1818 H Street NW, Washington, DC 20433
Telephone: 202-473-1000; internet: www.worldbank.org

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Executive Summary

Droughts are far more costly than the policies and infrastructure required to build water resilience, and they have the potential to reduce a city's economic growth. Investing in urban drought risk reduction will not only reduce losses and damages but can also trigger positive economic, environmental, and social cobenefits. These cobenefits include increased productivity and economic growth; improved access and reduced disruptions to essential services and reduced failures in public water supply; increased disaster resilience; strengthened coordination and governance; enhanced planning processes and long- and medium-term policy and development planning; reduced inequalities, poverty, health risks, social instability, and conflict; and the development of prosperous and resilient cities.

Urban drought can be considered a subtype of socioeconomic drought, which is a temporary water shortage condition in an urban area and urban life, caused by either a sharp decrease in water supply or a sudden increase in water demand. Cities in Africa face converging challenges that heighten the risk of urban drought: rapid urbanization (that is unplanned and unprepared for), rising climate threats, and skyrocketing demand for increasingly constrained water resources (with slums growing at a faster rate than increases in water and sanitation services provision).

This document offers guidance on the use of the Urban Drought Risk Management Framework (UDRMF) in the Southern African Development Community (SADC). The Framework aims to provide practical recommendations on how to assess, prepare for, and cope with, the current and likely future impacts of urban droughts, recognizing the linkages between urban drought, poverty, urbanization, and development. National and local government officials can use the UDRMF and this guidance to improve urban drought risk management and disaster risk resilience in the SADC through policy and institutional reform and resilient investments.

The UDRMF builds on international best practices and is aligned with recent work developed by the World Bank, with a strong emphasis on integrated, proactive, comprehensive, and people-centered risk management. **It aims to reduce existing drought risk and potential impacts of urban droughts, while preventing new risk and strengthening resilience, recognizing the linkages between urban drought, poverty, urbanization, and development**. Guided by the principles of addressing underlying risk factors and 'building back better', it targets the most vulnerable, promoting gender equality and social inclusion, fostering partnerships, and enhancing cross-sectoral coordination at all levels to enhance coherence across climate and disaster risks, water management, land use, poverty reduction, and development policies. It thus does not approach drought risk as natural hazards only.

This framework is based on a three-pillar approach of interconnected, multidisciplinary, and multi-institutional activities. These pillars are: (1) monitoring and early warning systems; (2) impact and vulnerability (risk) assessment; and (3) mitigation, preparedness, and response. Jointly, the pillars **emphasize the importance of risk management and resilience, planning and preparedness, and early warning systems to permit timely and tailored interventions**. These objectives align directly with the Sendai Framework for Disaster Risk Reduction priorities of improving understanding of hazard risk, enhancing disaster preparedness, strengthening governance to improve the effectiveness of crisis management, and 'building back better' during the recovery phase to reduce long-term vulnerability (Jedd et al. 2021).[1]

[1] The World Meteorological Organization (WMO) alliance with the Global Water Partnership (GWP) and the United Nations Convention to Combat Desertification (UNCCD) promotes the same principles and guidelines of applying the three pillars to address the drought hazard as the Sendai Framework

The final step in the UDRMF planning process is the creation of a detailed set of procedures to ensure adequate evaluation of drought assessment and response systems. The urban drought risk management plan is monitored, periodically evaluated, learned from, updated, and improved with the intention to determine if progress is being made toward predefined goals, to identify positive and negative effects, and to ensure the plan's continued suitability to the evolving water utility needs. To maximize the effectiveness of the system, two modes of evaluation must be in place: an ongoing or operational evaluation program and a post-drought evaluation program.

As urban drought risk rises in the SADC, its countries face a unique opportunity to manage such droughts effectively and consider likely future challenges. This guidance note showcases the examples of Blantyre (Malawi), Bulawayo (Zimbabwe), Cape Town (South Africa), Dar es Salaam (Tanzania), Gaborone (Botswana), Lilongwe (Malawi), Toliara (Madagascar), and Windhoek (Namibia) to present existing challenges, windows of opportunity, and local good practices relevant to UDRMF implementation.

for Disaster Risk Reduction (UNDRR 2015) and the Hyogo Framework for Action supported by United Nations (United Nations Office for Disaster Risk Reduction) and the United Nations Educational, Scientific and Cultural Organization's International Hydrological Programme (Verbist et al. 2016). The three-pillar approach applies to all four types of droughts since the pillars oversee the full 'drought life cycle' as defined by the WMO.

Abbreviations

FEWS NET	Famine Early Warning Systems Network
GWP	Global Water Partnership
NDMC	National Drought Mitigation Center (University of Nebraska, United States)
SADC	Southern African Development Community
SADRI	Southern Africa Drought Resilience Initiative
UDRMF	Urban Drought Risk Management Framework
UNCCD	United Nations Convention to Combat Desertification
WMO	World Meteorological Organization

Introduction

Droughts have had costly impacts in Southern Africa, causing 88 percent of all fatalities associated with disasters related to weather, climate, and water. From 1971 to 2020, more than 140 million people in the region were affected by droughts, which caused US$3.6 billion in damages (EM-DAT n.d.).

Urban drought—even when temporary—often has severe socioeconomic implications for a city. Typically manifesting as a sharp decrease in water supply or a sudden increase in water demand, urban drought or water scarcity has impacts that are often aggravated by economic disparity, poor water management and governance, and institutional inefficiency (Ray and Shaw 2019a). Often, both impacts and risks cascade rapidly through economic systems in the form of unemployment, migration, and social instability, related to failures in public water supply, health risks, food insecurity, and conflict (UNDRR 2019).

Cities constitute economic centers for development, and urban drought may severely affect all economic drivers in urban centers, thus affecting the economic development of the country and the region at large. Analytical and institutional foundations are needed to catalyze national and regional investment in integrated drought resilience.

Droughts are far more costly than the policies and infrastructure required to build water resilience, since water scarcity often impedes a city's economic growth (Zaveri et al. 2021). Estimates show that water shortages can slow a city's economic growth by up to 12 percent—depending on the size of the shock—enough to reverse development progress and compounding the vulnerability of migrants. Growing populations are expected to result in an 80 percent increase in demand for water in urban areas by 2050—and this demand is expanding faster than the service provision capabilities of the cities. Climate change impacts and urban population growth are putting increasing strain on existing, often inefficient water infrastructure, putting cities at risk of running out of water (Zaveri et al. 2021).

Whilst urban drought crisis management focuses on immediate response and interventions, integrated urban drought risk management is more proactive. The latter emphasizes proactive risk management, resilience planning, preparedness, and early warning systems to facilitate timely, tailored interventions (Jedd et al. 2021). Reactive urban drought crisis management, in contrast, tends to be ineffective at reducing vulnerability to drought, and it is often dependent on external assistance (Hayes, Knutson, and Wilhite 2005; Wilhite and Knutson 2008).

The Urban Drought Risk Management Framework (UDRMF) can help mitigate urban drought risk and strengthen resilience by jointly addressing multiple components of urban drought risk management, including disaster risk reduction, climate change adaptation strategies, and national water resources management policies.[2] The Framework does not view droughts merely as natural hazards but acknowledges and provides guidance to manage the interfaces and causalities between drought and society. By identifying who and what is at risk, and why, urban drought impact and vulnerability assessments aim to inform targeted drought mitigation, preparedness, and responses to address the root causes of current and future impacts and compounding risks. The assessment also underscores the importance of more communication and collaboration across sectors and levels of government.

[2] For more detail, see the Integrated Drought Management Programme website at https://www.droughtmanagement.info.

An urban drought policy should establish a clear set of principles or operating guidelines to govern drought risk management and its impacts. Any such policy should be directed toward reducing risk by developing better awareness and understanding of drought hazards and the underlying causes of societal vulnerability (Hayes, Knutson, and Wilhite 2005; Wilhite and Knutson 2008). Urban drought planning includes proactive measures, like conservation and reallocation, as well as contingency provisions, like rationing and water transfers, in defining drought-stage triggers.

Urban drought risk management investments—and building resilience to climate extremes and disasters—can help avoid disaster losses and deliver social, economic, and environmental benefits. Investments in disaster risk management and climate change adaptation can help increase productivity, drive innovation, reduce or avoid environmental degradation, and improve access to basic services (Vorhies and Wilkinson 2016). Smart, systematic investments in urban water resilience can ensure that communities have safe, reliable, and affordable water, and that water resources are protected through preparedness and water-sensitive infrastructure (Workalemahu Habtemariam et al. 2021).

To effectively prepare for increased water scarcity and the recurrence of urban drought, cities in the Southern African Development Community (SADC) region must adopt more adaptive and innovative solutions. The World Bank has had the opportunity to work on water security with and learn from some of the region's cities and governments. For example, in response to the 2015–18 Cape Town water crisis—which saw the World Bank and other entities provide technical assistance—the city's innovative diversification of water sources and its other initiatives have shown that 'business as usual' supply-side infrastructure solutions alone do not suffice for meeting increasing demand amid water scarcity. Related lessons have emerged from other cities in South Africa such as Nelson Mandela Bay, and in the SADC region.

Strengthening urban drought resilience is recognized as integral to achieving the Sustainable Development Goals by 2030. Urban drought is directly connected to at least 5 of the 17 Sustainable Development Goals proposed in the 2030 Agenda for Sustainable Development, and to 20 of their targets and 28 corresponding indicators at both national and city levels (Zhang et al. 2019). The relevant goals are Goal 6: Clean water and sanitation; Goal 11: Sustainable cities and communities; Goal 12: Responsible consumption and production; Goal 13: Climate action; and Goal 15: Life on land (Zhang et al. 2019).

This document offers guidance on the use of the Urban Drought Risk Management Framework in the Southern African Development Community. The Framework aims to provide practical recommendations on how to assess, prepare for, and cope with the current and likely future impacts of urban droughts, recognizing the linkages between urban drought, poverty, urbanization, and development. It builds on the latest available information to provide a conceptual framework, guidelines, and case studies that national and local government officials can use to improve urban drought risk management and disaster risk resilience in the SADC through policy and institutional reform and resilient investments.

Urban Drought Risk

The Concept of Urban Drought

Wilhite and Glantz (1985) identified four types of droughts: meteorological, hydrological, agricultural, and socioeconomic. The first three types deal with ways drought is measured as a physical phenomenon, originating from precipitation deficiencies and increases in temperature and evapotranspiration. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall. The four types of droughts can be recognized according to the duration of lack of precipitation, increases in temperature and evapotranspiration, as well as intensity of each of those climatic indicators.

Drought often increases the imbalance between demand and supply of economic goods. Water supply may increase because of improved production efficiency, new technology, or the construction of reservoirs that increase surface water storage capacity. It is important to identify possible convergence in trends of water supply and water demand since they are dynamic in time and space, that could signal higher vulnerability to drought (Botterill and Wilhite 2005). If both supply and demand are growing, the critical factor is the relative rate of change, as vulnerability to and the incidence of drought may increase in future as supply and demand trends converge.[3]

Urban drought can be considered a subtype of socioeconomic drought (Wang et al. 2019; Zhang et al. 2019), which is a temporary water shortage condition in an urban area and urban life, caused by either a sharp decrease in water supply or a sudden increase in water demand. Water stress or water scarcity due to population growth and climate variability is intensified by economic disparity, poor water management and water governance, and low institutional efficiency (Ray and Shaw 2019a).

Human activity and unplanned urban development increase urban drought risk. Severe droughts in highly populated environments cannot be seen as purely natural hazards (Van Loon et al. 2016). Urban drought risk may be exacerbated by: (1) increased deforestation and land use changes, increased prevalence of impervious surfaces (built-up areas), and reduced infiltration, water storage and groundwater recharge; (2) increased water demand and use; and (3) increased contamination of surface water and groundwater (Zhang et al. 2019).

Urban Drought Challenges in the Southern African Development Community

Cities in Africa face converging challenges: rapid population growth, rapid urbanization (and slum growth), rising climate threats, and skyrocketing demand for increasingly constrained water resources. Water insecurity threatens economies, livelihoods, and the health and well-being of billions of people.

Rapid urban population growth and increasing infrastructural inequalities can lead to higher vulnerability to urban droughts. On average, by the year 2030, about 70 percent of the population of Southern Africa will be urban (UN DESA 2018), and Sub-Saharan Africa could have as many as 86 million internal climate migrants by 2050 (Clement et al. 2021).

[3] For more details, see the "Types of Drought" web page of the National Drought Mitigation Center website at https://drought.unl.edu/Education/DroughtIn-depth/TypesofDrought.aspx.

Often, the rapid pace of urbanization in Africa has adverse environmental consequences and heightens problems linked to infrastructural inadequacies. Water management systems are particularly threatened by exponential population growth, rapid and mass urbanization, higher water consumption levels, land use changes, growth of built-up areas, and climate variability. Reduced infiltration due to drastic and long-term rainfall reduction and increased freshwater pollution threaten the sustainability of urban water systems (Ray and Shaw 2019b).

Water stress or water scarcity due to population growth and climate variability is intensified by economic disparity, poor water management, and water governance issues, as well as institutional inefficiency (Ray and Shaw 2019a). 'Water scarcity' and 'urban drought' are sometimes used interchangeably to describe an imbalance between water supply and demand, but a more nuanced conceptualization is required. Two main elements can be considered to differentiate water scarcity and urban drought: (1) geographic extent: water scarcity refers to all manners of water shortage in all geographic locations, whereas urban drought refers to an imbalance in water supply and demand in an urban area; and (2) duration: urban drought reflects a rather temporary water stress or change in balance between supply and demand, whereas water scarcity is generally considered a long-term problem or a state of imbalance (Zhang et al. 2019).

The Intergovernmental Panel on Climate Change report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* highlights exposure and vulnerability as determinants of risk (Cardona et al. 2012). The authors stress: "The severity of the impacts of weather and climate events depends strongly on the level of exposure and vulnerability to these events (high confidence), and that high exposure and vulnerability are generally the outcomes of skewed development processes, such as those associated with environmental mismanagement, demographic changes, rapid and unplanned urbanization in hazardous areas, failed governance, and scarcity of livelihood options for the poor (high confidence)" (Cardona et al. 2012)[4]. Moreover, there is a need to fully understand the nature of exposure, vulnerability, and risk, as well as the decision-making context, to anticipate possible impacts and to design and implement appropriate risk reduction strategies and mitigation actions (Cardona et al. 2012)**.**

People living in informal settlements or slums are particularly vulnerable to urban drought as such areas often lack adequate water management facilities and a sustainable water supply, and possess less adaptive capacity and resilience to deal with disasters (Bates et al. 2008; Zhang et al. 2019). The combination of overcrowding, low-quality housing, and inadequate access to safe water and sanitation increases the vulnerability of these settings, and their inhabitants, to drought and other natural disasters (Lall, Henderson, and Venables 2017)**.**

Rural, urban, and peri-urban areas are becoming increasingly interconnected, heightening the potential for intersectoral conflict over shared water resources. Within this context, managing water resources during a drought and simultaneously preventing intersectoral conflict is a major challenge (Zipper et al. 2017). Urban and peri-urban growth, without appropriate interventions, can exacerbate water conflicts across cities, between cities and rural areas, and between economic sectors (for example, human consumption, industry, agriculture).

The indirect effects of drought could cascade rapidly through economic systems in the form of unemployment, migration, and social instability related to failures in public water supply, health risks, food insecurity, and conflict (UNDRR 2019). Figure 1 highlights urban drought challenges in the Southern African

[4] Based on the "Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties", confidence in the validity of a finding is based on the type, amount, quality, and consistency of evidence and the degree of agreement. Confidence is expressed qualitatively. A level of confidence is expressed using one of five qualifiers: very low, low, medium, high, and very high. Increasing levels of evidence and degrees of agreement are correlated with increasing confidence (IPCC 2012).

Development Community (SADC). Box 1 highlights the disaster, fragility, and conflict nexus, and the urgent need to invest in more resilient water services.

Figure 1 Urban Drought Challenges in the SADC

Rapid Urbanization and Increasing Water Demand

African cities are experiencing the fastest pace of urbanization in history. On average, by the year 2030, about 70 percent of the population of Southern Africa will be urban *(UN* DESA 2018*)*.

Urban drought risk may be exacerbated by:

- Increased deforestation, land use changes and built-up areas, and reduced infiltration, water storage and groundwater recharge
- Increased water demand and use
- Increased contamination of surface water and groundwater.

Rising Climate Threats and Increasingly Constrained Water Resources

Droughts lead to reduced streamflow and inflow to reservoirs, and reduced water storage and freshwater availability.

Droughts can cause disruptions well beyond the origin and immediate location of the hazard. Droughts may increase migration and result in uncontrolled urban agglomerations.

Sub-Saharan Africa could have as many as 86 million internal climate migrants by 2050 (Clement et al. 2021).

Inefficient Water Systems

In Africa, urbanization of people has not been accompanied by the urbanization of capital (Lall, Henderson, and Venables 2017), causing water demand to exceed service provision capacities. Sustainable growth of cities depends on reliable water systems that are robust enough to cope with drought.

There is increasing strain on existing, often inefficient water infrastructure (Zaveri et al. 2021). Water systems, in many cases, are not (or are barely) meeting current demand and will be unable to meet future demand without significant investments.

Urban drought risk is intensified by economic disparity, poor water management, water governance issues, and institutional inefficiency (Ray and Shaw 2019a).

Disproportionate Impacts on the Urban Poor

Socioeconomic factors are key to understanding drought vulnerability of the urban system. Water insecurity threatens economies, livelihoods, and the health and well-being of billions of people.

Rapid and uncontrolled urbanization in Africa had already resulted in 200 million people living in slums by 2014. On average, 60 percent of Africa's urban population is packed into slums (Lall, Henderson, and Venables 2017).

More frequent and intense droughts, and insufficient and inequitable access to basic water services can undermine security, well-being, and development prospects, disproportionately affecting the urban poor (Bates et al. 2008; Hallegatte et al. 2017; Zhang et al. 2019).

Source: Original figure for this publication.

Box 1 Disasters, Fragility, and Conflict

Cities in Southern Africa face multiple and complex crises, including disasters, climate change impacts, environmental degradation, pandemics, forced displacement and migration, political crises, and conflict. To ensure resilient development and peacebuilding, it is necessary to address the underlying impacts of conflict and crises and the links between disasters, climate shocks, fragility, and conflict, as well as other threats such as forced displacement. From 2005 to 2009, more than 50 percent of people affected by disasters worldwide lived in countries affected by fragility, conflict, and violence; in some years, this figure reached as much as 80 percent (GFDRR 2015).

The Southern Africa region is affected by political fragility and high levels of inequality and human insecurity. Climate-related events, such as droughts, have directly or indirectly affected economic prosperity, livelihoods, and health and well-being, and increased vulnerability. Water stress and shortages have been identified as central reasons for migration, and extended periods of severe drought have led to widespread impacts and heightened existing vulnerabilities such as poverty and inequality. Water scarcity is increasingly also a conflict-compounding factor, and limited and inequitable access to water in Southern Africa is increasingly leading to violent tensions (Maunganidze, Greve, and Kurnoth 2021).

While cities can bring many benefits, they can also exacerbate risks of disasters, violence, marginalization, poverty, climate shocks, and conflict. Africa's fast pace of urbanization—with a large share of urban expansion occurring in urban slums—poses a complex scenario in which disaster, fragility, conflict, violence, and climate risks converge. In societies affected by fragility, conflict, and violence, basic services are often weak, under threat, and in need of reform. In such contexts, risk management programs could serve as an entry point for broader institutional and inclusive reform and investments in key sectors such as water supply and sanitation, infrastructure, health, and education (GFDRR 2015).

Benefits of Urban Drought Risk Management

Resilient investment can become a source of savings for countries because when a country invests resources in strategic, productive sectors, there is a multiplier effect for sustainable development (UNDRR 2021). Investing in risk reduction will reduce the costs of disasters and reconstruction processes, and the poverty levels of affected populations. Public and private investments in disaster risk prevention and reduction are cost-effective and essential to save lives, prevent and reduce losses, and ensure effective recovery and rehabilitation—and thus resilience to disasters.

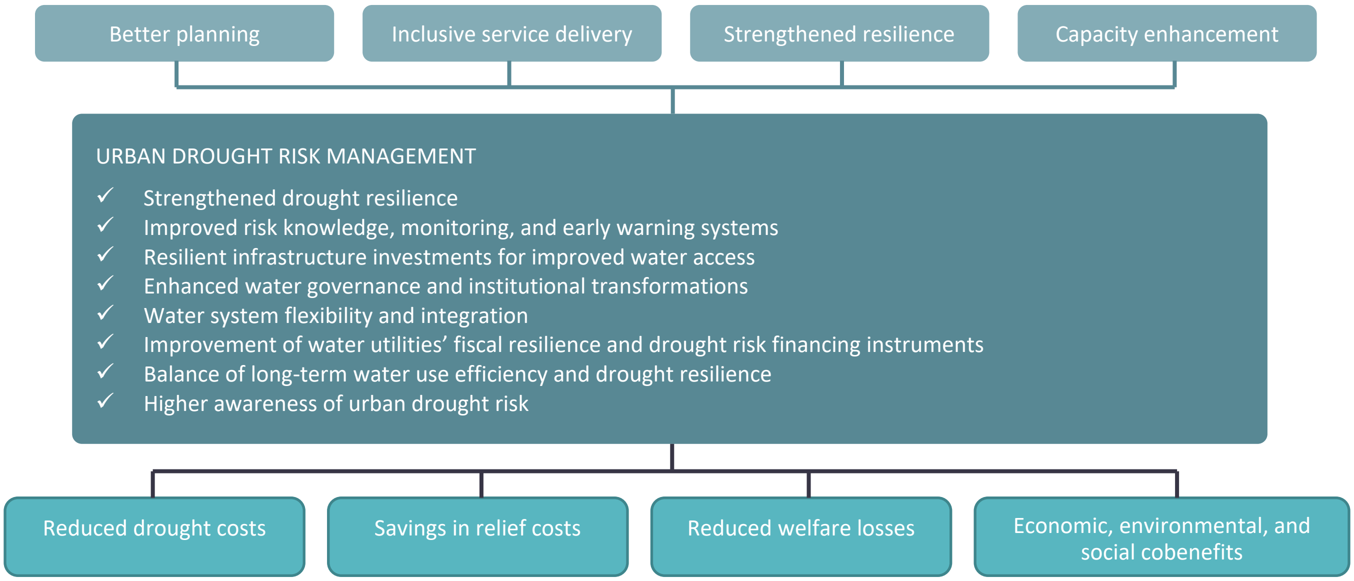
Investing in making cities more resilient to crises and disasters can reduce economic and human costs, mainly by reducing impacts on the poorest populations in urban areas, who are the most affected (World Bank Group 2016). According to the report *Investing in Urban Resilience* (World Bank Group 2016), if high climate impact is added to the existing inequality in access to infrastructure and basic services, natural disasters will push "tens of millions" of urban inhabitants into extreme poverty. Disasters and the effects of climate change, such as increased food prices, could therefore reverse many development gains.

Investing in urban drought risk management and adaptation to climate change will not only reduce losses and damages, but can also generate positive economic, environmental, and social cobenefits. For example, such investments can:

- Increase productivity, drive innovation, reduce or avoid environmental degradation, and improve access to basic services (Vorhies and Wilkinson 2016)
- Reduce the impacts of extreme hydro-meteorological events and increase resilience, thereby reducing losses and damage and their cascading impacts, and mitigate complex risks with long-term environmental and social consequences
- Strengthen risk knowledge, water governance, and institutional and financial capacity to manage and deal with urban drought; promote climate-friendly and risk-aware investments; and facilitate recovery planning under the principles of building back better. Improved preparedness can also reduce the reallocation of public resources from social and development programs to finance post-disaster rehabilitation and care
- Strengthen the links between disaster risk management, integrated water resources management, and climate change workstreams, promoting integration of urban drought risk management into urban planning for resilient cities and long-term development planning policies
- Have very positive impacts on poverty reduction in the long term. Poverty is both an underlying risk driver and a consequence of disasters, and poor people suffer disproportionately from the impacts of disasters. Due to the disproportionate impacts of natural disasters on the poor (Hallegatte et al. 2017), investing in resilient mitigation and preparedness measures will strengthen poverty reduction strategies
- Reduce disruptions to essential services, reduce the impacts of disasters on vulnerable populations, and prevent more people from falling into poverty because of disasters.

Preventive management strategies have a far wider appeal than simply the capacity to mitigate urban drought risks, as they bring about substantial socioeconomic cobenefits. Many urban drought risk management measures not only build resilience to droughts, but also to socioeconomic and environmental shocks. Therefore, several approaches to urban drought risk management are 'low- and no-regrets' options preventing many of the negative impacts and direct costs of droughts and, especially, lesser-known indirect costs. The benefits of adopting urban drought risk management approaches include reduced drought and r drought relief costs, and substantial socioeconomic cobenefits. A comprehensive investment portfolio of resilience measures linked to thorough drought policy enforcement is both viable and much needed in the Southern African Development Community (SADC) (Figure 2).

Figure 2 Benefits of Urban Drought Risk Management



Source: Adapted from Gerber and Mirzabaev (2017).

Enhancing urban drought resilience involves long-term planning against the backdrop of a changing climate. Low- and no-regrets investment options are aimed at reducing vulnerability to existing and future hazards regardless of climate change uncertainty and provide benefits across a range of future climate and development scenarios. These investments can bring cobenefits across multiple sectors and stakeholders. The Intergovernmental Panel on Climate Change report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, which explores climate change impacts, adaptation, and vulnerability, addresses the need to move toward adaptive water management and the adoption of resilient or no-regrets approaches (Field et al. 2012). Low- and no-regrets measures both reduce climate risk and provide other economic, environmental, or social cobenefits (Hallegatte 2009).

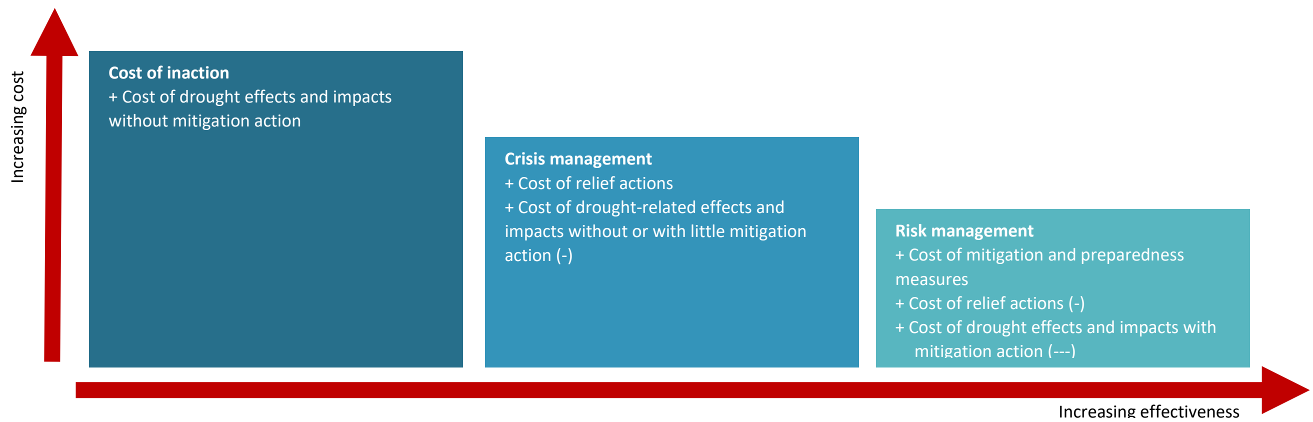
Adaptive water management using flexible and low- or no-regrets solutions can enhance resilience to uncertain hydrological changes and impacts due to climate change. Consideration should be given to low- and no-regrets solutions for which moderate investment—under almost any scenario—clearly leads to risk reduction and increased coping capacity, as well as economic, environmental, and social cobenefits (Field et al. 2012). Improved irrigation systems and broader access to drinking water, electricity, and finance would support higher economic growth and poverty reduction during prolonged dry spells and water shortages (IMF, 2021)

Assessing and monetizing impacts, before, during, and after an urban drought will help identify who and what is affected, and why. This can then help inform the best response and recovery strategy for the context, which will aim to reduce the vulnerabilities or root causes that led to the impacts (building back better principles). Monetizing impacts and actions—to the extent possible—and determining the benefits of action versus the costs of inaction (Venton et al. 2019), can also enable governments and other institutions to develop cost-effective and sustainable solutions, and improve mitigation, preparedness, and response. The recovery strategy should consider the current and likely future urban drought risk, given climate and development trends.

The costs of action are usually lower than the costs of inaction, and the returns from investing in forecasted urban drought risk management actions are higher than those of investing in reactive crisis management. Actions involving urban drought preparedness and mitigation lower the eventual drought relief costs, in addition to helping mitigate the costs of inaction (Figure 3).

Proactive government policies can lead to more efficient and forward-looking urban drought risk management strategies, supported by scientific data on climate, drought, and drought mitigation measures. Path dependence and the lack of information on the costs and benefits of urban drought risk management (preventive approach) versus crisis management (reactive or responsive approach) measures should be addressed to avoid the persistence of the latter approach.

Figure 3 Costs of Drought under Different Action Scenarios



Source: Adapted from Gerber and Mirzabaev (2017).

Urban Drought Risk Management

Purpose of Urban Drought Risk Management Policies and Plans

An urban drought risk management policy should establish a clear set of principles or operating guidelines to govern the (risk) management of drought and its impacts. Any such policy should be directed toward reducing risk by developing awareness and understanding of drought hazards and the underlying causes of vulnerability. The policy should be consistent and equitable for all regions, population groups, and economic sectors, and reflect the Sustainable Development Goals. The overriding principle of drought policy should be an emphasis on risk management through mitigation and preparedness measures (Hayes, Knutson, and Wilhite 2005; Wilhite and Knutson 2008).

Institutional arrangements and a supporting legal framework that define clear roles and coordination mechanisms for institutions and organizations at the national, regional, and city level are crucial for the sound implementation of a drought risk management policy. Lessons learned from Australia, California (United States), Cape Town (South Africa), and Mexico make clear the need to strengthen institutions and build systems between the different levels of government for effective water resources management and communication throughout the 'drought life cycle'. Reducing urban drought risk and vulnerability requires coherent actions from both city and water managers.

A comprehensive drought policy must include systematic monitoring, early warning, and information systems to support impact and vulnerability assessments and decision-making. The policy must also guide and encourage the identification and adoption of appropriate local-level mitigation and response measures aimed at risk reduction, and predefined early warning thresholds to mitigate drought impacts**.**

Adaptation to recurrent and more intense droughts has to be local and context-specific, and policy intervention should consider and respect local complexities (Kallis 2008). A government resolution introducing the legal and institutional framework for the drought planning process is needed in those countries that lack appropriate legislation for drought risk management. Such a resolution should appoint responsible bodies (for example, ministries, municipalities, government agencies) and clearly assign their roles and responsibilities in the drought risk management system (Fatulová et al. 2015).

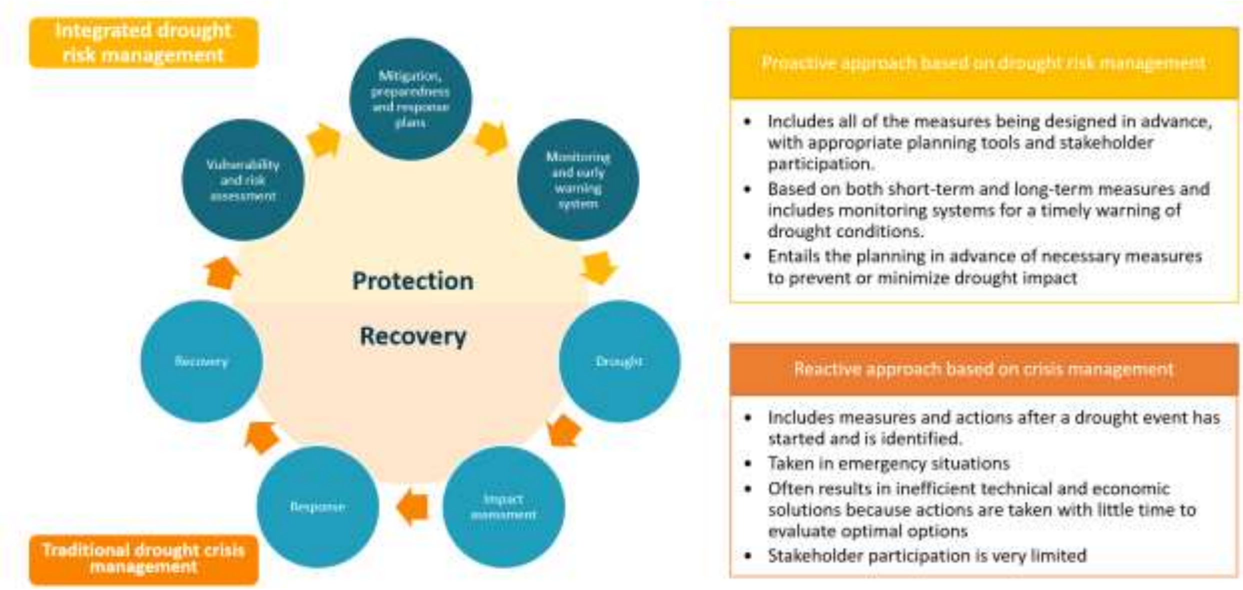
Purpose of the Urban Drought Risk Management Framework

The Urban Drought Risk Management Framework (UDRMF) emphasizes the importance of risk management and resilience, planning and preparedness, and early warning systems to permit timely and tailored interventions. These objectives align directly with the Sendai Framework for Disaster Risk Reduction priorities of improving understanding of hazard risk, enhancing disaster preparedness to facilitate effective responses, strengthening crisis management governance to improve the effectiveness of interventions, and 'building back better' during the recovery phase to reduce long-term vulnerability (Jedd et al. 2021).[5]

[5] The World Meteorological Organization (WMO) alliance with the Global Water Partnership (GWP) and the United Nations Convention to Combat Desertification (UNCCD) promotes the same principles and guidelines of applying the three pillars to address the drought hazard as the Sendai Framework for Disaster Risk Reduction (UNDRR 2015) and the Hyogo Framework for Action supported by United Nations (United Nations Office for Disaster Risk Reduction) and the United Nations Educational, Scientific and Cultural Organization's International Hydrological Programme (Verbist et al. 2016). The three-pillar approach applies to all four types of droughts since the pillars oversee the full 'drought life cycle' as defined by the WMO.

The preparation of drought risk management plans at *national* and *urban* level requires a clear and agreed conceptual framework for drought risk management and definitions related to drought. Two basic approaches are currently applied (Fatulová et al. 2015) (Figure 4).

Figure 4 Planning Approaches: Integrated Drought Risk Management versus Drought Crisis Management



Source: Original figure for this publication.

Drought risk management must involve a proactive approach, which includes all the measures being designed in advance, using appropriate planning tools, and with stakeholder participation. Drought risk management includes monitoring and early warning systems for the timely identification of drought risks and conditions, and is based on proactively planned, short- and long-term measures to prevent or minimize drought impacts. The usefulness of drought risk management is measured in economic and social benefits (Fatulová et al. 2015), which show that it is the best option for managing urban drought.

In the absence of an urban drought risk management plan, national and local governments and water utilities tend to focus on drought crisis management—which begins only after a drought event has begun*. This approach is taken in emergency situations and often results in inefficient technical and economic solutions, because actions are taken quickly, with little time to evaluate optimal options and very limited stakeholder participation (Hayes, Knutson, and Wilhite 2005; Wilhite and Knutson 2008).*

Figure 5 highlights the existing drought policy and legal framework in the Southern African Development Community (SADC).

The key world drought management initiatives use planning methodologies to develop and implement drought policy at a national, regional (watershed), city, or water utility level. The Integrated Drought Management Programme of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) proposes a 10-step approach, while the United Nations Convention to Combat Desertification (UNCCD) sets out an 8-step process for the implementation of its Drought Initiative (Box 2). These two global initiatives share the principles and guidelines of the three-pillar approach to address drought hazards as set out in the Sendai Framework for Disaster Risk Reduction 2015–2030 and the Hyogo Framework for Action 2005–2015 and are supported by both the United Nations Office for Disaster Risk Reduction and the United Nations Educational, Scientific and Cultural Organization's International Hydrological Programme (Verbist et al. 2016)[6][7].

Figure 5 Existing Drought Policy and Legal Framework in the SADC

7 Southern African Development Community (SADC) countries have a national drought plan, but these need to be reviewed and updated

4 of these 7 countries also have a national drought contingency plan

4 SADC countries have only a national drought contingency plan, while 2 countries have no national drought instrument

All SADC countries have a disaster risk reduction management plan, but these focus mainly on floods

Windhoek is the only *city* with a drought response plan (2015), but its contents do not comply with the Australian, Californian, and Mexican approaches

Mbabane and Pretoria have a disaster risk management operational plan (2016)

All SADC countries have a disaster risk management or civil protection or preparedness and relief legal framework that is not up to date. Eswatini, Lesotho, and Namibia are the only countries with water acts or water policies and strategies

Source: Original figure for this publication.

Box 2 Comparison of Processes for Development of a Drought Policy and Preparedness Plan

To develop a drought policy and preparedness plan, both the 10-step process (Integrated Drought Management Programme of the World Meteorological Organization [WMO] and the Global Water Partnership [GWP]) and the 8-step process (Drought Initiative of the United Nations Convention to Combat Desertification [UNCCD]) apply the same concepts and tasks. It is therefore easy to adapt either to the urban context in cases where national implementation is difficult. In both cases, the three pillars are the foundation of the comprehensive plan (prepared at step 5) for implementation before, during, and after the occurrence of a drought.

Integrated Drought Management Programme of WMO-GWP	**Drought Initiative of the UNCCD**
The 10-step drought policy and preparedness plan process is as follows:	The 8-step drought policy and preparedness plan process is as follows:
Step 1: Appoint a national drought management policy commission	Step 1: Appoint a national drought plan task force
Step 2: State or define the goals and objectives of a risk-based national drought management policy	Step 2: Define the goals/objectives of the national drought plan
Step 3: Seek stakeholder participation; define and resolve conflicts between key water use sectors, considering also transboundary implications	Step 3: Seek stakeholder participation
Step 4: Inventory data and financial resources available, and identify groups at risk	Step 4: Conduct inventory/situation analysis
Step 5: Prepare/write the key tenets of the national drought management policy and preparedness plans, including the following elements: monitoring, early warning, and prediction; risk and impact assessment; and mitigation and response	Step 5: Prepare/write the national drought plan
Step 6: Identify research needs and fill institutional gaps	Step 6: Identify needs and fill institutional gaps
Step 7: Integrate science and policy aspects of drought management	Step 7: Communicate the national drought plan and educate stakeholders on its use

[6] For more detail, see the Integrated Drought Management Programme website at https://www.droughtmanagement.info.
[7] https://www.unccd.int/land-and-life/drought/drought-initiative

Step 8: Publicize the national drought management policy and preparedness plans and build public awareness and consensus	
Step 9: Develop education programs for all age and stakeholder groups	
Step 10: Evaluate and revise national drought management policy and supporting preparedness plans	Step 8: Evaluate the national drought plan

Integrated Urban Drought Risk Management Principles: The Three-Pillar Approach

The UDRMF builds on international best practices, with a strong emphasis on integrated, proactive, comprehensive, and people-centered risk management. The Framework aims to reduce existing drought risk and potential impacts of urban droughts, while preventing new risk and strengthening resilience, recognizing the linkages between urban drought, poverty, urbanization, and development. Guided by the principles of addressing underlying urban risk factors and building back better, it targets the most vulnerable, promoting gender equality and social inclusion, fostering partnerships, and enhancing cross-sectoral coordination at all levels to enhance coherence across climate and disaster risks, water management, land use, poverty reduction, and development policies.

The UDRMF is based on a three-pillar approach centered around interconnected, multidisciplinary, and multi-institutional activities. These pillars are: (1) monitoring and early warning systems; (2) impact and vulnerability (risk) assessment; and (3) mitigation, preparedness, and response (also known as drought risk mitigation measures).

The World Bank recently issued the EPIC Response Framework, a general framework for drought and flood actions, under which the UDRMF fits into the niche of urban drought. Furthermore, the UDRMF shares and fulfills the concepts and aims of the World Bank's City Resilience Program and Utility of the Future Program and recommendations from recent World Bank reports, *(including High and Dry: Climate Change, Water, and the Economy; Uncharted Waters: The New Economics of Water Scarcity and Variability; Water Scarce Cities: Thriving in a Finite World; and Ebb and Flow, Volume 1. Water, Migration, And Development).*[8]

Pillar 1: Urban Drought Monitoring and Early Warning Systems

Drought early warning systems that are linked to predefined mitigation, preparedness, and response actions are key to the effective management of drought risk. Drought monitoring involves the continuous assessment of the natural indicators of drought severity, spatial extent, and impacts. That information, if used effectively, can be the basis and trigger for mitigation and response actions that aim to reduce the vulnerability of people and systems at risk (Box 3 and Box 4). Using that information to elicit an appropriate response represents an early warning.

[8] For more details about the EPIC Response Framework, see the World Bank website at https://www.worldbank.org/en/topic/water/publication/an-epic-response-innovative-governance-for-flood-and-drought-risk-management. For an overview of the City Resilience Program, see the World Bank website at https://www.worldbank.org/en/topic/disasterriskmanagement/brief/city-resilience-program. For an overview of the Utility of the Future Program, see the World Bank website at https://www.worldbank.org/en/topic/water/publication/utility-of-the-future. For an overview of the key findings of the *High and Dry* report, see the World Bank website at https://www.worldbank.org/en/topic/water/publication/high-and-dry-climate-change-water-and-the-economy. For the key findings of the Uncharted Waters: The New Economics of Water Scarcity and Variability report see website at https://openknowledge.worldbank.org/handle/10986/28096. The Water Scarce Cities: Thriving in a Finite World report can be found at the World Bank website at https://openknowledge.worldbank.org/handle/10986/29623. For the Ebb and Flow Volume 1. Water, Migration, And Development report see World Bank website at https://openknowledge.worldbank.org/handle/10986/36089.

Box 3 Relevant Urban Drought Monitoring and Early Warning Indicators and Indexes

Drought monitoring and early warning systems emphasize climate-based and hydrological indicators and indexes that track changes in components of the hydrological cycle. Data are derived primarily from point-based, in situ observations, but these are coupled with ad hoc satellite imagery and global data sets when ground data are lacking, incomplete, or unreliable.

Drought indicators and indexes are variables that are used to describe the physical characteristics of drought severity, spatial extent, timing, and duration. The timing of a drought may be as significant as its severity in determining impacts and outcomes (Svoboda and Fuchs 2016).

No single indicator or index can represent the diversity and complexity of drought conditions across the spatial and temporal dimensions affected by drought. To fully capture the multiscale, multi-impact nature of drought in all its complexity, use of a 'composite' index is the recommended option. 'Hybrid' in nature, a composite index combines many parameters, indicators, and/or indexes into a single product (Svoboda and Fuchs 2016).

Furthermore, no single indicator or index can be used to determine appropriate actions for all types of droughts, given the number and variety of sectors affected. The preferred approach is to use different thresholds with various combinations of inputs. Ideally, this will involve prior study to determine which indicators/indexes are best suited to analyzing the timing, geographic area, and type of climate and drought. This takes time because it relies upon a trial-and-error approach (Svoboda and Fuchs 2016).

The Integrated Drought Management Programme carried out a comprehensive collation and analysis of the most frequently used drought indicators and indexes that are being applied across drought-prone regions. The indicators and indexes covered in the World Meteorological Organization *Handbook of Drought Indicators and Indices* are categorized by type and ease of use and grouped under the following classifications: (a) meteorology; (b) soil moisture; (c) hydrology; (d) remote sensing; and (e) composite or modeled. The handbook does not attempt to address the full complexities of impacts and the entire range of socioeconomic drought indicators and indexes (Svoboda and Fuchs 2016).

The presentation of drought information in a single map, with a simple classification system, is preferred over multiple maps depicting various indicators with various classification schemes. Decision-making based on quantitative index-based values is essential for the appropriate and accurate assessment of drought severity and to inform a comprehensive or operational drought plan or early warning system (Svoboda and Fuchs 2016).

The most common and recommended drought indicator for water storage and runoff is the Streamflow Drought Index. This very simple and effective index is based on cumulative streamflow volumes for overlapping periods of 3, 6, 9, and 12 months within each hydrological year (Nalbantis 2008). A recently launched predictive and operational drought monitoring tool (Forecast-Informed Reservoir Operations) could be an alternative resource to test.

Box 4 Relevant Sources of Urban Drought Monitoring and Early Warning Data and Information

It is useful to use satellite information and data interpretation to monitor urban drought in Sub-Saharan Africa. This is because ground data and observations are inadequate or lacking (for example, geographically not well-distributed, and stations with incomplete time series data) owing to multiple factors (that is, budget, vandalization, institutional capacity, or new management priorities). Such data therefore do not meet World Meteorological Organization (WMO) recommendations.

The alternative is to use watershed-scale drought monitoring, for which mainly three options covering nationwide are available[9]:

- The National Drought Mitigation Center of the University of Nebraska (United States), in support of the World Bank and as part of the Southern Africa Drought Resilience Initiative, developed for each country of the Southern African Development Community (SADC) a drought monitor. Each monitor uses satellite data (four indicators to develop the Composite Drought Index at 5-kilometer resolution) [a] on a regional and national scale, which are updated monthly. The Composite Drought Index categories are based on the same percentile classes as the US Drought Monitor and North American Drought Monitor. In addition, each monitor provides the same analysis for the wet classifications as well as the drought classifications, helping emergency management agencies and hydrometeorological services to address both climate extremes.
- The Intergovernmental Authority on Development's Climate Prediction and Applications Center and Southern African Development Community (SADC) Climate Services Centre use parts of the Combined Drought Indicator tripod, along with the

[9] Also 'locally based monitoring' is in some local cases another option however its accuracy needs specific testing for calibration

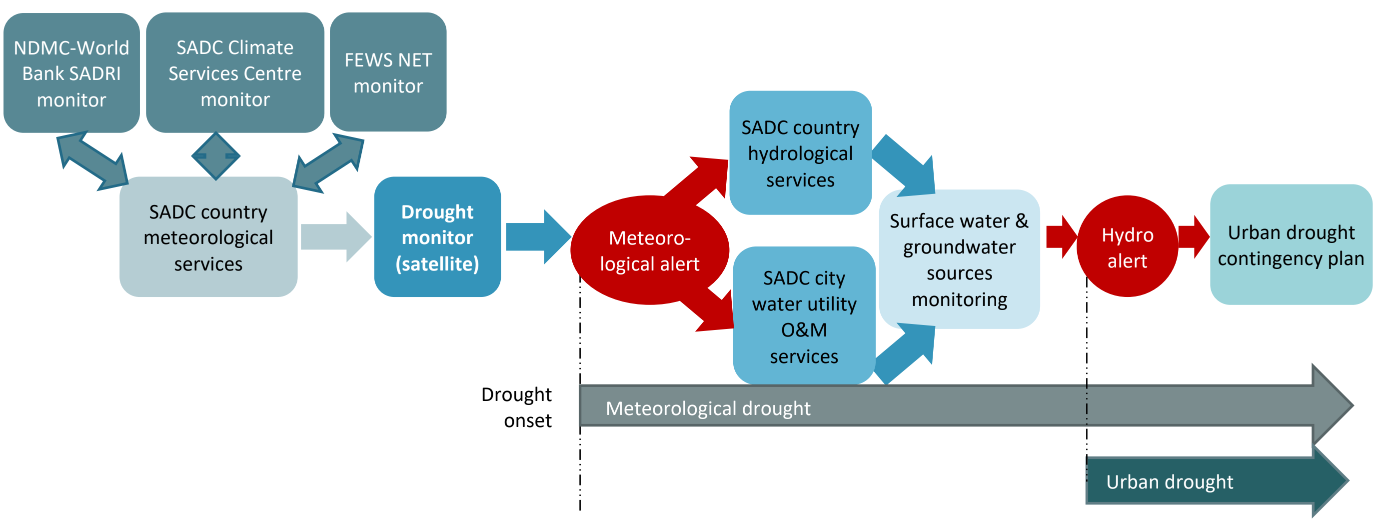
Standardized Precipitation Index, the WMO-recommended standard. Secondly, a remote sensing product is applied to analyze drought impacts on vegetation and crops (using the Drought Severity and Monthly Standardized Difference Vegetation Index) (Group on Earth Observations n.d.).

- The United States Geological Survey's Famine Early Warning Systems Network (FEWS NET) provides access to geospatial data, satellite images, and derived data products in support of FEWS NET drought monitoring efforts across the world. The portal is provided by the FEWS NET Project, part of the Early Warning Focus Area at the United States Geological Survey Earth Resources Observation and Science Center. Available tools include the interactive web-based mapping software Early Warning eXplorer, which allows users to visualize continental-scale rainfall estimate, land surface temperature, Soil Moisture Index, and Normalized Difference Vegetation Index data and anomalies at various time steps and review time series analysis.

[a] The four indicators are: (1) Land Surface Temperature anomaly (LSTa)—for details, see the US Geological Survey website at https://lpdaac.usgs.gov/products/mod11c3v006; (2) Normalized Difference Vegetation Index anomaly (NDVIa)—for details, see the US Geological Survey website at https://lpdaac.usgs.gov/products/mod13c2v006; (3) Standardized Precipitation Index (SPI)—for details, see the Climate Hazards Center website at https://www.chc.ucsb.edu/data/chirps; and (4) Root Zone Soil Moisture anomaly (RZNSMa)—for details, see the NASA Goddard Earth Sciences Data and Information Services Center website at https://disc.gsfc.nasa.gov/datasets/FLDAS_NOAH01_C_GL_M_001/summary.

Capacity building to develop relevant urban drought monitoring and early warning frameworks would greatly benefit SADC cities. Urban drought monitoring and early warning systems should leverage existing drought monitoring capabilities and tools, such as global drought monitors, coupled with hydrometeorological data (dam, stream, and piezometric measurements) and models (Figure 6). Both Madagascar and South Africa issue specific urban drought bulletins and warnings. South Africa bases its bulletins on data from the Standardized Precipitation Index, Vegetation Condition Index, and Temperature Condition Index, as well as national dam levels. The United Nations Children's Fund uses groundwater elevation data to issue drought bulletins. Most SADC countries develop traditional forecasts based on precipitation and temperature and some issue agricultural bulletins based on the Normalized Difference Vegetation Index.

Figure 6 Recommended Urban Drought Monitoring and Early Warning Framework for SADC Countries



Source: Original figure for this publication.
Note: NDMC: National Drought Mitigation Center; SADRI: Southern Africa Drought Resilience Initiative; SADC: Southern African Development Community; FEWS NET: Famine Early Warning Systems Network; O&M: operation and maintenance.

Pillar 2: Impact and Vulnerability (Risk) Assessment

To manage drought risks effectively, it is important to understand the likely impacts and to identify who and what is at risk, and why. Assessing risk and vulnerability before droughts occur allows decision-makers and communities to devise measures that prevent or reduce the worst impacts. Assessing vulnerability to drought involves prediction of the likely effects on the economy and society of a drought of a certain severity and extent.

The vulnerability profile is a cornerstone of drought risk reduction planning (UNDRR 2009). The risk associated with drought for any region or group is a product of exposure to the natural hazard and vulnerability to the event. Drought by itself does not trigger an emergency; whether or not it causes relevant impacts depends on its effect on local people, communities, and society, and this, in turn, depends on their vulnerability to the stress caused by the drought. The observable damage of droughts can be altered by the actions of society and, by adequately assessing risk and vulnerability, quantitative predictions of the cost of droughts can be made (UNCCD 2019a). Progress toward reducing or modifying vulnerability factors could then be measured and a clear economic case presented for such interventions.

Impact and vulnerability assessments aim to inform appropriate drought mitigation, preparedness, and response (pillar 3). Understanding the multifaceted nature of exposure and vulnerability is a prerequisite for designing and implementing effective drought risk management strategies. Such strategies include policy recommendations to reduce urban drought vulnerability, enhance adaptive capacity, and reduce underlying disaster risk drivers, and resilient investments to mitigate risk and ensure uninterrupted service provision. Urban drought impact and vulnerability assessment aims to improve understanding of both the natural and human processes associated with urban droughts. Comprehensive or simplified urban drought impact and vulnerability assessment is highly dependent on available, systematic, and reliable data sources (appendix A).

Urban droughts can have various types of impacts affecting citizens, businesses, and industries. Box 5 lists how the increasing frequency of droughts and more erratic nature of rains in many countries—combined with underlying economic, environmental, and social vulnerabilities—result in greater impacts for at-risk populations (World Bank 2019).

Box 5 Examples of Economic, Environmental, and Social Impacts of Urban Droughts

Economic impacts include:	Environmental impacts include:	Social impacts include:
• Direct and indirect losses in production and profits (for businesses/industry) • Unemployment • Tourism losses • Revenue losses for government • Increased cost of transporting water • Additional costs to rehabilitate water sources or generate new water sources • Welfare losses due to water demand constraints • Reduced economic development	• Damage due to increased groundwater depletion and land subsidence • Reduced levels of bodies of water • Deterioration in water quality • Loss of biodiversity	• Mental and physical stress • Waterborne diseases • Increased health issues • Loss of human life • Public safety issues • Increased conflict • Alteration of recreational activities • Public dissatisfaction • Inequity in drought impacts by socioeconomic group, age, gender, and disability status • Reduced quality of life

The impacts of a drought differ according to city sector and drought phase (Szalińska, Otop, and Tokarczyk 2018). Studies of drought vulnerability focused on the urban scale will explicitly provide decision-makers with the theoretical basis to reduce urban drought vulnerability and mitigate urban droughts that do occur (Wang et al. 2019). Reducing urban drought risk and vulnerability requires coherent actions from both city and water managers—that is, with both performing their own roles but collaboratively, as part of a supportive intergovernmental or interdepartmental system (Szalińska, Otop, and Tokarczyk 2018).

Water management systems are particularly threatened by exponential population growth, and rapid and mass urbanization; an increase in both a city's population and its urban areas results in an increased demand for products and services (Szalińska, Otop, and Tokarczyk 2018). Africa's rapid pace of urbanization and related infrastructural inadequacies may result in higher vulnerability to urban droughts. Water shortages may result from the current and likely future climatic conditions and infrastructure limitations in terms of guaranteeing water availability and distribution (Bates et al. 2008; Hallegatte et al. 2017).

People living in slums are particularly vulnerable to urban drought as slums often lack an adequate water management facility and sustainable water supply and have less adaptive capacity and resilience to disasters (Bates et al. 2008; Zhang et al. 2019). In Africa, urbanization of people has not been accompanied by the urbanization of capital. Housing, infrastructure, and other capital investments are lacking, especially outside the city center (Lall, Henderson, and Venables 2017). The impact level of an urban drought will depend on both the magnitude of the shortage and the socioeconomic vulnerability of the exposed population and sectors, leading to the urban poor being disproportionately affected by the drought (Bates et al. 2008; Hallegatte et al. 2017). Box 6 highlights general considerations for the selection of appropriate indicators and indices to assess urban drought impacts and vulnerability.

Climate change impacts and disasters exacerbate existing inequalities and have a disproportionate impact on women and girls. Past disasters have shown that low-income women and those marginalized due to marital status, age, disability status, social stigma, or caste are especially disadvantaged. Socioeconomic, cultural, and gender inequalities, such as limited access to health care, education, and labor markets, are considered drivers of vulnerability. Poor people are faced with unequal opportunities to cope with shocks, being deprived from access to water services and having their needs inequitably ignored.

Women and children are disproportionately exposed to water insecurity related to extreme weather. Inequalities in urban water security are multidimensional and interconnected through the socioeconomic context (Grasham, Korzenevica, and Charles 2019). It has been broadly recognized that the adverse impacts of climate change continue to overly burden the poorest and the most vulnerable, especially poor women (UNDP 2016; UNEP et al. 2020). Gender norms and power dynamics shape both the impacts of extreme weather events on women and men of different backgrounds and their ability to cope (UNEP et al. 2020). Though some SADC countries have undertaken efforts to achieve gender equality, women continue to be widely excluded from political participation, decision-making processes, and educational and economic opportunities, and suffer higher levels of poverty and lower levels of literacy than men (Maunganidze, Greve, and Kurnoth 2021).

Box 6 Selecting Appropriate Indicators for Urban Drought Impact and Vulnerability Assessment

Vulnerability to drought is complex to assess and assessment outcomes will depend heavily on both the sectoral focus and geographic context of the assessment (Meza et al. 2019). Given their capacity to synthesize complex conditions and developments, indicators and indexes can be valuable tools for assessing urban drought impacts and vulnerability. Generally, vulnerability is assessed using a composite index that aggregates proxy indicators, thereby accounting for the various factors or aspects of vulnerability.

Vulnerability is more of a theoretical concept than an observable one, so methodologies for assessing vulnerability must be established to make the theoretical concept operational. Use of indicators constitutes one approach to making theoretical concepts operational (Hinkel 2011). As indicators serve the purpose of solving a problem, their potential can only be discussed adequately in light of the specific problem in question. The development of indicators involves three basic steps (Cap-Net UNDP 2020): (1) definition of the change that is to be measured (in other words, scoping the assessment); (2) selection of the indicating variables that best describe the change to be measured; and (3) aggregation of the indicating variables.

Indicators to assess urban drought vulnerability must address the root causes of the impacts that are or may be caused by urban drought. Water supply is influenced both by factors upon which water availability depends (for example, institutional capacity for water resources management, water storage capacity, diversification of water sources, international water treaties, and national allocation rules) as well as factors upon which water distribution depends (for example, production efficiency, technology, distribution systems, and institutional capacity of water utilities or water departments). The degree to which a society may be affected by a water shortage will depend, however, on population exposure and socioeconomic factors (for example, degree of urbanization—and urbanization trends—level of poverty, proportion of population living in slums, level of inequality). To receive support and be operational, indicators must satisfy a number of criteria (Cap-Net UNDP 2020; GIZ, Eurac Research, and UNU-EHS 2018):

1. **Relevance**: Indicators represent well the issue that needs to be addressed
2. **Simplicity:** Ease of comprehension by decision-makers and other users of the indicator/index, and potential for replication by third parties
3. **Affordability:** Data must be relatively easy to obtain and process, and accessible with reasonable efforts and resources; and (4) suitability for comparisons across countries and time.

To receive support and be operational, indicators must satisfy a number of criteria (Cap-Net UNDP 2020; GIZ, Eurac Research, and UNU-EHS 2018): (1) relevance: indicators represent well the issue that needs to be addressed; (2) simplicity: ease of comprehension by decision-makers and other users of the indicator/index, and potential for replication by third parties; (3) affordability: data must be relatively easy to obtain and process, and accessible with reasonable efforts and resources; and (4) suitability for comparisons across countries and time.

Pillar 3: Mitigation, Preparedness, and Response

The impact and vulnerability assessment informs the selection and prioritization of recommended mitigation or preparedness measures. The analysis identifies the weaknesses and gaps to be filled for each of the broad components: water availability, distribution systems, and population exposure and vulnerability. The spatial resolution and comprehensiveness of the impact and vulnerability assessment are key to understanding what measures are relevant for the water utility, city, or country.

Therefore, the appropriate urban drought mitigation, preparedness, and response measures aim to reduce impact and vulnerability based on the specific context of the water utility and city. The selection of measures includes the identification of appropriate triggers to phase in and phase out mitigation actions, particularly short-term actions, during drought onset and termination. It also involves the identification of national and local institutions, agencies, or organizations responsible for developing and implementing an urban drought risk management plan. Reducing the impacts of droughts involves both structural measures (that is, engineering projects) and nonstructural measures (that is, policies, public awareness, and a legal framework) for demand and supply sides.

Mitigation and preparedness measures can be subdivided into long-, medium-, and short-term options. Long-term measures are usually included in the development strategies of the concerned urban sectors; hence, revisiting these strategies to ensure their alignment with drought risk management is an important step when developing an urban drought risk management policy. Medium-term measures are typically implemented in a timely manner, as needed, before, during, and after a drought, based on triggers provided by drought early warning systems (pillar 1). Short-term emergency response measures, which are implemented if a severe urban drought occurs, will focus on responding to the basic needs of the affected population, while considering and contributing to long-term development. Ultimately, efforts to characterize a 'drought life cycle' are essential to improve the linkages between the stages of urban drought and the implementation of risk-informed mitigation, preparedness, and response actions.

Two groups of mitigation measures are recommended according to the risk and vulnerability identified (Box 7):
1. Necessary preventive measures to minimize drought impacts in advance.
2. Contingency (responsive) measures to reduce the impacts of an existing urban drought.

Box 7 Recommended Preventive and Responsive Urban Drought Mitigation Measures

Recommended preventive measures	Recommended responsive measures
Policy and institutional arrangements • Develop urban drought risk management policies and plans, establish institutional arrangements, and improve water governance • Enhance institutional water utility transformations and improve coordination with city managers and urban planners to reduce urban drought risk **Monitoring and early warning systems** • Develop or enhance the urban drought monitoring and early warning systems (urban drought monitoring networks, forecasting, and early warning capabilities) • Implement an impact-based urban drought forecasting framework (to forecast hazards and possible consequences) **Impact and vulnerability assessment** • Develop impact and vulnerability assessments considering present and future conditions (that is, climate change, urbanization trends and population growth, future water demand) to better inform mitigation, preparedness, and response • Improve knowledge of the main water sources, including water quality • Assess current conditions of water infrastructure and identify leaks to improve and increase coverage **Mitigation, preparedness, and response** • Design and construct drought-resilient infrastructure to improve water efficiency and availability (reservoirs) • Reduce non-revenue water • Diversify water sources and develop new water supply projects • Improve the efficiency and equity of water supply and use • Achieve a balance of long-term water use efficiency and drought resilience • Coordinate water shortage contingency planning and implementation • Build a flexible and comprehensive water supply system • Improve water suppliers' fiscal resilience and drought risk financing instruments • Improve social awareness of urban drought and increase social participation in implementation of mitigation, preparedness, and response measures	**Monitoring and early warning systems** • Monitor and alert the progress of urban drought (using existing monitoring networks, forecasting, and early warning capabilities) and communicate this knowledge on a regular basis at all levels • Develop impact-based forecasts and recommend appropriate mitigation and early action to reduce urban drought impacts **Impact and vulnerability assessment** • Update the impact and vulnerability assessments considering the effects of the response measures on vulnerability indicators • Develop impact assessments to identify vulnerable populations and stakeholder sectors and to assess the root causes of impacts **Mitigation, preparedness, and response** • Coordinate the water shortage contingency plan and its implementation • Select appropriate water allocation methods for different users • Balance water uses (agricultural and human consumption) • Reduce non-revenue water • Improve the efficiency and equity of water supply and use • Implement ready water supply sources, projects, or measures (water trucks, water tanks, and so on) • Adopt demand reduction programs that include voluntary and mandatory restrictions, considering possible direct and indirect impacts (restrictions may lead to large welfare losses) • Apply water suppliers' fiscal resilience and drought risk financing instruments • Implement a communication strategy to enhance the social awareness of urban drought and to organize social participation in implementation of mitigation, preparedness, and response measures

California's *Urban Drought Guidebook* provides relevant guidelines for urban drought risk management and contingency planning at the urban level. It provides a 7-step process to address water shortages caused by droughts (State of California 2008), and its principles are equivalent to those of the 10-step (Integrated Drought Management Programme) or 8-step (Drought Initiative) processes that are more focused on developing a national drought framework. The *Urban Drought Guidebook* contains a water shortage contingency planning checklist, which gives an overview of the entire planning cycle to help keep track of tasks, roles, and responsibilities (appendix B). Tasks are not necessarily in the order that a particular water supplier will follow, and some tasks can be carried out simultaneously. California released a new *Water Supply Strategy: Adapting to a Hotter, Drier Future* which (August 2022) which uses the concepts of the Guidebook for improving water conservation to stretch water supply and enable water suppliers to become more resilient to current and future droughts. This is to be supported by financing and subsidies in view of the current drought conditions in the state and in the Colorado River basin, where an important part of the water supply for human consumption comes from.

Even in upper-middle- and high-income countries that currently suffer no lack of water access, it is likely that ever stricter water policy would be introduced and/or water rationed should 'megadroughts' occur in future (Kallis 2008). Drought mitigation measures are mostly concerned with reducing demand for water, focusing on the various types of households, water types, water-related appliances, and relevant policies, and are less dedicated to the many options around the expansion of waterworks to increase water supply. One major asset that SADC cities do have in common is reasonably good knowledge (data and information) of their water utilities, supply systems, and end clients, as well as direct communication and community engagement, an established legal framework and protocols, and internet connectivity—all of which allows the cities to implement mitigation measures in a timely manner (Figure 7) (Box 8).

The measures taken and considered in drought preparedness and mitigation plans can be grouped as follows:

- Updating of appropriate policies and legal instruments
- Reduction in water demand (water conservation)
- Increase in water supply, plus diversification of sources (including to remove redundant systems)
- Additional communication
- Educational measures and social participation.

Figure 7 summarizes the advancements and gaps in urban drought risk management for the SADC region.

Box 8 Considerations of the SADC Context in Defining Supply- and Demand-Side Mitigation Measures

The supply and demand-side measures (see Box 7 – mitigation, preparedness, and response section) need to consider the features of the SADC context. The governance (transboundary surface and groundwater), as well as the water quantity and quality for the supply-side are relevant topics. As regards of the demand-side the unplanned growth and the reliability of the water supply services are crucial themes to consider:

Supply-side measures:

- The 12 mainland African states in the Southern African Development Community (SADC) are linked by 21 river basins that cross international political boundaries. Fifteen of the basins are considered most relevant to the risk of socioeconomic drought, and only six basins are covered by state agreements to share water through the principles of cooperation. Interbasin and even intrabasin challenges need to be considered when selecting supply-side measures (Eslamian and Eslamian 2017). Therefore, the selection of supply-side measures must consider water governance as well as availability.
- The 12 mainland African states of the SADC share 22 known transboundary aquifer systems. Groundwater in the region is a vital resource, often used by rural communities and peri-urban or informal settlements as their only reliable source of drinking water (Turton 2010).
- Africa has the lowest conversion ratio of mean annual precipitation to mean annual runoff of any continent in the world, which poses a fundamental challenge to development. Both surface water pollution, caused by industrial and municipal wastewater discharges, and the poor quality of groundwater in some places exacerbate the scenario of cities having insufficient water availability to cope with urban drought (IGRAC 2013; Turton 2010).
- Many cities, like Windhoek, have used groundwater as a supply measure (local source) with ground water recharge or direct potable use (blended treated wastewater with groundwater) to increase the potential.

Demand-side measures:

- The rapid pace and pattern of urbanization in Africa has led to cities that are overcrowded owing to the unplanned growth of informal settlements (slums). The same cities are isolated, as can be seen from satellite images that show mixed land use and localized economic activities. As a result, these cities are costly to run and lack sufficient infrastructure connectivity and public services provision, including water supply and sanitation (Lall, Henderson, and Venables 2017).
- The housing pattern in cities follows no urban development plan, making it difficult to identify types of water users and to control demand for water (SADC 2008).
- Even for those cities with reasonable water supply and sewerage coverage, the supply of water is sometimes unpredictable and limited to a few hours per day owing to poorly operated and maintained infrastructure, and sewage is not disposed of safely (SADC 2008; Turton et al. 2006).
- Due to the continuous urban drought events and water supply reductions the water users, like in Bulawayo, have changed its behavior to conserve and use water more efficiently.

Figure 7 Urban Drought Risk Management: Regional Overview

Monitoring and Early Warning Systems

- Southern African Development Community (SADC) cities lack appropriate monitoring and early warning systems for urban drought.
- Most water utilities rely on dam level monitoring, and response measures begin after the drought event has begun and has been identified.
- Several drought monitors, which primarily use remote sensing information, have been developed for the region.
- An urban drought monitoring framework that builds on global drought monitors coupled with hydrometeorological data (dam and streamflow measurements) is recommended.

Impact and Vulnerability Assessment

- While many SADC countries have performed or even regularly conduct drought impact and vulnerability assessments, appropriate urban drought impact and vulnerability assessments have not yet been developed for SADC cities.
- The rapid pace of urbanization, economic disparity, inequity, high water stress, and limited capacities and infrastructure to guarantee water availability and distribution are common elements of urban drought vulnerability in the SADC.
- Impact and vulnerability assessments should aim to inform appropriate mitigation, preparedness, and response.

Mitigation, Preparedness, and Response

- Systems for urban drought mitigation, preparedness, and response are limited in most SADC cities.
- Deficient urban drought early warning systems and lack of appropriate urban drought impact and vulnerability assessments lead to untimely and inefficient response measures.
- Lack of timely and preplanned, cost-efficient mitigation, preparedness, and response measures, and overall reactive strategies, result in higher welfare losses and greater economic, social, and development constraints.
- Increased capacities, and water and disaster risk governance are needed to improve urban drought mitigation, preparedness, and response.

Source: Original figure for this publication.

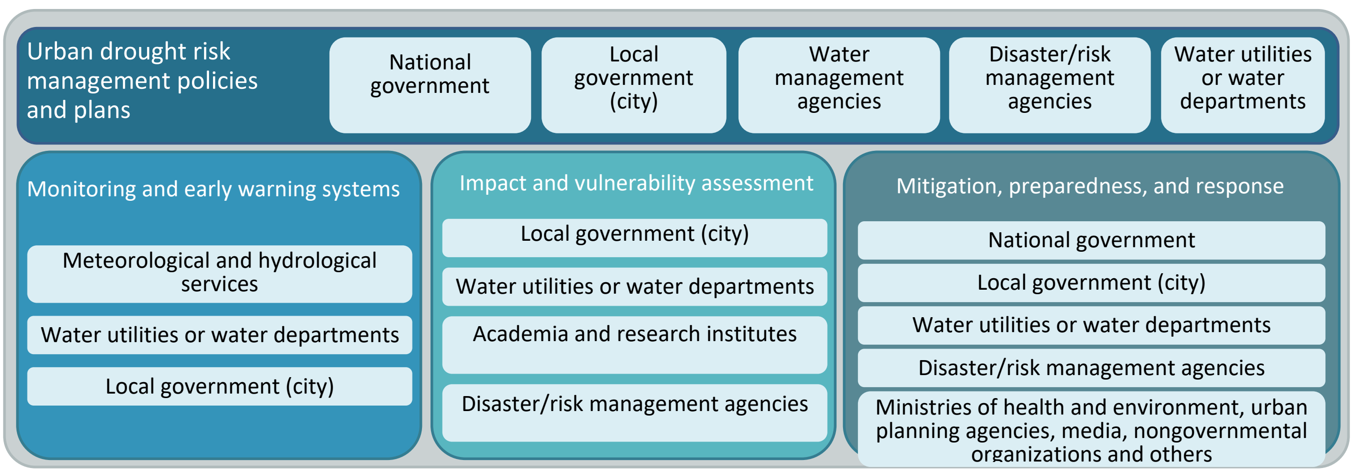
Governance

To increase urban drought resilience, the governance system for urban water services needs to be strengthened. Coordination mechanisms at different levels of government and across agencies need to be strengthened. Urban drought risk management is tightly linked to work in the areas of urbanization, water resources, and disaster risk management. Mainstreaming the concept of urban drought risk management through ongoing or future projects in these major areas in the SADC will generate and enhance climate resilience in the region’s cities and water utilities (Figure 8).

For urban drought risk management policy implementation, water agencies at the national level are the natural leadership.[10] The capabilities of national meteorological and hydrological services across the SADC could be strengthened to develop comprehensive urban drought monitoring and early warning systems, defining clear roles and responsibilities for information management, early warning, and early action. Most national water agencies already have a department of water affairs that can take the lead in the technical aspects of drought monitoring and early warning. These departments also typically include a hydrology section or division responsible for providing reservoir and groundwater information.

Implementing effective urban drought risk management calls for the strengthening of capacities at all levels. The water utilities of SADC capital cities have diverse institutional arrangements and differ in their capacity to implement mitigation measures (preventive and responsive). Some water utilities are decentralized, but others are linked to the city management (as water departments) or are nationally operated water utilities. The biggest challenge for all water utilities (and for national and city institutions or departments) remains the need for sufficient financial and technical resources, the development of urban drought risk management capacity at all levels, and proper coordination mechanisms between different spheres of government. This includes building capacity not only in formal water management institutions (government) but also within civil society and at the community level, as water resources and drought risk management decision-making must take place at all these levels. In an engagement in August 2022 with water-stressed Nelson Mandela Bay in South Africa, the need for creating well run service providers was identified as foundational for a resilient water service – given that resilience is one part of a service providers business – whether it be water resource related or any other potential internal or external shock (Kingdom, 2022).

Figure 8 Governance of Urban Drought Risk Management



Source: Original figure for this publication.

Although there are similarities among SADC countries in terms of climate, hydrological conditions, and water governance arrangements, the region is in fact marked by large disparities in such factors. Developing more international water transfer schemes in the region—with the drier countries of the south relying more on water from the region's wetter northern countries, especially when severe droughts hit—could reduce urban drought vulnerability and enhance resilience. Such schemes come with a range of social, economic, environmental, and political implications, however, which could make their establishment and implementation complicated (Box 9).

[10] Some national water agencies are linked with agriculture, while others link with energy or natural resources management, and a minority of countries have a stand-alone water ministry.

Box 9 Regional Governance for Transboundary Waters

The 1944 Water Treaty between Mexico and the United States, concerning water distribution and allocation, introduced the concept of ‘extraordinary drought’ as an exceptional circumstance under which the full agreed volumes need not be allocated to one another. Even though the concept is not precisely defined, the two countries have managed to agree, through the signature of minutes (legally binding implementing agreements that stem from the interpretation of the Treaty), on how and when a reduction (shortage) in allocation is required. Minutes 319, 323, and 325 have proven that it is desirable to agree on shared waters and ensure binational cooperation with mitigation, preparedness, and response measures before, during, and after an extraordinary drought affects cities and the relationship between the two countries.

European Union and Jordanian case studies recommend promotion of and support for an efficient system of gathering, monitoring, and sharing drought information related to all affected sectors. This can be achieved through coordination and facilitation of the implementation of bilateral and multilateral environmental agreements, conventions, treaties, or declarations concerning transboundary basins (Al Adaileh et al. 2019).

Many African cities rely on shared water sources in transboundary river basins and aquifers. Five of the Southern African Development Community (SADC) states have water resources dependency ratios of over 50 percent—that is, they rely on water generated beyond their borders to supply more than half of their total stock of water resources. This links the future of basin states with downstream impacts on water quantity or quality or flow patterns (Malzbender and Earle 2007). Lack of international agreements to enable an even water distribution can result in further reductions in supply in the event of urban droughts.

Some Sub-Saharan African countries have water agreements but not all river basins and countries are covered by clear water distribution rules in case of drought. The SADC Protocol on Shared Watercourses—the legal instrument governing transboundary water resources management in the region—is crucial as “a framework that contains the accepted key elements of international water law and makes transboundary water resources management mandatory in the SADC region” (Malzbender and Earle 2007, p. 15).

Case Studies

Development of the Urban Drought Risk Management Framework (UDRMF) was informed by case studies on urban drought risk and urban drought risk management at the city and water utility level. The case studies were designed to collect and analyze information on: (1) urban drought monitoring and early warning systems; (2) urban drought impact and vulnerability assessment; (3) urban drought mitigation, preparedness, and response plans and practices; (4) governance, policies, and institutions for urban drought risk management; (5) lessons learned from urban drought events; and (6) challenges and means for short- and long-term urban drought risk reduction and resilient development.

Engagement was established with water utilities or water departments, national water resources management agencies, disaster/risk management agencies, and city managers. Semi-structured interviews with predefined questionnaires were conducted to collect key information, understand the unique context and the current and future challenges of the various cities and water utilities, and document good and bad experiences in urban drought risk management. Findings enabled the identification of gaps to be bridged, as well as short- and long-term measures that need to be implemented to improve the urban drought risk management (three-pillar approach) and disaster risk resilience of the cities.

Dar es Salaam, Tanzania: Becoming a Megacity, Leading to Surface Water Deficits

- With a population estimated at over 7 million, Dar es Salaam is the fifth largest city in Africa today, and it is expected to become a megacity of more than 10 million by 2030 (Todd et al. 2019).
- 70 percent of the city is unplanned, largely in the form of informal settlements (World Bank Group 2017).
- Dar es Salaam is forecast to have one of the greatest surface water deficits in the world (Flörke, Schneider, and McDonald 2018).
- Urban water demand is expected to increase by 80 percent by 2050, while climate change will alter the timing and distribution of water (Flörke, Schneider, and McDonald 2018).

Gaborone, Botswana: Sustainable Financing and Resilient Infrastructure Investments Required to Build Gaborone's Water Resilience

- Gaborone is vulnerable to droughts, which are compounded by urban growth and poor infrastructure and planning and water demand management (Ziervogel 2019).
- The 2015/16 drought in Botswana heavily strained water supply in Gaborone. The government implemented the North South Carrier Scheme infrastructure project to transfer water from the Northern region to Gaborone Dam.
- The water utility has opted for public-private partnerships to navigate water financing needs, but a water resilience investment plan is required to address financing gaps for enhancing Gaborone's water security.

Toliara, Madagascar: Climate-driven Internal Migration Puts Increasing Pressure on the Existing Aging and Inefficient Water Infrastructure

- Madagascar is ranked as 'highly vulnerable' and is poorly prepared to address climate-related impacts.
- Toliara is one of the preferred destinations for migrants seeking refuge from the persistent droughts in the southern part of the country. Mass migration in recent years has led to the proliferation of urban slums and increased pressure on the already limited urban water infrastructure (USAID 2018).
- In a context of water deficiency, the population uses various alternative resources to meet its drinking water needs, including untreated water taken from wells or from the Fiherenana River.

Blantyre, Malawi: Inadequate Water Infrastructure and Governance, Leading to Unmet Water Demand and High Operating Costs

- While the availability of water resources in Malawi is considered satisfactory, per capita water availability is declining owing to population growth and catchment degradation (World Bank 2019).
- Blantyre is Malawi's main commercial city and hosts most of the private sector headquarters in the country (Mawenda, Watanabe, and Avtar 2020).
- The water demand shortfall was 50 percent in 2021 and, in the absence of interventions, is likely to rise to 80 percent by 2052 (National Planning Commission 2021).
- Major challenges for the water utility include rising operating costs, increasing water demand due to population growth, aging infrastructure leading to high system losses, inadequate collection of revenue, and high energy demand.

Lilongwe, Malawi: Rapid Population Growth, Environmental Degradation, and Pollution Put Strain on Water Services

- Lilongwe, Malawi's capital and largest city, is witnessing a high rate of urbanization, accelerated by the relocation of all government head offices from Blantyre to Lilongwe in 2005.
- Rapid population growth, weak legal frameworks, and limited resources have led to environmental degradation, pollution, deforestation, and uncontrolled development on fragile land (UN-Habitat 2011).
- Competing water uses: the economy of the city (and country) relies on the agricultural and commercial sectors.
- The water utility is under strain in terms of capacity, is not financially sustainable, and lacks the required skills to manage droughts (LWB 2020).

Bulawayo, Zimbabwe: Economic Development and Welfare Stymied by Water Rationing

- Bulawayo is the second largest city in Zimbabwe, with a population of nearly 1 million.
- Rapid and unplanned urban growth is resulting in inadequate services and infrastructure and high levels of pollution.
- Bulawayo has good potential for economic development but this has been stymied by a lack of sufficient water.
- Dam yield is already insufficient to meet demand, a situation that is expected to worsen in future as demand grows.
- Additional surface water supply sources for Bulawayo have been identified but not developed further.
- Drought-related water shortages have prevailed over the years, leading to a perpetual water rationing regime, with associated losses for economic development and welfare.

Windhoek, Namibia: Building Urban Drought Resilience in a Water-scarce Context Through Urban Water Management

- Namibia is the most arid country in Sub-Saharan Africa, with a generally hot and dry climate marked by sparse and erratic rainfall. The country has perennial rivers only on its very northern and very southern borders, which are 750 kilometers and 900 kilometers from Windhoek respectively.
- Windhoek is the capital of Namibia and a leading pioneer in integrating the use of various water resources.
- The city has introduced a comprehensive water management strategy, as well as very strict urban planning measures aimed at protecting and conserving water resources.

Cape Town, South Africa: Setting the Path Toward Urban Drought Risk Management to Avoid Approaching Another 'Day Zero'

- South Africa is one of the 30 driest countries in the world (Walz et al. 2018).
- From 2014 to 2018, South Africa experienced persistent drought conditions, which intensified into the worst drought recorded in the Southern African Development Community region in a century and a true emergency for the city of Cape Town. The drought led to critically low water levels, putting the water supply chain under extreme duress (Vogt et al. 2018). Significant restrictions were imposed on agricultural and domestic water use.
- Cape Town has developed a water strategy that includes diversification of the city's water sources to include more groundwater supplies; reuse and desalination; and improvements in water storage augmentation and management.

Relevant lessons from the case studies are highlighted in Box 10, and key city lessons in Box 11.

Box 10 Cross-cutting Lessons Learned from SADC Case Studies to Improve Urban Drought Risk Management

1. Demand reduction approaches that include mandatory restrictions can lead to large welfare losses and long-term economic and social impacts. Water shortages have the potential to exaggerate and exacerbate historical divisions, especially considering preexisting inequality in access to water. For example:
   - The impact of water shortages is disproportionately felt by the urban poor.
   - Restrictions that limit water consumption can also impact on other sectors, and the city and country economies.
   - Water shortages have the potential to exaggerate and exacerbate historical divisions.
   - Prioritizing human consumption of water is not always possible in a low- and lower-middle-income country context. Balancing competing water uses—such as domestic use and use by the industrial, commercial, and agricultural sectors—is sometimes necessary to manage or mitigate economic losses that can lead to high social impacts.
   - Demand reduction measures challenge the fiscal stability and commercial viability of water utilities; financial models must allow and account for reduced direct income. Reduced water consumption posed a serious loss of income for the City of Cape Town during the 2015–18 drought, leading to a shortfall of close to US$14 million.

2. Crisis management has been ineffective in reducing urban drought vulnerability, often causing dependence on external assistance and aid, due to urban population growth, infrastructure decay, low fiscal and institutional capacity, and poor water governance.

3. Water supply in the Southern African Development Community is highly susceptible to power outages, which are common across the region, highlighting the importance of the urban drought–electricity nexus.

4. Early warning systems are constrained by limited data, which compromises drought forecasting. These systems need to be enhanced by: (1) improving drought monitoring, forecasting, and warning capabilities, including for potential impacts; (2) improving hydrological monitoring and forecasting; (3) ensuring accurate monitoring of dam levels; (4) improving communication strategies; and (5) linking urban drought contingency plans and practices for both demand reduction and supply augmentation.

5. Improving urban drought risk and vulnerability knowledge is essential to better inform mitigation, preparedness, and response. Assessment of urban drought impacts across different sectors and population groups allows for targeted mitigation and response

actions and effective recovery, thereby reducing long-term socioeconomic impacts and building disaster resilience. Assessing the linkages between drought, poverty, and urbanization is key for effective development planning.

6. Appropriate data and decision support systems are needed for effective mitigation, preparedness, and response actions. Context-specific and drought phase-dependent mitigation, preparedness, and response measures need to be established to mitigate impacts and reduce losses and damage, while addressing the root causes of current and likely future impacts.
7. Clear, credible, multimodal communication about drought situations and responses is a precondition for public participation and support, and for promotion and education about water savings, water storage levels, incentives to reduce water use, requirements and expectations about drought, and planned supply options.
8. Water governance is the cornerstone of effective urban drought risk management. It must include systems and relationships across spheres and agencies of national and sub-national government, decentralized utilities and/or municipal departments and entities, stakeholders and communities at risk. Institutional arrangements and a supporting legal framework hinge on clear roles and coordination mechanisms at all levels of government, and among climate, water, disaster risk, and urban decision-makers.
9. In most cities, water infrastructure is inadequate to meet the current and likely future demand for water. Resilient investments in water infrastructure are needed, including for diversification of water sources and improvement of distribution networks (and appropriate energy systems). Investment planning must consider climate trends and scenarios (climate risk assessment), population growth, and urbanization trends (also considering likely internal migration projections) and their combined impacts on water resource availability and supply.
10. Water infrastructure investments need to be complemented by policy reform to enhance water governance and urban drought risk knowledge, develop urban drought policies and plans, improve land use planning and urban development strategies, define intervention policies for slums and poverty/inequity reduction strategies, improve urban drought risk management capacities and fiscal resilience of water utilities and cities, and enable drought risk financing instruments.
11. Implementing a water-sensitive, resilient, and equitable city vision of drought resilience, built at the highest levels of decision-making for the city and the public must also be sensitized to enhance awareness of necessary measures.

While the above are cross-cutting messages, Box 11 provide a few practical lessons from specific cities.

Box 11 City-specific practical lessons

Dar es Salaam, Tanzania
The fast pace of urbanization and increased infrastructural inequalities has lead to higher vulnerability to urban droughts. 70% of Dar es Salaam is unplanned, largely in the form of informal settlements. People living in slums are particularly vulnerable to urban drought as these areas often lack adequate water management facilities and sustainable water supply, devoid of adaptive capacity and resilience to deal with disasters. Assessing the conditions that make city and its population susceptible to suffer adverse effects when impacted by droughts (vulnerability factors) need to be identified. Dar es Salaam is forecasted to have one of the greatest surface water deficits. The city is highly dependent on surface water, as a supplement, also draws on boreholes to a lesser extent. Surface water offtakes are susceptible to the variable rainfall patterns and droughts. Diversification of the water sources is a desirable supply-side measure reducing the vulnerability caused by climate uncertainty and up stream legal and illegal users.

Gaborone, Botswana
The gaps in coordination and information flow between various agencies and ministries showed the importance of a continuous exchange between and among related stakeholders for efficient drought preparedness. With multiple policies, committees, and departments playing a role in drought management, clear coordination by a leading entity is required to ensure alignment of roles, responsibilities, and clear actions to be taken when droughts strike the city.

Sustainable financing and resilient infrastructure investment is required for building Gaborone's water resilience. Gaorone has focused its efforts on Public-Private Partnerships (PPP's) to navigate short-medium term water financing needs, The PPP's in this context can lead to regulatory and procurement challenges. The Urban Drought Management Strategy could be complemented by the development of a water resilience investment plan, which responds to the financial gaps and needs within Gaborone

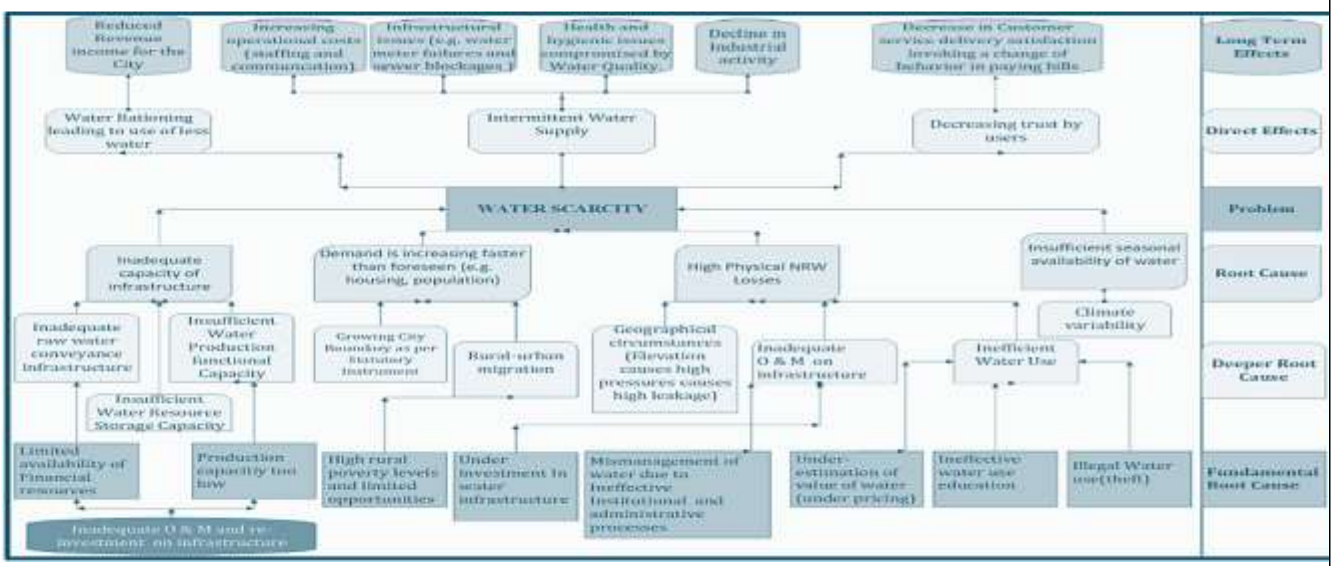
Toliara, Madagascar
The UNICEF groundwater early warning system (GEWS) to monitor groundwater availability and quality to improve drought emergency responses in southern regions (Toliara city included) has proven to be useful but unsustainable over time due to limited project funds. It needs to secure funding to secure its operation before handing it over the Madagascar autohorities. The response capacity relies heavily on humanitarian aid, which has not reduced the underlying vulnerability. Building adaptive capacity may involve both incremental and transformative (often post- disaster) change, creating more resilient development by addressing basic service

deficits, reducing poverty, managing risk, aligning policies and incentives to resilience objectives, and working with the private sector to share the financial and technical burden of these efforts

Blantyre, Malawi
Blantyre case study highlights the urban drought and electricity nexus. Falling lake water levels and reduced river flows, which decrease the power production affect the water supply which is highly susceptible to power outages, as water needs to be pumped uphill through a 48-km pipeline to the city overcoming the elevation of 800 m, with additional booster stations necessary to distribute water throughout the hilly city terrain.

Lilongwe, Malawi
Lilongwe Water Board (LWB) has inadequate capacity to forecast drought reliabily. Knowledge, skills, and tools are urgently required for national and city institutions involved in drought monitoring and early warning systems to improve urban drought management. The LWB is developing a climate change strategy based on recent drought response experience (2015/2016), prioritizing improved monitoring and warning systems capacity, skills development, and reducing water wastage.

Bulawayo, Zimbabwe
Water rationing, tariffs, rainfall, population growth and gross domestic product are the main factors influencing water consumption in Bulawayo. Therefore water conservation has become a culture and way of life in Bulawayo with the council and citizens recognizing that water is a finite resource that needs to be conserved Urban Droughts have caused significant impacts to the industry sector, especially for those whose manufacturing processes rely on potable water. The Water Utility managed to stretch the limited water resources to balance access to water for domestic purposes and industrial use to keep economic activity



Windhoek, Namibia
Efforts to introduce wastewater recycling for direct potable water supply have failed in many cities because of the perception that reclaiming drinking water from municipal effluent is generally unacceptable to the public. However, Winhoek's 40 years of experience shows that with persistent, well-designed, and targeted communication to the public, this perception can be changed. Windhoek has made significant advancements in building drought resilience in a water scarce context by applying integrated drought and water management, city water management plans, both demand reduction and supply augmentation, and robust efficiency measures.

Cape Town, South Africa
Lack of appropriate data and information for decision support on drought conditions challenged mitigation and response actions. At the beginning of the drought, data on water supply and the status of the catchment was not well understood or communicated, which made it difficult to pull information together clearly in one place. Another challenge was communicating the drought to citizens, explaining the phenomena, its severity, and what the city was doing in response. Better communication around the technical nature of these decisions has helped citizens to understand the importance of restrictions, and the reasons behind the City's interventions.

Monitoring and Evaluation

The final step in the Urban Drought Risk Management Framework (UDRMF) planning process is the development and adoption of a detailed set of procedures to ensure adequate evaluation of drought assessment and response systems. The urban drought risk management plan is monitored, periodically evaluated, learned from, updated, and improved with the intention of ensuring the plan's continued suitability to water utility needs.[11]

To maximize the effectiveness of the system, two modes of evaluation must be in place:
1. An ongoing or operational evaluation program that considers how societal changes such as new technology, new research results, legislative action, or changes in political leadership may affect the system's operation.
2. A post-drought evaluation program that documents and critically analyzes the assessments, plans, and responses of the water utility, government, nongovernmental organizations, and others as appropriate, and implements recommendations to improve the system.

The first mode of evaluation is intended to review urban drought risk management planning as a dynamic process rather than a discrete event. Operational evaluation programs are necessary to help keep drought assessment and response systems current and responsive to the changing needs of society. Once an urban drought risk management plan is in place, it should be monitored routinely to ensure that societal changes that may affect water supply, demand, or regulatory practices are considered for incorporation (Wilhite 1991).

The scope of the operational evaluation program should cover at least four segments: impact, effectiveness, efficiency, and appropriateness (Figure 9). Water utilities can use the questions presented in the figure as a basis to select and develop program-specific evaluation system questions, indicators, and data collection tools that are consistent with this overall scope but tailored to the specific operational evaluation program.

Progress toward the desired outcomes in an urban drought risk management plan is best measured using two types of indicators:
1. High-level drought resilience indicators, to monitor overall patterns in drought resilience over the long term as the plan is implemented, and to refine the measures or support the development of new interventions.
2. Measures-level indicators, to track how each measure is contributing to the drought resilience outcomes.

A post-drought evaluation should be conducted or commissioned in response to each major drought event as soon as the drought has ended. Post-disaster assessment allows institutions to preserve and benefit from institutional memory that transcends changes in the political administration, changes in leadership, and the destruction of critical documentation of events and actions taken.

Post-drought evaluation should include an analysis of the physical aspects of the drought: its impacts on soil, groundwater, plants, and animals; its economic and social consequences; and the extent to which predrought

[11] *Monitoring*: Continuous and systematic observation of how the urban drought risk management plan is implemented, situational change in the problems that the plan is intended to address, and early indicators of outcomes. This is to ensure that urban drought risk management plans are on track to achieve their intended outcomes, and to support adaptive management and communicate progress. *Evaluation*: Evidence-based assessment of the appropriateness, effectiveness, efficiency, and impact of the urban drought risk management plan. This includes evaluating the delivery of urban drought risk management plans; their economic, environmental, and social outcomes (intended and unintended); and the potential contribution they could make to long-term urban drought resilience. *Learning*: The generation and sharing of insights and information across the UDRMF to improve urban drought risk management plan delivery and inform the design of future policies and plans to build urban drought resilience. This includes developing a shared understanding of urban drought resilience and identifying the factors that enable or constrain desired outcomes.

planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in postdrought recovery. Evaluations should not only focus on those situations in which coping mechanisms failed but also establish what has been learned from any successes. Provision must be made to implement the recommendations that emanate from the evaluation process. Drawing on evaluations of previous responses to severe drought is recommended as a planning aid to determine the relative effectiveness of various technical and relief actions. To ensure unbiased appraisals, water utilities or governments should place the responsibility for evaluating the response to urban drought in the hands of independent organizations, such as universities, nongovernmental organizations, or specialized agencies (UNEP 1992; Wilhite 1991) (Box 12)

Box 12 Barcelona Urban Drought 2007–08

The Barcelona´s 2007–08 drought was one of the most severe urban drought events in history. It is an illustrative case study on the economic costs of urban drought due to the availability of economic information on both the drought's impacts and the mitigation measures taken. The information includes the direct costs of the affected sectors, indirect costs affecting the Catalan economy, and non-market welfare losses because of environmental quality worsening and the restrictions on domestic water supply. Total losses are estimated at 1,661 million euros, almost 1 percent of Catalonia's gross domestic product.

Both demand and supply mitigation measures were implemented to address the drought. Supply-side measures included groundwater pumping and desalination. Demand reduction actions included the watering of gardens reduction, ornamental fountains with no supply, cleaning of streets with drinkable water banned, filling of private swimming pools regulation, and contingency plans for municipalities development. A campaign to encourage water conservation was launched. In 2010, within a new management and financing model for water in Catalonia based on public participation. Water-saving devices were also distributed among the population to reduce domestic consumption.

Table B12.1 summarizes the total annualized costs of the drought and provides a preliminary idea of the cost efficiency ratio of the demand- and supply-side measures for which information was available. Infrastructure interventions are cost-efficient and imply an increase in adaptative capacity to face water scarcity and drought. It can be noted that crisis management measures are far more costly, with demand reduction actions significantly more cost-efficient than supply augmentation measures, which typically involve the transport of water.

Table B12. 1 Annualized Cost of the Drought Event in Barcelona and Cost Efficiency Ratio of Some of the Implemented Measures

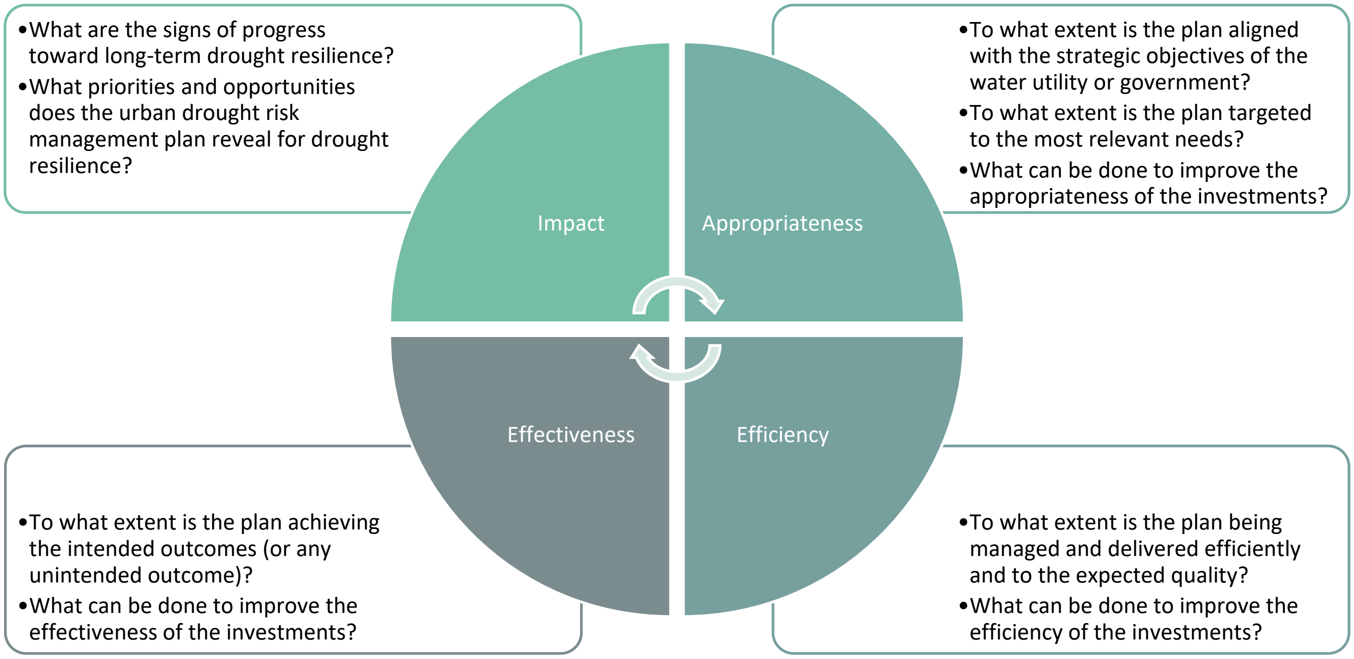
Item	€ (millions) per year
Cost of measures	**76.52**
Total value of losses	**1,584.15**
Water agency and suppliers' income losses	*18.67*
Direct losses affected economic sectors	*445.06*
Economy indirect losses	*358.47*
Non-market welfare losses[13]	*761.95*

Measure	Cost efficiency ratio (€/m^3)
Demand constraint (crisis management)	1.18[12]
Water transport by ship (crisis management)	**32.59**
Water transport by truck (crisis management)	2.3
Well recovery and groundwater supply (risk management)	**0.18**
Desalinated water supply (risk management)	0.48

Source: Martin-Ortega and Markandya (2009); Table from same report, page 25).

[12] The demand-side cost-efficiency ratio is calculated by relating the estimated welfare losses due to water restrictions on households for secondary uses of water (€594.19 million), plus the public expenditures in communication and awareness-raising campaigns (€3.65 million), to the total amount of water saved by the restriction measures (506 cubic hectometers), obtaining a ratio of €1.18 per cubic meter.
[13] The non-market welfare losses estimated for the water restrictions on households for secondary uses of water, and the social costs related to the worsening of the environmental conditions of the river basin due to water scarcity.

Figure 9 Scope of the Operational Evaluation Program



Source: Original figure for this publication.

Box 13 Postdrought Evaluation: Key Questions

The postdrought evaluation review team should ask the following questions:

- Was the urban drought risk management plan followed? If not, why not?
- Were the actions taken and (preventive) measures implemented effective in mitigating the impacts of the drought? Which actions and relief measures were effective, and which were not?
- Should the plan have included other actions or assistance measures?
- Did aid reach all groups in the stricken area? If not, why not? How were the target groups for aid identified?
- Were the measures timely in relation to the drought event period?
- Was it possible to correct errors in the plan during the emergency?
- What financial and human resources were allocated to the drought relief effort? Where did the resources come from and how were they controlled?
- How efficient was the logistical support and the available infrastructure? What obstacles (if any) were encountered that reduced the efficiency of the response?
- How effective was the coordination of response efforts between government, nongovernmental organizations, and other entities? How did this cooperation affect the flow of information or assistance?
- Was media coverage accurate and realistic in providing details of the drought event? What kinds of media were involved? What role did they play in the emergency?

Appendix A: Applying a Simplified Urban Drought Impact and Vulnerability Assessment

A simplified urban drought impact and vulnerability assessment can be conducted using the Impact and Vulnerability Assessment Workbook developed as part of the *Urban Drought Risk Management Toolkit for Task Team Leaders in the Southern African Development Community*. The results obtained from the application of the Excel Workbook aim to inform opportunities or requirements for mitigation measures, policy recommendations, and resilient investments.

Together, the Toolkit and Workbook offer guidance on the processes of recognizing factors that influence vulnerability, identifying and selecting proper indicators for risk components, and developing a composite index using the aggregation of proxy indicators, thereby accounting for the various factors or aspects of vulnerability.

Given their capacity to synthesize complex conditions and developments, indicators and indexes can be valuable tools for assessing urban drought impacts and vulnerability. To construct an urban drought vulnerability index for each of the main cities of the Southern African Development Community (SADC), three families of indicators are proposed, concerning: (1) water availability; (2) water distribution systems; and (3) population exposure and socioeconomic vulnerability. Users can select from a set the indicators that best represent the relevant aspects of vulnerability for the context and assign the relative importance of the chosen indicators using a relative importance scale.

The indicators are standardized to make the data comparable and eliminate the effect of dimension. Indicators are divided into positive and negative indexes, depending on the evaluation effect, whether positive or negative. For each indicator, the Workbook provides a description, explains its relevance, and gives example data sources.

For urban drought impact and vulnerability assessment, consideration of an indicator related to the number or percentage of people living in slums is recommended. Reliable data that meet the criteria (accessible and systematically recorded at city level) are crucial for a sound analysis. Particular attention should be given to this element since the urban population in most SADC countries relies on noncontrolled and highly climate-dependent water sources.

Appendix B: Water Shortage Contingency Planning Checklist

Water Shortage Contingency Planning Checklist

1 First steps
Designate a Water Shortage Response Team Leader
Designate a team member from each department/division
Set priorities
Identify potential supplemental water supply sources
Identify potential interconnections
Identify regional suppliers for potential cooperative actions
Establish a community advisory committee

2 Supply
Quantify worst-case supply (minimum) for next five or more years
Local surface water
Wholesale water
Groundwater
Recycled water
Other

3 Water quality
Project water quality changes by source
Identify water treatment devices necessary to use on degraded quality sources
Identify low-quality water sources and develop plan for blending

4 Demand
Quantify worst-case demand by season for next five or more years
Single family
Multifamily
Commercial
Industrial
Institutional
Landscape
Recycled
Agricultural
Wholesale
New connections

5 Supply and demand balance
Quantify yearly shortage for next five or more years

6 Increase supply
Project possible supplemental water supplies and carryover
Schedule well driller for new or rehabilitated wells
Plan to increase supplier efficiency
Meters
System losses
System pressure
System flushing
Supplier landscaping

7 Decrease demand
Determine minimum supply necessary to meet health and safety requirements
Plan public relations campaign and recommend customer actions for step 1
Adopt and publicize the water waste ordinance and time-of-day irrigation restrictions
Make non-potable water stations available for non-potable uses
Review pricing structure and rates by stage
Select water allocation method by customer class and stage
Adopt restriction enforcement rules and penalties
Selected stage- and customer-class demand reduction programs to help customers
Plan for catastrophes with cascading failures (50 percent supply shortage or more)

8 Complete draft water shortage contingency plan
Establish stage triggers based on priorities and quantifiable supply availability by source
Include carefully crafted flexibility to triggers
Identify lag-time and seasonal issues related to each demand reduction program
Establish structure and impacts of limited-number-of-days irrigation programs
Develop revenue plan to balance budget by stage
Develop customer appeal procedure
Establish monitoring program to track water production and use

9 Community involvement
Complete draft plan
Provide draft plan to community
Contact significantly affected customers (agriculture, green industry, tourism industry, and so on) and request input
Contact local suppliers and government agencies and request input
Hold at least three public meetings to receive comments on draft plan
Incorporate useful community suggestions into the draft plan
Adopt the finalized Water Shortage Contingency Plan

10 Supplier capabilities and resources
Establish required capabilities for billing, data tracking, and customer support
Identify required changes to existing computer systems
Make required computer system changes and test thoroughly
Prepare customer information brochures
Meter reading
Leak detection
Plumbing hardware recommendations and rebate programs
Customer assistance programs offered by supplier staff
Identify the need for new full- and part-time contract staff
Procure space for additional staff and increased customer visits
Develop media contacts
Identify and purchase water conservation devices for distribution to customers
Develop training program for staff
Develop training programs for affected businesses
Establish water waste and information hotline

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