practical guidance and tools to reduce water consumption. For example, educational materials can be distributed to homeowners about water-efficient appliances and fixtures such as low-flow showerheads and dual-flush toilets, rainwater harvesting systems, and greywater reuse techniques.

iii. **Encourage businesses to implement water-saving measures:** This might involve hosting workshops for businesses on water-efficient practices, providing recognition or incentives for

businesses that achieve significant water reductions, and promoting the use of water-efficient technologies in industrial processes.

iv. **Conduct research on water conservation:** This can involve investigating the impact of existing conservation measures, identifying barriers that prevent or hinder water conservation, and exploring innovative approaches and technologies for water conservation.

4.2.2. Goal 2: To protect natural resources and ecosystems

Considering West Rand's high environmental vulnerability (EnVI), particularly the impact of mining activities on the district's natural resources – it is critical to protect the natural resources and ecosystems in the district. Protecting and restoring natural ecosystems such as wetlands and riparian areas, will enhance West Rand's biodiversity, support water resource management, and provide natural buffers against climate-related hazards such as wildfires and surface water flooding. Some of the actions that could be taken 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: Conservation, protection and restoration of West Rand's natural open spaces and ecosystems, with the aim of exploiting climate change adaptation benefits

In light of the evolving climate dynamics in the West Rand district, this programme emerges as an essential strategy for a resilient future. It addresses the significant risks posed by climatic variations, such as drought, increasing temperature, heat extremes, wildfires, and flooding, on the district's natural resources, ecosystems, and open spaces, and prioritizes their conservation, protection, and restoration. This is geared towards leveraging these spaces' inherent ability to provide ecosystems services such as absorbing greenhouse gases, acting as buffers against severe weather events, and providing vital habitats for a wide range of species. The adaptation actions under this programme are outlined below.

i. **Assess natural resources and ensure that natural open spaces, ecosystems, and resources are conserved, protected, and restored:** This adaptation action involves regular monitoring and scientific analysis of the condition and health of natural spaces and resources, including the various rivers and wetlands found in the district municipality.

ii. **Implement nature-based solutions to mitigate/buffer against the impacts of climate change and severe weather, particularly in climate-risk zones:** For example, in areas susceptible to wildfires, measures might include managing vegetation to reduce fuel loads, creating firebreaks, and conducting controlled burns. In flood-prone zones, restoring wetlands and implementing sustainable land use and management practices to reduce runoff could be key actions.

Programme 2.2: Enhancement of West Rand's Natural Resource Management

Considering the rapidly changing climate within the West Rand District Municipality, this programme represents an integral strategy for building the district's resilience and ensuring sustainable development. It addresses the pressing need for careful stewardship of the district's natural resources, such as water and soil, and seeks to strengthen institutional and community capacity to manage these resources sustainably in the face of climate change. The adaptation actions associated with this programme are outlined below.

i. **Monitor and prevent soil erosion to ensure the long-term health and productivity of natural ecosystems, as well as maintain the quality of water resources:** This includes regular monitoring

of erosion hotspots, land-use planning that factor in erosion risk, as well as the implementation of soil conservation measures, such as sustainable agricultural practices.

ii. **Provide training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines:** The training can help to build capacity and knowledge of these regulations, ensuring that those involved in natural resource management have the skills and understanding needed to comply with the regulations and guidelines effectively.

iii. **Establish a District Municipal Environmental Management Forum (DEMF):** Such a forum could serve as a platform to enhance collaboration and coordination between sectoral departments, conversation organisations, and agencies related to natural resource management. Attach Key Performance Indicators (KPIs) for various sectoral departments to the attendance of the forum.

Programme 2.3: Integrate Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) into the Spatial Development Framework (SDF)

This programme underscores the vital importance of acknowledging the intrinsic and instrumental value of natural spaces and ecosystems in the planning and development agenda of the West Rand District Municipality. The district's climate change projections further demonstrate the necessity of this initiative. The adaptation actions under this programme are outlined below.

i. **Ensure critical biodiversity and ecological support areas are integrated into municipal spatial plans at all scales:** The municipality's ecologically vital areas should be incorporated into the municipal spatial planning process to guarantee their preservation and sustainable use.

ii. **Identify and map natural open spaces, ecosystems, and natural resources, and integrate them into the Spatial Development Framework and the Open Space Framework.**

iii. **Identify undeveloped open spaces with potential for green infrastructure:** Such spaces can provide vital climate adaptation benefits, such as heat mitigation, increased stormwater management, as well as the provision of habitats for biodiversity, therefore contributing to the overall resilience of the municipality.

iv. **Assess the value of open spaces and ecosystem services:** Quantify and appreciate the ecological, economic, and socio-cultural value offered by the local municipality's open spaces and the services its ecosystems provide.

4.2.3. Goal 3: To reduce the exposure and vulnerability of human systems to climate change and extreme weather events

To minimise the damage, disruption and loss stemming from the unavoidable impacts of climate change, it is essential to reduce the exposure and vulnerability of elements found in human systems (i.e., lives, livelihoods, assets, and human settlements) present in the West Rand district, to climate-related hazards and extreme events. Reducing exposure and vulnerability will therefore involve a combination of infrastructural, behavioural, and institutional changes. For human systems, this might involve building climate-resilient infrastructure, developing or improving existing disaster risk reduction strategies, and enhancing social safety nets for the most vulnerable. This goal also aims to reduce the district's socioeconomic and physical vulnerability, as well as the exposure its human systems to key climate-related hazards

Programme 3.1: Identification and prioritisation of climate change risks, and the consequent development of appropriate response measures for settlements

Identifying and prioritising climate change risks and developing appropriate response measures for settlements is crucial to ensure the long-term resilience of communities to the impacts of climate change. Informal settlements and vulnerable communities are likely to face exacerbated challenges in terms of access to quality housing, health, and livelihoods due to climate change. To address these challenges, the West Rand district could consider the implementation of this programme, which is aimed at achieving resilience and adaptation to climate change by assessing and identifying the risks and impacts of climate change, and then developing suitable measures to reduce those risks. The programme could include conducting a vulnerability assessment to identify populations and locations most at risk to climate change impacts, establishing an early warning system, building local capacity for climate change adaptation and resilience through partnerships with other relevant stakeholders, as well as developing and implementing land use planning and zoning regulations that account for climate change impacts. These activities aim to enhance community resilience and ensure the long-term sustainability of settlements in the face of climate change. The adaptation actions identified under this programme are outlined below.

i. **Conduct a risk and vulnerability assessment to identify the populations and locations most at risk to climate change impacts:** Helps in establishing priority areas for interventions and formulating effective, targeted climate change adaptation strategies.
ii. **Develop and implement early warning systems to help communities prepare for, and respond to, climate change risks:** Having robust early warning systems is crucial to prepare communities for impending hazards, and to facilitate timely responses to minimise the impact.
iii. **Establish partnerships with local stakeholders, such as community groups and NGO:** These partnerships foster local capacity-building, making communities more skilled at handling climate change-related challenges, a critical need in a region frequently exposed to various environmental threats.
iv. **Develop and implement land use planning and zoning regulations that take into account the potential impacts of climate change:** Integrate climate change considerations into land use planning and zoning regulations (land use management) and adopt planning practices that consider potential climate impacts.

Programme 3.2: Climate resilient spatial planning

This programme is fundamental in the West Rand district's endeavour to mitigate and adapt to the impacts of climate change. It acknowledges that traditional approaches to spatial planning may not be adequate in the face of climate change, which presents new and evolving challenges. The programme seeks to integrate climate change considerations into spatial planning, fostering resilience and ensuring the municipality's urban and peri-urban spaces are better prepared for future climate conditions. The adaptation actions under this programme are outlined below.

i. **Ensure that spatial planning frameworks consider a long-term view of climate hazards, while incorporating green infrastructure:** Integrate an understanding of future climate hazards into spatial planning and recognises the crucial role of green infrastructure in climate adaptation, such as wetlands, swales, rain gardens, as well as retention and detention ponds for flood regulation.
ii. **Develop local-level climate-resilient planning instruments – precinct plans:** At the local level, these plans will guide development that's designed to withstand climate impacts and ensure the longevity and sustainability of the City's communities.

iii. **Ensure collaborative strategic planning that incorporates input from all relevant municipal functions:** Collaboration should occur from the strategic planning phase to the project implementation phase
iv. **Create mechanisms to strengthen public participation in planning and decision-making processes:** Public involvement ensures plans reflect local needs and knowledge, thus improving the effectiveness and acceptance of climate-resilient plans (i.e., securing buy-in
v. **Develop and design urban, rural and townships to be more resilient:** This involves designing the municipality's urban, rural and township areas with climate resilience in mind, such as designing urban green spaces to mitigate heatwaves and floods.
vi. **Identify climate risk zones and hotspots that affect vulnerable municipal infrastructure and assets:** Helps to prioritise where resilience needs to be built most urgently, and where infrastructure upgrades or changes may be necessary.

Programme 3.3: Integrated fire management for climate resilience

This programme is pivotal for the West Rand district, given its present conditions and forecasted wildfire risk. The programme seeks to systematically mitigate the risk and consequences of wildfires through a series of focused activities. The adaptation actions identified as part of this programme are outlined below.

i. **Conduct a comprehensive evaluation of fire hazards:** Examine fire ecotypes, the likelihood and severity of wildfire occurrences, and their socioeconomic repercussions.
ii. **Chart a strategic fire deterrence roadmap:** The "strategic fire deterrence roadmap" should define preventative steps and actions to alleviate wildfire risk, such as maintaining firebreaks, controlling flammable vegetation, and applying safe land-use practices.
iii. **Engage communities and educate them on fire safety:** Raising awareness about fire risks, preventative measures, and actions to take during a wildfire.
iv. **Invest in advanced fire detection and monitoring infrastructure:** Establish advanced fire detection and monitoring infrastructure to keep track of wildfires, potentially employing remote sensing technologies and early warning systems.
v. **Develop an Emergency Preparedness and Response Strategy:** Ensure prompt and effective containment and rescue operations.
vi. **Conduct post-fire restoration and ecosystem rehabilitation:** This action could involve efforts to restore the ecosystem and rehabilitate affected regions.
vii. **Undertake fire management policy and by-law development:** This would involve establishing regulations to bolster wildfire management and climate resilience
viii. **Promote and support innovation in fire management techniques:** This could stimulate studies into improved wildfire management strategies.
ix. **Encourage inter-organisational collaboration and form strategic partnerships:** Promote collaboration and enable the exchange of knowledge, resources, and support.
x. **Strengthen fire management capacities and ensure effective use of resources:** Boost the competencies of wildfire management personnel, and thus ensure the efficient use of resources, and improve infrastructure where necessary.

Programme 3.4: Development of West Rand District Municipality's Dolomite Risk Management By-law

In an effort to manage the risks associated with the predominant dolomitic bedrock found within the West Rand district municipal area, such as the development of hollow bedrocks and sinkholes which destroy critical infrastructure and thus exacerbate the district's physical vulnerability and susceptibility to selected climate

hazards such as inland flooding – it will be to the benefit of the district, as well as its residents, to develop a dolomite risk management by-law to manage the associated risks and minimise negative impacts. The actions under this programme are outlined below, these reflect some of the requirements that could be in included in the by-law.

i. **Establish and maintain a Dolomite Risk Management Section within the West Rand District Municipality to mitigate the risks associated with development on dolomite land:** The department responsible for Disaster Management could set up a Dolomite Risk Management Section and thus appoint a permanent dolomite risk manager, to consequently develop and administer a Dolomite Risk Management strategy (with standards, guidelines and regulations) for dolomite land in the West Rand district municipal area.
ii. **Establish and maintain a dolomite risk management data base**: It is recommended that the district's dolomite risk management section first establish (and continuously maintain) a dolomite risk management data base containing information that is relevant for the day-to-day management of dolomite risks in the municipal area.
iii. **Identify the actors responsible for implementing and undertaking dolomite risk management standards and regulations in their area**: This could include registered land owners, as well as recognized mandated land management bodies or their nominees, amongst other actors.
iv. **Identify, notify and train persons to respond to emergency situations resulting from dolomite hazards such as sinkhole and subsidence formation**.
v. **Require relevant development applications to be accompanied by a Dolomite Risk Management Plan**: West Rand district could require the development and submission of a Dolomite Risk Management Plan for proposed new developments in fulfilment of an obligation set out in the dolomite risk management by-law.
vi. **Require all sites proposed for new developments on dolomite land to undergo a hazard assessment**: The West Rand district could require all sites proposed for new developments on dolomite land to undergo a hazard assessment.
vii. **Establish and maintain a groundwater level monitoring and control system**: The Dolomite Risk Management Section of the West Rand district could establish and maintain a groundwater level monitoring and control system in the dolomite aquifers within its area of jurisdiction. The specifications under this by-law provision could include (a) Establishing a network of groundwater level monitoring boreholes to ensure adequate coverage of the dolomite aquifers in the West Rand district; (b) requiring dolomite experts / practitioners to undertake the hazard assessment of a site on behalf of a developer to indicate the need for groundwater level monitoring on a site; (c) requiring site developers, where necessary, and if required for pre-proclamation approval, to drill and install a groundwater level monitoring borehole, or boreholes, in accordance with the specifications of the Dolomite Risk Management Section, within a servitude in favour of the West Rand District Municipality; (d) requiring the Dolomite Risk Management Section to, at regular, appropriate and scientifically determined intervals, measure the groundwater levels; and (e) requiring groundwater monitoring boreholes to be maintained in an operational condition.
viii. **Design, maintain and repair infrastructure and services on dolomite land in accordance with the requirements and standards set out by the Dolomite Risk Management Section**: The West Rand district's Dolomite Risk Management Section could develop requirements and standards for designing, maintaining and repairing infrastructure and services located and taking place on dolomite land. And thus, require developers to adhere to such specifications.

ix. **Develop an evacuation plan or guidelines for unsafe hazardous areas**: The West Rand district Municipality could develop an evacuation plan or guidelines for unsafe hazardous areas. The specifications under this provision could include (a) providing the district with power to, as required, evacuate areas deemed to be unsafe in the event of the pending occurrence or occurrence of a sinkhole or subsidence; (b) authorising the district to enter private property to investigate potentially hazardous conditions that are considered to be life threatening beyond the boundaries of the property; (c) authorising the district to terminate water bearing services on private property for a necessary period of time to preclude the occurrence of a pending sinkhole or subsidence which may endanger the public; and (d) authorising the Disaster Management function of the district to identify areas declared unsafe and institute immediate appropriate remedial actions or measures, where an event occurs on private land and is deemed as a serious threat to the safety of third parties.

x. **Review Dolomite Risk Management standards, guidelines and requirements as necessary**: It is necessary for the district to review the Dolomite Risk Management standards, guidelines and requirements (as captured in the dolomite risk management strategy) regularly as new information arises and shifts in trends take place.

Programme 3.5: Community-based adaptation in communities most at risk to climate-related hazards

This programme is crucial for building resilience and mitigating the impacts of climate change in the West Rand district. It's built around the understanding that local communities, often the first to feel the impacts of climate change, need tailored, place-based adaptation solutions. The programme emphasizes empowering local communities and leveraging their knowledge in creating and implementing climate adaptation strategies. The adaptation actions identified under this programme are outlined below.

i. **Conduct detailed risk and vulnerability assessments in communities to identify drivers of risk:** By identifying these risks at a granular level, the municipality can develop adaptation measures that are specific, targeted, and effective.

ii. **Develop and implement community-based adaptation measures to reduce risks and build resilience:** Promote climate-smart agricultural practices, ensuring food security, and building community resilience.

iii. **Provide training and education to build community capacity and promote sustainability:** Equip community members with the knowledge and skills needed to adapt to climate change.

iv. **Conduct comprehensive community engagements and raise public awareness initiatives on climate change**: Ensure that awareness campaigns are inclusive, accessible, and relevant to all members of the community.

4.2.4. Goal 4: To develop climate-resilient, low-carbon, diverse and inclusive local economies, particularly in the mining, tourism and agricultural sectors, that are socially responsible, environmentally sustainable and that provide job opportunities for unskilled, semi-skilled and skilled local residences

Considering the Gauteng Province's (and the West Rand district's) plans to diversify the district's economy by expanding the agricultural and tourism sectors, it is important that these plans to expand and diversify the economy are carried out in a low-carbon manner, with the intention of having both sectors contribute towards building West Rand's resilience to climate change impacts, while simultaneously creating diverse and inclusive local economies within the district, that provide job opportunities for residents with all types of skills levels. In so doing, the district is able to meet most of its development priorities as captured in the IDP, i.e.,

particularly development priorities 1,2,3,5,6,7,9,10 and 12 – while simultaneously meeting relevant climate response objectives captured in this plan. The agricultural sector, in particular, has various opportunities for expansion at its disposal, especially within the West Rand district municipal area. Moreover, the fact that agricultural development, investment and beneficiation forms part of the district's core objectives (see WRDM's pipeline projects outlined in the district's DDM profile and the rural nodes identified in the district's SDF; as summarised in section 3.1.1 of this plan), means that it will be to the benefit of those who rely on the sector for employment, sustenance and economic development (i.e., revenue and wealth generation), to increase its resilience to the impacts of climate change. This can be done by providing farmers with (i) access to resilient crop varieties and efficient irrigation systems; (ii) training in sustainable farming techniques; (iii) financial risk management tools; and (iv) market opportunities, i.e., to help the agricultural sector withstand shocks and stresses such as climate change impacts, market fluctuations, and pest outbreaks.

Programme 4.1: Low-carbon local economic transformation

The low-carbon local economic transformation programme in the West Rand district is a strategic initiative aimed at transitioning the local economy towards more sustainable, low-carbon practices. The district is home to a range of industries, including agriculture, mining, tourism and local businesses, many of which rely heavily on carbon-intensive practices. This programme aims to address these challenges and promote environmental sustainability while also supporting economic growth and job creation. The adaptation and mitigation actions under this programme are outlined below.

i. **Promote the use of renewable energy technologies in agricultural, mining, as well as beneficiation industries to reduce carbon emissions:** This involves advocating for and facilitating the adoption of renewable energy technologies such as solar power, wind power, and bioenergy across key sectors.
ii. **Establish incentives for businesses in the local municipality to switch to low-carbon, adaptive operations:** Promote the use of incentives like subsidies or tax reductions to encourage businesses to adopt green technologies and reduce their carbon footprints and contribute to adaptation.
iii. **Introduce sustainable mining techniques that minimise environmental impact, as well as the local municipality's carbon footprint:** Promote and implement sustainable mining practices, which could include improved waste management, water conservation, land rehabilitation, and the use of energy-efficient technologies.

Programme 4.2: Inclusive and diverse economic development

The *inclusive and diverse economic development* programme for the West Rand district aims to foster an economy that provides opportunities for all citizens, irrespective of their skill level, and reduces dependence on a single sector by promoting economic diversity. This programme is particularly important in the context of West Rand, where income sources may be limited and primarily concentrated in specific sectors such as mining. The actions identified under this programme are outlined below.

i. **Implement skills training programmes aimed at individuals with different skills levels to facilitate diverse job creation:** Equip the residents of the Vhembe District Municipality with skills that are relevant to various sectors including agriculture (beneficiation), mining (beneficiation), tourism, and others.
ii. **Develop policies to support the growth of Small, Micro and Medium-sized Enterprises (SMMEs):** Policies could be designed to provide financial, technical, and logistical support to SMMEs in key sectors such as agricultural and mining beneficiation, as well as tourism.

iii. **Introduce economic diversification initiatives that can create new industries:** Identify and foster growth in potential new industries, such as eco-tourism, agro-processing, renewable energy, organic farming and mining beneficiation.

Programme 4.3: Social responsibility and environmental stewardship

Within the context of the West Rand district, the *social responsibility and environmental stewardship* programme aims to foster a culture of care and respect for the environment among the local community, businesses, and other stakeholders. It seeks to safeguard the natural resources, biodiversity, and ecosystems in the district by promoting responsible practices and mitigating environmental degradation. The adaptation actions identified under this programme are outlined below.

i. **Develop and implement environmental protection regulations:** In line with local municipality's commitment to environmental stewardship, new regulations may be established to protect the region's natural resources, biodiversity, and ecosystems.
ii. **Launch community awareness campaigns:** Raising awareness about the importance of environmental sustainability and responsible practices is crucial for instilling a culture of environmental stewardship in the municipality.
iii. **Establish partnerships with local communities, businesses, and NGOs:** Partnerships enable collaborative work on socially responsible initiatives such reforestation projects, cleanup drives, and the promotion of community-based tourism that respects local cultures and environments.

Programme 4.4: Climate-resilient agricultural communities

This programme aims to respond to the risks that climate change impacts pose on the agricultural sector (including impacts such as increased temperatures and increased drought conditions) on farming communities, and aims to enable those communities to respond and adapt to the impacts of climate change, in order to protect livelihoods and food security. The adaptation actions under this programme are outlined below.

i. **Enhance capacity for climate change adaptation in farming communities and industry:** Support subsistence farmers in accessing extension services, fostering knowledge sharing between relevant stakeholders, and through the development of community gardens that can be utilised for agriculture and food production.
ii. **Enhance social protection for farming communities:** Support farmer organisations in accessing financing and securing insurance, as well as documenting, assessing and (where applicable) applying indigenous knowledge and coping strategies.

Programme 4.5: Climate-smart transport strategy for resilience and efficiency

This programme aims to improve accessibility, affordability, and resilience of transport infrastructure and services in the West Rand district, while mitigating their environmental impact. The programme takes into consideration the unique challenges faced by the region including poor road conditions, the inability of the transport system to meet basic accessibility needs, unaffordability of transport services for vulnerable populations, lack of flexibility in response to customer demands, and inadequate infrastructure development. The adaptation and mitigation actions under this programme are outlined below.

i. **Establish an evidence-base and assess vulnerability of the transport and mobility sector**: Developing an understanding the current state of the transport system in the City, including the number of taxis, condition of roads, accessibility of the transport system, and affordability of services.

ii. **Develop and implement a low-carbon, inclusive transport plan:** Designing an integrated transport system that addresses the region's specific challenges through a low-carbon framework, promoting the use of energy-efficient vehicles, optimizing routes for fuel efficiency, and encouraging public transit, walking and cycling, where feasible, to reduce carbon emissions.

iii. **Enhance the resilience of the local transport infrastructure to climate shocks:** Strengthening transport infrastructure such as roads and taxi stands, to withstand the impacts of climate change, including more frequent or intense floods, storms, and heatwaves.

iv. **Monitor, evaluate, and continually improve the transport plan and infrastructure resilience:** This will involve tracking the performance of the new transport plan, assessing how well the improved infrastructure is withstanding climate shocks, and making necessary adjustments.

5. Implementation Framework

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

5.1. Goal 1: To ensure water security in the face of climate change

Adaptation programme 1.1: Integrated Water Supply Management				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Address human resources constraints for effective water management	Temperature increases Increased Water Demand Drought Heat extremes Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Human Resources function	Medium term (5 – 10 years)	High priority
ii. Undertake water resource management planning	Temperature increases Increased Water Demand Drought Heat extremes Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function	Long term (>10 years)	High priority
iii. Diversify water supply	Temperature increases Increased Water Demand Drought	West Rand District and Local Municipalities: Water and Sanitation function	Long term (>10 years)	High priority

		Heat extremes Environmental Vulnerability: Water Quality			
iv.	**Review, or develop, and implement a treated effluent (wastewater) reuse strategy**	Temperature increases Increased Water Demand Drought Heat extremes Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function	Medium term (5 – 10 years)	Medium priority
v.	**Review, or develop, and implement a groundwater management strategy**	Temperature increases Increased Water Demand Drought Heat extremes Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function	Medium term (5 – 10 years)	High priority
vi.	**Review, or develop, and implement a stormwater management strategy**	Temperature increases Increased Water Demand Drought Heat extremes Flooding Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Roads and Stormwater function West Rand District: Disaster Management function	Medium to Long term (5 to >10 years)	High priority

vii.	**Review bulk water master plan**	Temperature increases Increased Water Demand Drought Heat extremes Flooding Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function	Medium term (5 – 10 years)	High priority
viii.	**Implement monitoring mechanisms and protect water sources by reducing pollution**	Temperature increases Increased Water Demand Drought Heat extremes Flooding Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function West Rand District: Environmental Management function	Medium to Long term (5 to >10 years)	High priority

Adaptation programme 1.2: Integrated Water Demand Management				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Implement water conservation measures	Temperature increases Drought Heat extremes Increased Water Demand	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Community services	Short term (< 5 years)	High priority

ii.	**Implement alien invasive species clearing initiatives in catchment areas**	Temperature increases Drought Heat extremes Increased Water Demand Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Environmental Management	Short term (< 5 years)	High priority
iii.	**Adopt a Water Sensitive Urban Design and Planning (WSUDP) approach for brownfield and greenfield developments**	Temperature increases Increased Water Demand Drought Heat extremes Flooding Environmental Vulnerability: Water Quality Population growth pressure Urbanisation	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Environmental Management West Rand District and Local Municipalities: Spatial Planning and Land Use Management West Rand District and Local Municipalities: Integrated Development Planning West Rand District and Local Municipalities: Technical Services and Building Regulations functions West Rand District and Local Municipalities:	Long term (> 10 years)	High priority

		Parks and Recreation function		

Adaptation programme 1.3: Education and Awareness Raising around Climate Change and Sustainable Water Use				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Develop water conservation education programmes	Temperature increases Drought Heat extremes Increased Water Demand	National and Provincial departments of Water and Sanitation (Water Wise) West Rand District and Local Municipalities: Water and Sanitation function West Rand District: Community services function	Short term (<5 years)	High priority
ii. Promote water conservation in households	Temperature increases Drought Heat extremes Increased Water Demand	West Rand District and Local Municipalities: Water and Sanitation function West Rand District: Community services function	Short term (5> years)	High priority
iii. Encourage businesses to implement water-saving measures	Temperature increases Drought Heat extremes Increased Water Demand	West Rand District and Local Municipalities: Water and Sanitation function West Rand District: Community services function	Short to Medium term (<5 to years)	High priority
iv. Conduct research on water conservation	Temperature increases	Research and Tertiary institutions	Short term (<5 years)	High priority

	Drought Heat extremes Increased Water Demand	National and Provincial departments of Water and Sanitation West Rand District and Local Municipalities: Water and Sanitation function		

5.2. Goal 2: To protect natural resources and ecosystems

Adaptation programme 2.1: Conservation, protection and restoration of West Rand's natural open spaces and ecosystems, with the aim of exploiting climate change adaptation benefits				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Assess natural resources and ensure that natural open spaces, ecosystems, and resources are conserved, protected, and restored	Temperature increases Drought Wildfires Heat extremes Flooding Environmental vulnerability: Encroachment High population growth pressure	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Engineering and Technical Services function West Rand District and Local Municipalities: Land Use Management function	Medium term (5 – 10 years)	High Priority

ii. **Implement nature-based solutions to mitigate/buffer against the impacts of climate change and severe weather events, particularly in climate-risk zones**	Temperature increases Drought Wildfires Heat extremes Flooding	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Parks and Recreation function West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Engineering and Technical Services function West Rand District and Local Municipalities: Disaster Management function	Medium to Long term (5 to >10 years)	High priority

Adaptation programme 2.2: Enhancement of West Rand's Natural Resource Management				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. **Monitor and prevent soil erosion to ensure the long-term health and productivity of natural ecosystems, as well as maintain the quality of water resources**	Temperatures increases Heat extremes Increased Water Demand Flooding	West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities:	Medium term (5 – 10 years)	High priority

		Environmental vulnerability: Water Quality	Environmental Management function Mining Houses		
ii.	**Provide training to municipal staff and stakeholders on biodiversity and natural resource management regulations and guidelines**	Temperatures increases Drought Heat extremes Increased Water Demand Flooding Wildfire Environmental vulnerability: Water Quality and Encroachment	West Rand District and Local Municipalities: Environmental Management function	Short term (<5 years)	High priority
iii.	**Establish a District Municipal Environmental Management Forum (DEMF) to enhance collaboration and coordination between sectoral departments, conversation organisations and agencies related to natural resource management**	Temperatures increases Drought Heat extremes Increased Water Demand Flooding Wildfire Environmental vulnerability: Water Quality and Encroachment	West Rand District and Local Municipalities: Environmental Management function	Short term (<5 years)	High priority

Adaptation programme 2.3: Integrate Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) into the Spatial Development Framework				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Ensure that critical biodiversity and ecological support areas are integrated into West Rand's municipal spatial plans at all scales	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability: Encroachment and Water Quality	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function	Short term (<5 years)	High priority
ii. Identify and map natural open spaces, ecosystems, and natural resources, and integrate into the Spatial Development Framework and the Open Space Framework	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability: Encroachment and Water Quality	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities:	Short term (<5 years)	High priority

			Disaster Management function West Rand District and Local Municipalities: Parks and Recreation function		
iii.	**Identify undeveloped open spaces with potential for green infrastructure**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability: Encroachment and Water Quality	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Parks and Recreation function	Medium term (5 – 10 years)	Medium priority
iv.	**Assess the value of open spaces and ecosystem services**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Parks and Recreation function	Short term (<5 years)	Medium priority

5.3. Goal 3: To reduce the exposure and vulnerability of human systems to climate change impacts and extreme weather events

Adaptation programme 3.1: Identification and prioritisation of climate change risks and development of appropriate response measures for settlements				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Conduct a vulnerability assessment to identify the populations and locations most at risk to climate change impacts	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Spatial Planning function West Rand District and Local Municipalities: Integrated Development Planning function	Short term (<5 years)	High Priority
ii. Develop and implement early warning systems to help communities prepare for, and respond to, climate change risks	Temperature Increases Drought Heat extremes Wildfire Flooding	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities:	Short term (<5 years)	High Priority

			Integrated Development Planning function		
iii.	**Establish partnerships with local stakeholders, such as community groups and NGOs, to build local capacity for climate change adaptation and resilience**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Community Services function West Rand District and Local Municipalities: Cooperate Services department	Medium term (5 – 10 years)	High priority
iv.	**Develop and implement land use planning and zoning regulations that take into account the potential impacts of climate change**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function	Short term (<5 years)	High priority

		West Rand District and Local Municipalities: Water and Sanitation Services function		

Adaptation programme 3.2: Climate resilient spatial planning				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Ensure that spatial planning frameworks consider a long-term view of climate hazards, while incorporating natural infrastructure	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Water and Sanitation function	Medium term (5 – 10 years)	High priority
ii. Develop local-level climate-resilient planning mechanisms - precinct plans	Temperature Increases Drought Heat extremes Wildfire Flooding	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities:	Medium term (5 – 10 years)	Medium priority

		Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Water and Sanitation function		
iii.	**Ensure collaborative strategic planning that incorporates input from all relevant departments (from the strategic planning phase to the project implementation phase)**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Integrated Development Planning function Intergovernmental Forum	Short term (<5 years)	High priority
iv.	**Create mechanisms to strengthen public participation in planning and decision-making processes**	Temperature Increases Drought Heat extremes Wildfire Flooding	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function	Short term (5> years)	High priority

	Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Spatial Planning function West Rand District and Local Municipalities: Integrated Development Planning function West Rand District and Local Municipalities: Community services function		
v. Develop and design urban, rural and townships to be more resilient	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Building Regulations and Engineering Services functions West Rand District and Local Municipalities: Water and Sanitation function West Rand District and Local Municipalities: Environmental Management function	Short term (<5 years)	High priority

vi.	**Identify climate risk zones and hotspots that affect vulnerable municipal infrastructure and assets**	Temperature Increases Drought Heat extremes Wildfire Flooding Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Spatial Planning and Land Use Management functions West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Water and Sanitation function	Short term (<5 years)	High priority

Adaptation programme 3.3: Integrated fire management for climate resilience					
Adaptation Actions		**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i.	**Conduct a comprehensive evaluation of fire hazards**	Temperature Increases Wildfire Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions	Short term (5> years)	High priority
ii.	**Chart a strategic fire deterrence roadmap**	Temperature Increases Wildfire	West Rand District and Local Municipalities: Disaster Management,	Short term (5> years)	High priority

		Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	Fire and/or Emergency Services and/or Public Services and/or Community Services functions		
iii.	**Engage communities and educate them on fire safety**	Temperature Increases Wildfire Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions	Short term (continuous)	High priority
iv.	**Invest in advanced fire detection and monitoring infrastructure**	Temperature Increases Wildfire Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions	Medium term (5 – 10 years)	High priority
v.	**Develop a Fire Emergency Preparedness and Response Strategy**	Temperature Increases Wildfire Environmental Vulnerability Socioeconomic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions	Short term <5 years)	High priority
vi.	**Conduct post-fire restoration and ecosystem rehabilitation**	Temperature Increases Wildfire Environmental Vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public	Short to Medium term (<5 to 10 years)	Medium priority

		Physical Vulnerability	Services and/or Community Services functions West Rand District and Local Municipalities: Environmental Management		
vii.	**Undertake policy and by-law development**	Temperature Increases Wildfire Environmental Vulnerability Socio-economic vulnerability Physical vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions West Rand District and Local Municipalities: Environmental Management	Short term (<5 years)	High priority
viii.	**Promote and support innovation in fire management techniques**	Temperature Increases Wildfire Environmental Vulnerability Economic Vulnerability Socio-economic Vulnerability Physical Vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions West Rand District and Local Municipalities: Environmental Management West Rand District and Local Municipalities:	Medium to Long term (5 to >10 years)	High priority

			Water and Sanitation function		
ix.	**Encourage inter-organizational collaboration and form strategic partnerships**	Temperature Increases Wildfire Environmental Vulnerability Economic Vulnerability Socio-economic Vulnerability Physical Vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions Section 80 Public Safety Committee Department Public Safety Office of Community Safety	Short term (continuous)	High priority
x.	**Strengthen fire management capacities and ensure effective use of resources**	Temperature Increases Wildfire Environmental Vulnerability Economic Vulnerability Socio-economic Vulnerability Physical Vulnerability	West Rand District and Local Municipalities: Disaster Management, Fire and/or Emergency Services and/or Public Services and/or Community Services functions	Short to Medium term (5> to 10 years)	High priority

Adaptation programme 3.4: Development of West Rand District Municipality's Dolomite Risk Management By-law					
Adaptation Actions		**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i.	**Establish and maintain a Dolomite Risk Management Section within the West Rand District Municipality to mitigate the risks associated with development on dolomite land**	Flooding Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Disaster Management	Short term (5> years)	High priority

		Physical Vulnerability: Infrastructure decline			
ii.	**Establish and maintain a dolomite risk management data base**	Flooding Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function	Short to Medium term (5> to 10 years)	High priority
iii.	**Identify the actors responsible for implementing and adopting and applying dolomite risk management standards and regulations (as part of the dolomite risk management by-law) in their area**	Flooding Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function	Short term (5> years)	High priority
iv.	**Identify, notify and train persons to respond to emergency situations resulting from dolomite hazards such as sinkhole and subsidence formation, as part of the dolomite risk management by-law**	Flooding Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function	Medium term (5 – 10 years)	High priority
v.	**Require relevant development applications to be accompanied by a Dolomite Risk Management Plan**	Flooding Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Town Planning and Land Use Management functions	Medium term (5 – 10 years)	Medium priority
vi.	**Require all sites proposed for new developments on dolomite land to undergo a hazard assessment**	Flooding Environmental Vulnerability: Water Quality	West Rand District and Local Municipalities: Disaster Management	Medium term (5 – 10 years)	Medium priority

		Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Town Planning and Land Use Management functions		
vii.	**Establish and maintain a groundwater level monitoring and control system**	Flooding Increased Water Demand Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Water and Sanitation function	Short to Medium term (<5 years to 10 years)	High priority
viii.	**Design, maintain and repair infrastructure and services on dolomite land in accordance with the requirements and standards set out by the Dolomite Risk Management Section**	Environmental Vulnerability: Water Quality Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Technical Services and Engineering Services functions	Medium term (5 – 10 years)	High priority
ix.	**Develop an evacuation plan or guidelines for unsafe hazardous areas**	Flooding Physical Vulnerability: Infrastructure decline	West Rand District and Local Municipalities: Disaster Management function	Short term (5> years)	High priority
x.	**Review Dolomite Risk Management standards, guidelines and requirements as necessary**	Flooding Increased Water Demand Environmental Vulnerability:	West Rand District and Local Municipalities: Disaster Management function	Continuous	Medium to High priority

	Water Quality Physical Vulnerability: Infrastructure decline			

Adaptation programme 3.5: Community-based adaptation in areas most at risk to climate-related hazards				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Conduct detailed risk and vulnerability assessments in communities to identify drivers of risk and develop appropriate adaptation measures	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic Vulnerability Physical Vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function	Short term (5> years)	High priority
ii. Develop and implement community-based adaptation measures to reduce risks and build resilience	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities:	Medium term (5 – 10 years)	High priority

		Economic Vulnerability Socioeconomic Vulnerability Physical Vulnerability	Community services function		
iii.	**Provide training and education to build community capacity and promote sustainability**	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic Vulnerability Physical Vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Community services function	Short to Medium term (5> years to 10 years)	High priority
iv.	**Conduct comprehensive community engagements and raise public awareness initiatives on climate change**	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic Vulnerability	West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Community services function	Short term (5> years)	High priority

	Physical Vulnerability			

5.4. Goal 4: To develop climate-resilient, low-carbon, diverse and inclusive local economies, particularly in the mining, agriculture and tourism sectors, that are socially responsible, environmentally sustainable and that provide job opportunities for unskilled, semi-skilled and skilled local residences

Adaptation programme 4.1: Low-carbon local economic transformation				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Promote the use of renewable energy technologies in agricultural, mining, tourism and other local industries to reduce carbon emissions	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Energy/electricity and Technical Services functions West Rand District and Local Municipality: Local Economic Development function National and/or Provincial Department of Agriculture Private Sector: Mining Houses, Commercial and Agricultural Farmers, Business Owners/Operators	Long term (>10 years)	High priority

ii.	**Establish incentives for businesses in the district to switch to low-carbon operations**	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Local Economic Development function	Medium to Long term (5 years to >10 years)	High priority
iii.	**Introduce sustainable mining techniques that minimize environmental impact, as well as the district's carbon footprint**	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Local Economic Development function Private Sector: Mining Houses	Long term (>10 years)	High priority

Adaptation programme 4.2: Inclusive and diverse economic development				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Implement skills training programmes aimed at different levels to facilitate diverse job creation	Economic Vulnerability Socioeconomic Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Local Economic Development function	Medium term (5 – 10 years)	High priority
ii. Develop policies to support the growth of Small, Micro and Medium-sized Enterprises (SMMEs)	Economic Vulnerability Socioeconomic Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Local Economic Development function	Short term (<5 years)	High priority
iii. Introduce economic diversification initiatives that can create new industries	Economic Vulnerability Socioeconomic Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Local Economic Development function Gauteng Department of Economic Development (GDED)	Short term (<5 years)	High priority

Adaptation programme 4.3: Social responsibility and environmental stewardship				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Develop and implement environmental protection regulations	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Disaster Management	Short term (<5 years)	High priority
ii. Launch community awareness campaigns	Temperature Increases Drought Heat Extremes Wildfire Flooding Environmental Vulnerability Socioeconomic Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Disaster Management function West Rand District and Local Municipality: Community Services and/or Public Services function	Short to Medium term (<5 years to 10 years)	High priority
iii. Establish partnerships with local communities, businesses, and NGOs	Temperature Increases Drought Heat Extremes Wildfire	West Rand District: Corporate Services Department West Rand District and Local Municipality: Environmental Management function	Medium to Long term (5 to >10 years)	High priority

	Flooding Environmental Vulnerability Economic Vulnerability Socioeconomic Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Disaster Management function West Rand District and Local Municipality: Local Economic Development		

Adaptation programme 4.4: Climate-resilient agricultural communities				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Enhance capacity for climate change adaptation in farming communities and industry	Temperature Increases Drought Heat Extremes Increased Water Demand Wildfires Economic Vulnerability Environmental Vulnerability Socioeconomic Vulnerability Physical Vulnerability	Gauteng Department of Agriculture and Rural Development (GDARD) West Rand District and Local Municipalities: Local Economic Development function West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management function West Rand District and Local Municipalities: Water and Sanitation	Long term (>10 years)	High priority

ii. Enhance social protection for farming communities	Temperature Increases Drought Heat Extremes Increased Water Demand Wildfires Socioeconomic Vulnerability	Gauteng Department of Agriculture and Rural Development (GDARD) West Rand District and Local Municipalities: Local Economic Development function West Rand District and Local Municipalities: Environmental Management function West Rand District and Local Municipalities: Disaster Management	Long term (>10 years)	Medium priority

Adaptation programme 4.5: Climate-smart transport strategy for resilience and efficiency				
Adaptation Actions	**Key risk or vulnerability addressed**	**Responsible entity**	**Timeframe**	**Priority level**
i. Establish an evidence-base and assess vulnerability of the transport and mobility sector	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Transport function	Short term (<5 years)	High priority

ii.	**Develop and implement a low-carbon, inclusive transport plan**	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Transport function	Long term (>10 years)	High priority
iii.	**Enhance the resilience of the local transport infrastructure to climate shocks**	Temperature Increases Drought Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Environmental Management function West Rand District and Local Municipality: Transport function	Medium term (5 – 10 years)	High priority
iv.	**Monitor, evaluate, and continually improve the transport plan and transport infrastructure resilience**	Temperature Increases Drought	West Rand District and Local Municipality: Environmental Management function	Continuous	High priority

	Heat Extremes Wildfire Flooding Economic Vulnerability Socioeconomic Vulnerability Environmental Vulnerability Physical Vulnerability	West Rand District and Local Municipality: Transport function		

6. 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 supports and enables the implementation of climate adaptation measures.

Mainstreaming climate change involves several key elements, and recommendations are made in terms of each of these:

- **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. Various funding mechanisms are available to support climate change response initiatives, including national and international grants, public-private partnerships, and municipal budgets.
- **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.

7. Bibliography

Behsudi, A, 2021. What Is Mitigation vs Adaptation? IMF Finance Dev. Mag. 46–47.

Council for Scientific and Industrial Research (CSIR), 2023. Green Book l Adapting settlements for the future. GreenBook. URL https://greenbook.co.za/

Department of Cooperative Governance and Traditional Affairs (CoGTA). 2020. West Rand District Municipality, Municipal Profiles: District Development Model. Available from: https://www.cogta.gov.za/ddm/index.php/documents/

Department of Environmental Affairs (DEA), 2018. Climate Change Bill.

Department of Environmental Affairs (DEA), 2019. National Climate Change Adaptation Strategy.

IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC, 2021. Annex VII: Glossary [Matthews, J. B. R., J. S. Fuglestvedt, V. Masson-Delmotte, V. Möller, C., Méndez, R. van Diemen, A. Reisinger, S. Semenov (ed.)]. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E.

IPCC, 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press., Cambridge, UK and New York, NY, USA.

National Treasury, 2018. Supplementary Guidance Note for the Built Environment Performance Plan (BEPP) 2019/20– 2021/22: Integrating Climate Response Priorities into the BEPP.

Pieterse, A., 2020. Mainstreaming Climate Change Adaptation into Municipal Planning: Lessons from two South African Cases (PhD Thesis). University of Pretoria.

Pieterse, A., du Toit, J., van Niekerk, W., 2021. Climate change adaptation mainstreaming in the planning instruments of two South African local municipalities. Dev. South. Afr. 38, 493–508. https://doi.org/10.1080/0376835X.2020.1760790

Pieterse, A., Ludick, C., van Niekerk, W., Arnold, K., Chilwane, L., Mateyisi, M., Nangombe, S., Steenkamp, K., John, J., Kotzee, I., Lück-Vogel, M., 2023. GreenBook MetroView: Methodology for eThekwini. Pretoria.

Republic of South Africa (RSA), 2011. National Climate Change Response White Paper.

Republic of South Africa (RSA), 2013. Spatial Planning and Land Use Management Act, 16 of 2013.

Republic of South Africa (RSA), 2015. Disaster Management Amendment Act.

South African Bureau of Standards (SABS), 2023. Technical specification: Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities. Pretoria: SABS.

Statistics South Africa (Stats SA), 2024. Available from: https://www.statssa.gov.za/

West Rand District Municipality (WRDM). 2023. 2023/2024 Integrated Development Plan 2023/2024. Available from: wrdm.gov.za/wp-content/uploads/documents/idp/202324-Final-Reviewed-IDP-1.pdf