GREENBOOK
adapting settlements for the future

CITY OF MBOMBELA
THE ULTIMATE DESTINATION

City of Mbombela
Adaptation Action Plan

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List of Acronyms and Abbreviations

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

Glossary of Terms

Adaptation actions	A range of planning and design actions that can be taken by local government to adapt to the impacts of climate change, reduce exposure to hazards, and exploit opportunities for sustainable development (CSIR, 2019).
Adaptation planning	The process of using the basis of spatial planning to shape built-up and natural areas to be resilient to the impacts of climate change, to realise co-benefits for long-term sustainable development, and to address the root causes of vulnerability and exposure to risk. Adaptation planning assumes climate change as an important factor while addressing developmental concerns, such as the complexity of rapidly growing urban areas, and considers the uncertainty associated with the impacts of climate change in such areas – thereby contributing to the transformational adaptation of urban spaces. Adaptation planning also provides opportunities to climate proof urban infrastructure, reduce vulnerability and exploit opportunities for sustainable development (National Treasury, 2018; Pieterse, 2020).
Adaptive capacity	"The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2022, p. 2899).
Climate change adaptation	"In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2022, p. 2898).
Climate change mitigation	"A human intervention to reduce emissions, or enhance the sinks, of greenhouse gases (GHGs)" (IPCC, 2022, p. 2915). The goal of climate change mitigation is to achieve a reduction of emissions that will limit global warming to between 1.5°C and 2°C above preindustrial levels (Behsudi, A, 2021).
Climate hazards	Climate hazards are a sub-set of natural hazards and a grouping of hydrological, climatological, and meteorological hazards. This includes the spatial extent and frequency of, among others, floods, fires, and extreme weather events such as extreme rainfall and extreme heat. Sometimes referred to as hydrometeorological hazards. The potential occurrence of a climate hazard may cause loss of life, injury, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2022). Climate hazards can increase in intensity and frequency with climate change (Pieterse et al., 2023).
Climate risk	Risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and a hazard. Relevant adverse consequences include those on "lives and livelihoods, health and well-being, economic and sociocultural assets, infrastructure and ecosystems" (IPCC, 2022, p. 144). In the IPCC's 6th Assessment Report, it is confirmed that risks

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

1. Introduction

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

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

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

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

1. Drive and advance the local climate change response agenda.
2. Provide a foundational framework for strategy and planning within the Local Municipality.
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 City of Mbombela with a comprehensive strategy to navigate the complexities of climate change, reduce vulnerability and exposure, and champion sustainable development.

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

2. Policy Framework

South Africa's institutional policy and legislative framework makes provision for climate change adaptation at all levels of government, with local governments increasingly identified as the primary drivers of climate change adaptation. For instance, there exists various national policy and legislative mechanisms that promote, necessitate, guide and/or regulate climate change adaptation at the local level. These include the Disaster Management Amendment Act of 2015, the Spatial Planning and Land Use Management Act, i.e., Act No. 16 of 2013 (SPLUMA), the Climate Change Bill (B9 of 2022), the 2011 National Climate Change Response White Paper, as well as the 2019 National Climate Change Adaptation Strategy.

While the Disaster Management Amendment Act requires each organ of state, as well as provincial and local government to identify measures for, as well as indicate plans to invest in, disaster risk reduction (DRR) and climate change adaptation; SPLUMA identifies the principles of (1) spatial resilience – which involves accommodating "flexibility in spatial plans, policies and land use management systems, to ensure sustainable livelihoods in communities most likely to suffer the impacts of economic and environmental shocks" (Republic of South Africa., 2013, p. 20) – some of which may be induced by the impacts of climate change, and (2) spatial sustainability, which sets out requirements for municipal planning functions such as spatial planning and land use management to be carried out in ways that consider protecting vital ecosystem features such as agricultural land, i.e., from both anthropogenic and natural threats, including the impacts of climate change, as well as in ways that consider current and future costs of providing infrastructure and social services in certain areas (e.g., uninformed municipal investments may lead to an increase in the exposure of people and valuable assets to extreme climate hazards) amongst the key principles intended to guide municipal planning and development. The Climate Change Bill (DEA, 2018) sets out requirements for every District Intergovernmental Forum to serve as a Municipal Forum on climate change that coordinates climate response actions and activities in its respective municipality, while also requiring every municipality to report on their climate change response needs and draft resultant climate risk assessments, as well as climate change response and -implementation plans.

Moreover, the National Climate Change Response White Paper identifies local governments as critical role players that can contribute towards effective climate change adaptation through their various functions, including human settlement planning; urban development; municipal infrastructure and services provision; water and energy demand management; and local disaster response, amongst others. The National Climate Change Adaptation Strategy (DEA, 2019) outlines several actions that applicable at local government level, including the development and implementation of adaptation strategies and vulnerability reduction programmes for communities and individuals that are most at risk to the impacts of climate change; the development of municipal early warning systems; as well as the integration of climate change adaptation into municipal development plans and relevant sector plans.

3. Adaptation Principles, Approach, Programmes & Actions

Climate change mitigation and adaptation refer to the two primary strategies aimed at addressing the adverse effects of climate change, i.e., by either delaying, reducing, redistributing, or avoiding the impacts. Although disaster risk reduction and climate change mitigation form part of the overall climate change response agenda, the focus of this plan is on adaptation.

Climate change adaptation aims to reduce climate-related risks by adjusting a system to the actual or anticipated climate and seeking "to moderate or avoid harm [and] exploit beneficial opportunities" (IPCC,

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

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

3.1. Adaptation principles

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

i. Accountability: Local governments not only acknowledge but also assume responsibility for their climate change adaptation efforts. They willingly subject themselves to appropriate scrutiny and accept the duty to respond to this scrutiny.
ii. Continual learning and improvement: Recognising the uncertainties in knowledge and the dynamic nature of drivers of change, available knowledge and evidence, and the contextual factors, continual learning and improvement are essential for effective climate change adaptation.
iii. Mainstreaming and embedding: The effectiveness of climate change adaptation is maximised when integrated into local government operations, encompassing policies, plans, procedures, risk management, and implementation strategies.
iv. Flexibility: Embrace a flexible approach that considers technical, social, administrative, political, legal, environmental, and economic circumstances. This allows for the accommodation of a diverse range of data availabilities and technical and institutional capacities to meet goals and objectives.
v. Practicality: Set practical and achievable goals and objectives. Impractical targets may hinder the successful realisation of climate change adaptation benefits. Focus on easily measurable indicators/metrics with available underlying data and compare them across scales to avoid imposing additional burdens.
vi. Prioritisation: During the identification of adaptation plans and measures, prioritise areas based on the relative characteristics of climate change impacts (magnitude, likelihood, and urgency). Consider the capacities of stakeholders and the local government and community's ability to act.
vii. Proportionality: Undertake actions that are most effective under the current circumstances, including economic, social, cultural, and political contexts, capabilities, knowledge, and evidence base. Aspire for continual improvement in identifying and assessing adaptation measures.
viii. Relevance: Facilitate assessments that provide decision-makers and practitioners with meaningful information for adaptation planning, considering appropriate spatial scales and relevant time durations.
ix. Transparency: Ensure that reports and communications on climate change adaptation are openly, comprehensively, and understandably presented, providing accessible information for all interested parties (SABS, 2023).

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

3.2. Adaptation approach

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

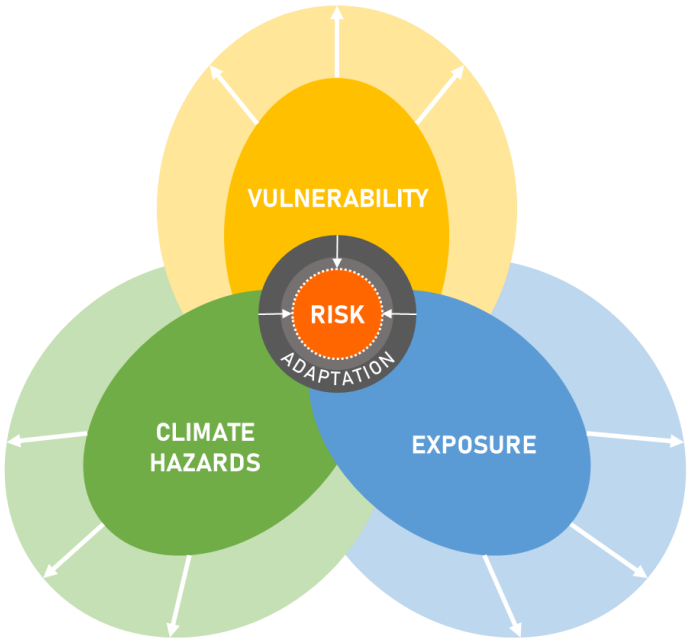

Figure 1 – The interplay between climate hazards, vulnerability and exposure that determines risk (based on IPCC, 2014 and IPCC, 2021)

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

The approach followed in this plan involves the following steps:

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

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

Table 1: The adaptation approach

Understand climate risk for a specific geographic area	A climate risk profile assesses risk by determining – in a specific geographic area and at a specific scale – the likelihood of a hazard to occur, the inherent vulnerability of various systems, and exposure of these systems to specific climate hazards. To be able to develop an appropriate adaptation plan, it is important to understand what contributes to risk and vulnerability.
Identify priority climate-related risks/zones	Identify the climate hazards and impacts that pose the greatest risk at present and in the future within a geographic area. If possible, also identify climate risk zones that need to be prioritised for intervention.
Establish adaptation goals	Identify adaptation goals to address priority risks/zones that speak to policy goals.
Develop adaptation programmes and actions	Develop adaptation programmes that speak to the identified adaptation goals and identify appropriate adaptation actions under each of the programmes that are mutually supportive. Adaptation actions should: • Be specific to a climate hazard/vulnerability/exposure. • Suggest a target or an indicator to measure progress. • Be assignable to a primary implementer. • Consider co-benefits and other possible implications. • Include mitigation as far as it builds resilience or reduces exposure and vulnerability.
Mainstream climate considerations into planning	Integrate evidence of climate risk, adaptation goals, programmes, and actions into existing instruments and processes. The aim is to ensure that climate change considerations are an integral part of all that local government is doing.

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

3.3. Adaptation programmes and actions

An adaptation programme is a structured and systematic set of actions, initiatives, and interventions aimed at local governments adapt to the impacts of climate change. It involves the practical implementation of specific goals identified in the plan.

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

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

- Infrastructure development, encompassing the construction of, for example, seawalls, levees, and storm surge barriers to protect against rising sea levels and extreme weather events. These engineered solutions provide immediate protection and buy time for longer-term adaptation efforts but are mostly very expensive to build.
- Green infrastructure initiatives offer sustainable and nature-based solutions. Municipalities can implement urban green spaces, green roofs, and permeable pavements to absorb excess water, reduce flooding, and mitigate the urban heat island effect. Such approaches not only enhance climate resilience but also contribute to improved air quality and overall urban liveability.
- Environmental protection such as restoring ecosystems like mangroves, dunes, and wetlands, not only provides natural buffers but also supports biodiversity.
- Integrated urban planning is essential to create climate-resilient municipalities. Land-use regulations should be adapted to consider climate risks, prioritising construction practices that enhance resilience. Elevating structures above projected flood- and sea levels and using climate-resilient materials in building design can minimise the impacts of flooding and storm damage.
- Early warning systems and emergency preparedness plans are critical tools to ensure swift responses to extreme weather events, minimising the impact on vulnerable communities.
- Innovative water management strategies are essential for municipalities facing changing precipitation patterns and increasing water scarcity. Diversifying water sources, implementing water efficiency measures, and investing in advanced stormwater management systems contribute to water security and sustainable resource use.
- Engagement and education are pivotal components of successful adaptation strategies. Empowering officials, and residents, to understand and respond to climate risks through awareness campaigns, education programmes, and participatory planning initiatives can enhance local adaptive capacity (CSIR, 2019).

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

4. Summary of Climate Risk Profile

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

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

4.1. Climate projections, vulnerabilities and impacts

The average annual temperature gradient in the City of Mbombela is anticipated to show a progressive increase from southwestern-to-northeastern parts of the municipality. Projections indicate annual average temperature increase of 2.4 °C for the south and eastern areas, and 2.3 °C for the northeastern areas of the municipality. The north (especially in the Kruger area) and the eastern parts experience between 11-45 very hot days in a year.

In future, the annual average rainfall is expected to remain at 1200mm in the interior and the eastern parts while some parts of the north and southwest are projected to experience an increase of up to 200mm per annum in rainfall. Areas in and around Matsulu will experience some decline of up to 200mm in rainfall in future.

Mbombela's socio-economic vulnerability has decreased between 1996 and 2011 – thus indicating that the number of vulnerable households has decreased (improved), particularly in terms of their access to basic and social services, and essential resources that influence their ability to withstand adverse shocks from the external environment, including those induced by climate change. The LM's economic vulnerability has however increased (worsened) within the same period, therefore indicating the municipality's high susceptibility to being adversely affected by external shocks. The LM has a very high physical vulnerability score, i.e., the fourth highest in the province – this alludes to the high structural vulnerabilities in the LM, particularly when considering the municipality's buildings and infrastructure.

The primary nodes of Mbombela and White River are projected to experience high growth pressure – thus alluding to the potential increase in the exposure of people and their assets to future climate conditions and their impacts. The population growth expected in Mbombela will also lead to increased pressure on service delivery and competition for resources. Under current climate conditions, water demand is already higher than water supply. High population growth coupled with increasing temperatures will further increase water supply vulnerability.

4.2. Priority climate-related hazards

The main climate risk facing the City of Mbombela is an increase in temperature - which leads to hotter and drier conditions towards 2050. Mbombela as well as the southern parts (i.e., Barberton) are at a higher risk of experiencing an increase in temperatures. Higher temperatures are associated with health hazards such as heat stress and the spread of vector borne diseases in both humans and livestock. The city's primary nodes of Mbombela, Hazyview and Matsulu are also at a high risk of wildfires.

Increasing temperatures coupled with the declining annual average rainfall will increase Mbombela's water supply vulnerability. Currently, the demand for water in the municipality outpaces the supply. This will likely be exacerbated by an increase in population especially in the two major nodes of Mbombela and White River. Furthermore, increasing temperatures will also impact on water demand, particularly for irrigation – thus contributing to a lower yield in agricultural produce. This could also contribute to reduced water security if existing systems are not able to meet the increasing demands.

Most of the settlements in Mbombela rely on surface water – which is significantly threatened by drier conditions projected over Mbombela. This indicates the need to diversify potable water supply (i.e., water sources), conserve available water, and improve groundwater recharge – given a significant increase in groundwater recharge potential projected towards 2050.

In addition to these risks, the City of Mbombela has a highly vulnerable economy (EcVI), and the settlement fabric (PVI) and natural environment (EnVI) are also vulnerable. This will undermine the City's ability to recover from external shocks, including climate hazards, if not properly addressed.

5. Adaptation Goals, Programmes and Actions

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

5.1. Adaptation goals

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

- Goal 1: To ensure water security and good water quality, protecting water resources under a changing climate.
- Goal 2: To protect and increase the resilience of critical municipal infrastructure.
- Goal 3: To build capacity of the public health sector and protect human health.
- Goal 4: To support resilient commercial, small-scale and subsistence farming systems (these contribute to food security and employment in the area).

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

5.2. Adaptation programme: Goal 1

Goal 1: To ensure water security and good water quality, protecting water resources under a changing climate.

Climate change will directly impact water availability in the municipality. This, coupled with projected population growth will further reduce the municipality's water security. Developing comprehensive water resource management strategies is essential to ensure sustainable and equitable access to water for all users (domestic, agricultural, industrial) to secure a sustainable water future.

Programme 1.1 Protect and conserve water across the municipality

This programme aims to protect critical water sources through the implementation of water conservation measures throughout the municipality to reduce demand and water losses.

Actions:

i. Implement water loss/leakage reduction strategies through conservation projects.
ii. Include water conservation strategies in housing and settlement planning. This entails including the consideration and implementation of water conservation technologies and designs in the retrofitting and design of human settlements.
iii. Conserve and preserve the wetlands.
iv. Undertake water awareness campaigns around water conservation technologies and techniques. Dynamic communication channels should also be established for this purpose.
v. Design a water pressure management system.
vi. Design systems to recycle water.

Programme 1.2: Improve groundwater recharge

This programme focuses on mechanisms that seek to secure appropriate groundwater recharge to improve charge mechanisms in the long term.

Actions:

i. Design groundwater recharge systems.
ii. Identify suitable sites for infiltration of rainwater runoff.
iii. Use cool, permeable paving.
iv. Clear alien invasive vegetation from infested catchments.
v. Protect and rehabilitate wetlands.

Programme 1.3: Diversify potable water supply

This programme includes the use of alternative water sources to help reduce the risk of water supply not meeting the demand for water.

Actions:

i. Develop an Integrated Water Resource Plan to guide the diversification of the water supply and enhance water security.
ii. Identify new potential water sources.
iii. Encourage the use of alternative water sources such as rainwater tanks, stormwater and recycled water by the government, developers and households.
iv. Design stormwater and rainwater harvesting systems for new developments or employ retrofitting.
v. Install greywater systems across settlements to capture greywater from showers, laundry and hand basins allowing this to be reused for functions such as flushing toilets and irrigation.

5.3. Adaptation programme: Goal 2

Goal 2: To protect and increase the resilience of critical municipal infrastructure

This involves implementing proactive measures that enhance infrastructure design, maintenance, and operational practices, while integrating climate adaptation considerations into infrastructure planning and investment decisions.

Programme 2.1 Appropriately design and maintain stormwater infrastructure to accommodate storm surges and increase the volume of stormwater runoff to prevent damage to infrastructure and assets
Stormwater runoff can be exacerbated by increased rainfall as a result of climate change. This can put tremendous pressure on the existing stormwater infrastructure.

Actions:

i. Identify existing storm water infrastructure that is vulnerable to the impacts of climate change.
ii. Develop natural buffer zones around critical storm water infrastructure.
iii. Retrofit or replace existing storm water infrastructure to meet revised design criteria.
iv. Regularly maintain storm water systems.
v. Design storm water management systems to mimic nature.

Programme 2.2 Protect and maintain road and public transport infrastructure
Heavy rainfall threatens the resilience of the road infrastructure therefore regular maintenance of paved roads as well as pre-emptive upgrades of gravel roads become paramount to improve climate resilience of the road infrastructure.

Actions:

i. Elevate roadways to protect them from floods.
i. Regularly maintain roads and public transport infrastructure.
ii. Consider using new technologies for road construction, operations and maintenance that are less fossil-fuel dependent, have lower embodied energy content, and have a lower greenhouse gas emissions profile.

Programme 2.3 Protect and maintain water provision services
Climate change and related hazards can affect the availability and quality of water and can disrupt services.

Actions:

i. Maintain water provision infrastructure regularly. This includes maintenance of water supply systems, water treatment systems, and water storage and distribution infrastructure.
ii. Installation of technology that can detect leaks in water supply reticulation and send notifications and alarms to relevant personnel.

Programme 2.4 Protect and maintain sanitation systems
Climate change can threaten sanitation systems such as treatment plants and septic tanks. This can ultimately be detrimental to the health of the people through the spread of infectious diseases.

Actions:

i. Increase the maintenance of tanks and pipes.
ii. Elevate sanitation facilities to protect them from floods.
iii. Identify appropriate and sustainable sanitation solutions.
iv. Consider re-routing collection, processing, and disposal systems.

5.4. Adaptation programme: Goal 3

Goal 3: To build capacity of the public health sector and protect human health

This involves developing and implementing proactive measures to curb climate related diseases to reduce health care demand. Moreover, improved access to health and emergency services is crucial amidst the rising impacts of climate change on the health of the population to ensure a healthy and sustainable future.

Programme 3.1 Increase capacity and resources at health facilities for climate change related impacts
Climate change presents complex and multifaceted challenges which require capacity building and upskilling of health professionals to increase their capability to diagnose and treat new and emerging climate related diseases. Health care facilities also need to be well equipped to respond to a wider range of climate-related public health emergencies.

Actions:

i. Develop a Community Services Plan to comprehensively dovetail municipal health needs and their climate change risks into development planning.
ii. Increase capacity and resources at health facilities for climate change related impacts.
iii. Develop nutrition programmes where climate impacts affect livelihoods and food security.
iv. Encourage and incentivise governmental structures, knowledge-based institutions and NGOs. operating in the municipality to undertake research into the linkages between human health and climate change in Mbombela's context.
v. Develop a Municipal Health Policy that includes climate driven health risks.

Programme 3.2 Reduce risk of water-borne diseases through the supply of safe drinking water and safe disposal of wastewater
Climate change contributes to a host of water borne diseases as a result of extreme weather events such as increased rainfall and flooding. This programme includes ensuring sustainable access to affordable clean drinking water as well as maintaining sewage systems and water treatment plants.

Actions:

i. Improve the capacity of wastewater treatment plants.
ii. Commission new wastewater plants for rural and new township developments.
iii. Develop and adopt improved maintenance and asset management plans of stormwater systems and wastewater treatment works, to ensure optimum function.
iv. Refurbish ageing infrastructure.
v. Reduce contamination of stormwater runoff.

Programme 3.3 Remove solid waste in time to avoid health and environmental impacts resulting from the decay of the waste
This programme includes implementing waste management strategies to expedite waste removal to curb vector-borne diseases and other environmental impacts.

Actions:

i. Increase the frequency of solid waste collection especially of putrescible waste to avoid nuisances such as odour, fly breeding and vermin.
ii. Reduce stream and river contamination from sewage and industrial trade effluent.

i. Ensure proper disposal of waste by developing appropriate waste disposal facilities and resources.

5.5. Adaptation programme: Goal 4

Goal 4: To support resilient commercial, small-scale and subsistence farming systems (these contribute to food security and employment in the area).

Programme 4.1 Introduce climate smart agricultural farming techniques

Extreme weather events as a result of climate change will have a significant impact on the agricultural sector. This programme entails the use of smart and innovative solutions to address the interlinked challenges of food security and climate change.

Actions:

i. Utilise organic fertilisers instead of chemicals.
ii. Introduce climate resilient cultivars.
iii. Introduce green roof ploughing.
iv. Promote the use of indoor vertical farms that use ultraviolet (UV) lights, to grow food in urban areas

Programme 4.2 Protect viable agricultural land in support of food security and local production, as well as increasing green space within the urban edge

This programme involves protecting agricultural land from conversion to non-farm uses as well as promoting the development of green spaces in urban areas. This is important to ensure long-term food security.

Actions:

i. Develop and update an Agricultural Policy for Mbombela that clearly articulates strategies for dealing with food security and the added pressures posed by climate change.
ii. Identify suitable areas for urban agriculture.

Programme 4.3 Manage the change in crop production areas

Climate change affects crop production at varying scales and intensities and across different localities and regions. This programme entails understanding these impacts; and this requires a great deal of research, knowledge sharing and stakeholder participation including with experts in the field.

Actions:

i. Research and improve understanding of climate change impacts on crop production.
ii. Conduct research on alternative agricultural production that can be implemented.
iii. Promote knowledge generation, knowledge sharing, stakeholder participation and awareness-raising in crop production.
iv. Implement evidence-based monitoring initiatives that feed into agricultural management systems.
v. Identify climate resilient land-uses that will support the agricultural industry's efforts to exploit new agricultural opportunities, new areas and new crops thus reducing climate change impacts on current agricultural potential.

6. Implementation Framework

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

6.1. Implementation framework: Goal 1

Goal 1: To ensure water security and good water quality, protecting water resources under a changing climate

Adaptation programme 1.1: Protect and conserve water across the municipality				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Implement water loss/leakage reduction strategies through conservation projects.	Drought	Water and Sanitation Division: Water Services Operation and Maintenance Support	Short, Medium and Long term	High
ii. Include water conservation strategies in housing and settlement planning.	Drought	City Planning and Development Division: Human settlement	Medium term	Medium
iii. Design systems to recycle water.	Drought	Water & Sanitation	Medium term	Medium
iv. Undertake water awareness campaigns around water conservation technologies and techniques.	Drought	Water & Sanitation, and Environmental Management and Planning	Medium term	Low
v. Design a water pressure management system.	Drought, Groundwater Depletion, and Surface Water Depletion	Water & Sanitation	Short term	High

Adaptation programme 1.2: Improve groundwater recharge				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Design groundwater recharge systems.	Drought, and Groundwater Depletion	Water & Sanitation	Medium term	High
ii. Identify suitable sites for infiltration of rainwater runoff.	Drought, Surface Water Depletion, and Groundwater Depletion	Water & Sanitation	Short term	High

iii. Use cool, permeable paving.	Flooding, Heat Stress, and Groundwater Depletion	City Planning and Development	Medium term	Low
iv. Clear alien invasive vegetation from infested catchments.	Drought, Surface Water Depletion, and Groundwater Depletion	Environmental Management	Short term	Medium
v. Protect and re-establish wetlands.	Drought, Surface Water Depletion, and Groundwater Depletion	Environmental Management	Medium term	Medium

Adaptation programme 1.3: Diversify potable water supply				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop Integrated Water Resource Plan to guide the diversification of the water supply and enhance water security.	Drought, Ground water Depletion, and Surface Water Depletion	Water and Sanitation	Short term	High
i. Identify new potential water sources.	Drought, Ground water Depletion, and Surface Water Depletion	Water and Sanitation	Short term	High
ii. Encourage the use of alternative water sources such as rainwater tanks, stormwater and recycled waste.	Drought	Water and Sanitation	Short term	High
iii. Design stormwater and rainwater harvesting systems for new developments or employ retrofitting.	Flooding Drought, and Surface Water Depletion	Roads and Stormwater	Short term	High
iv. Install greywater systems across settlements to capture greywater from showers, laundry and wash hand basins allowing this to be reused for functions such as flushing toilets and irrigation.	Drought	Water and Sanitation	Medium term	Medium

6.2. Implementation framework: Goal 2

Goal 2: To protect and increase the resilience of critical municipal infrastructure

Adaptation programme 2.1: Design and maintain storm water infrastructure to accommodate storm surges and increase the volume of storm water runoff				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Identify existing storm water infrastructure that is vulnerable to the impacts of climate change.	Flooding	Roads and Stormwater	Short term	High
ii. Develop natural buffer zones around critical storm water infrastructure.	Flooding	Roads and Stormwater	Medium term	Medium
iii. Retrofit or replace existing storm water infrastructure to meet revised design criteria.	Flooding	Roads and Stormwater	Short term	Medium
iv. Regularly maintain storm water systems.	Flooding	Roads and Stormwater	Short term	High
v. Design storm water management systems to mimic nature.	Flooding	Roads and Stormwater	Medium term	Low

Adaptation programme 2.2: Protect and maintain road and public transport infrastructure				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Elevate roadways to protect them from floods.	Economic and physical vulnerability	Roads and Stormwater	Long term	Low
ii. Maintain roads and public transport infrastructure.	Economic and physical vulnerability	Roads and Stormwater	Short term	High
iii. Use new technologies for road construction, operations and maintenance.	Economic and physical vulnerability	Roads and Stormwater	Long term	Low

Adaptation programme 2.3: Protect and maintain water provision services				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level

i. Maintain water provision infrastructure regularly.	Drought	Roads and Stormwater	Short term	High
ii. Install water leakage detection technologies.	Drought	Roads and Stormwater	Short term	High

Adaptation programme 2.4: Protect and maintain sanitation systems				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Increase the maintenance of tanks and pipes.	Drought, and Health risks	Water & Sanitation	Medium term	High
ii. Elevate sanitation facilities to protect them from floods.	Drought	Water & Sanitation	Long term	Low
iii. Identify appropriate and sustainable sanitation solutions.	Drought, and Health risks	Water & Sanitation	Medium term	Medium
iv. Consider re-routing collection, processing and disposal systems.	Health risks	Water & Sanitation	Medium term	Medium

6.3. Implementation framework: Goal 3

Goal 3: To build capacity of the public health sector and protect human health

Adaptation programme 3.1: Increase capacity and resources at health facilities for climate change related impacts				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop a Community Services Plan to comprehensively dovetail municipal health needs and their climate change risks into development planning.	Health risks	Municipal Health Services Ehlanzeni District Municipality Disaster Management Division	Short term	Low
ii. Increase capacity and resources at health facilities for climate change related impacts.	Health risks	Municipal Health Services Ehlanzeni District Municipality Disaster Management Division	Short to medium term	Medium
iii. Develop nutrition programmes where climate impacts affect livelihoods and food security.	Health risks	Municipal Health Services Ehlanzeni District Municipality Disaster Management Division	Medium term	Medium

iv. Encourage and incentivise governmental structures, knowledge-based institutions and NGOs to undertake health and climate change research.	Health risks	Municipal Health Services Ehlanzeni District Municipality Disaster Management Division	Medium term	Low
v. Develop a Municipal Health Policy that includes climate driven health risks.	Health risks	Municipal Health Service Ehlanzeni District Municipality Disaster Management Division	Short term	High

Adaptation programme 3.2: Reduce risk of water-borne diseases through the supply of safe drinking water and safe disposal of wastewater				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Improve the capacity of wastewater treatment plant.	Health risks	Water and Sanitation	Short term	High
ii. Commission new wastewater plants for rural and new township developments.	Health risks	Water and Sanitation	Medium term	Medium
iii. Develop and adopt improved maintenance and asset management plans of stormwater systems and wastewater treatment works, to ensure optimum function.	Health risks	Water and Sanitation	Medium term	Low
iv. Refurbish aging infrastructure.	Health risks	Water and Sanitation	Short term	High
v. Reduce contamination of stormwater runoff.	Health	Water and Sanitation	Short term	High

Adaptation programme 3.3: Remove waste in time to avoid health and environmental impacts resulting from the decay of the waste				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Increase the frequency of waste collections especially of putrescible waste	Health risks	Water and Sanitation	Short	High
ii. Reduce stream and river contamination from sewage and industrial trade effluent	Health risks	Water and Sanitation	Medium	High

iii. Ensure proper disposal of waste by developing appropriate waste disposal facilities and resources	Health risks	Community Services Division Solid Waste	Short and Medium	Medium

6.4. Implementation framework: Goal 4

Goal 4: To support resilient commercial, small-scale and subsistence farming systems (these contribute to food security and employment in the area)

Adaptation programme 4.1: Introduce climate smart agricultural farming techniques				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Utilise organic fertilisers instead of chemicals.	Environmental degradation, and Low crop production	Local Economic Development Sub-Division: Rural Development	Short term	Medium
ii. Introduce climate resilient cultivars.	Environmental degradation, Low crop production	Local Economic Development Sub-Division: Rural Development	Medium term	Low
iii. Introduce green roof ploughing.	Heat stress and low crop production	Local Economic Development Sub-Division: Rural Development	Short term	Low
iv. Promote the use of indoor vertical farms that use ultraviolet (UV) lights, to grow food in urban areas.	Low crop production	Local Economic Development Sub-Division: Rural Development s	Short term	Low

Adaptation programme 4.2: Protect viable agricultural land in support of food security and local production, as well as increasing green space within the urban edge				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Develop and update an Agricultural Policy for COM that clearly articulates strategies for dealing with food security and the added pressures posed by climate change.	Low crop production	Local Economic Development Sub-Division: Rural Development	Short term	Low
ii. Identify suitable areas for urban agriculture.	Low crop production, and heat stress	Local Economic Development Sub-Division: Rural Development	Medium term	Low

Adaptation programme 4.3: Manage the change in crop production areas				
Adaptation Actions	Key risk or vulnerability addressed	Responsible department	Timeframe	Priority level
i. Research and improve understanding of climate change impacts on crop production.	Low crop production	Local Economic Development Sub-Division: Rural Development	Medium term	Low
ii. Conduct research on alternative agricultural production that can be implemented.	Low crop production	Local Economic Development Sub-Division: Rural Development	Medium term	Low
iii. Promote knowledge generation, sharing, stakeholder participation and awareness-raising in crop production.	Low crop production	Local Economic Development Sub-Division: Rural Development	Medium term	Low
iv. Implement evidence-based monitoring initiatives that feed into agricultural management systems.	Low crop production	Local Economic Development Sub-Division: Rural Development	Medium term	Low
v. Identify climate resilient land-uses that will support the agricultural industry's efforts to exploit new agricultural opportunities, new areas and new crops thus reducing climate change impacts on current agricultural potential.	Low crop production, and environmental degradation	Local Economic Development Sub-Division: Rural Development	Medium term	Low

7. Implications for the City

The rising temperatures projected over the City of Mbombela will lead to hotter and drier conditions which have major implications on water shortages as well as health hazards such as heat stress and spread of vector diseases. This, coupled with population growth will directly impact water availability in the municipality. It is therefore crucial for the City of Mbombela to equip the water sector with climate change adaptation responses that will increase resilience when dealing with vulnerabilities such as decreased quality of drinking water and decreased water quality and quantity in the ecosystem. This indicates the need to diversify potable water supply, conserve available water, and improve groundwater recharge – given a significant increase in groundwater recharge potential projected towards 2050. This will require collaborative efforts of the different water service providers namely the City of Mbombela as a water service authority and Sembcorb Silulumanz Water Service Provider.

Extreme weather conditions coupled with declining annual rainfall over the municipality will also have negative implications on the agricultural sector and this will contribute to lower yield in crops and other agricultural produces. This has a major implication on the nutrition levels and the health of the residents. Under-nutrition and socio-economic stress are prime contributors to poor human resilience and contribute to conditions that facilitate the emergence and propagation of disease. This, coupled with vector-borne diseases in warmer areas will put a significant burden on health care facilities thus calling for an urgent need to capacitate and strengthen the health care sector. Adaptation to the potential effects of climate change on human health becomes pertinent. Mbombela therefore needs to increase the resilience of human health towards climate change impacts to deal with the impacts of increased heat stress and manage increasing occupational health problems. This would require collaborative efforts between the Municipality and the Ehlanzeni District Municipality.

The Municipality would need to improve climate change resilience of the agriculture sector to deal with the various vulnerabilities such as change in produce production areas as well as manage increasing risks to livestock. This will require dedicated resources to explore smart technologies and techniques that would improve the resilience of commercial, small-scale and subsistence farming systems; thus, contributing to food security and employment in the municipality.

Climate change also pose a threat to the municipal infrastructure such as roads, water and sanitation systems especially in areas that are prone to flooding such as the north and eastern areas of the COM . Mbombela has a very high physical vulnerability score, i.e., the fourth highest in the province. This alludes to the high structural vulnerabilities in the LM, particularly when considering the municipality's buildings and infrastructure. The Municipality should consider the appropriate design and maintenance of stormwater infrastructure to accommodate storm surges and increases in the volume of stormwater runoff to prevent damage to infrastructure and assets. Regular maintenance and refurbishment of the roads and water infrastructure is also encouraged.

8. Recommendations for Mainstreaming

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

Mainstreaming climate change involves several key elements:

- Policy integration: Embedding evidence of climate change, as well as climate change adaptation and mitigation considerations into sectoral policies and strategies, such as those related to disaster risk management, energy, water resources, transportation, and urban planning. This ensures that climate change is not treated as a standalone issue but is instead integrated into broader development agendas.
- Institutional integration: Incorporating climate change responsibilities and expertise within departments. This may involve establishing a dedicated but decentralised climate change unit, as well as fostering collaboration and coordination among departments and relevant external stakeholders. Incorporating climate response outcomes in the KPIs of all relevant departments, will ensure that progress towards climate goals can be tracked and measured.
- Capacity building: Enhancing the knowledge, skills, and capacities of politicians, decision-makers, and practitioners to understand and address climate change effectively. This includes providing training, technical assistance, and access to relevant information and tools, such as the GreenBook. By improving their understanding of climate change and the need for adaptation, these groups can better integrate climate considerations into their work.
- Budgeting and financing: Allocating resources and funding to support climate change adaptation and mitigation activities within existing budgets and financing mechanisms. This may involve reallocating funds from other priorities, leveraging external sources of finance, or integrating climate considerations into budget planning processes.
- Establishing networks and partnerships: Establishing networks or partnerships with civil society organisations, research councils, the private sector, different spheres of government, and other relevant entities could bolster climate adaptation efforts.
- Monitoring and evaluation: Establishing systems for monitoring and evaluating the effectiveness of mainstreaming efforts and tracking progress towards climate-related goals and targets. This helps ensure accountability and facilitates learning and adaptation over time.

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

9. Bibliography

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

Council for Scientific and Industrial Research (CSIR), 2019. Green Book | Adapting settlements for the future. GreenBook. URL https://greenbook.co.za/

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

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

Ehlanzeni District Municipality (MLM), 2023. Climate Change Vulnerability Assessment and Response Plan. 2016. Version 8.

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.

City of Mbombela (COM), 2023. City of Mbombela: Final Integrated Development Plan (IDP) Review 2023-2024.

City of Mbombela COM), 2019. City of Mbombela: Spatial Development Framework Review _2019.

City of Mbombela (COM), 2017. City of Mbombela: The City of Mbombela Climate Change Response Strategy and Implementation Plan Draft.

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.