City Drought Resilience Toolkit

Urban Drought Risk Management Toolkit for Task Team Leaders in the Southern African Development Community

SOUTHERN AFRICA
Drought Resilience Initiative
Cities

WORLD BANK GROUP
Water

CIWA

Plastic water storage tank. @Natalya Mateeva / Getty Images

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Executive Summary

There is much urgency for effective urban drought risk management in the SADC region, with countries, cities, and for water utilities addressing their current and likely future challenges. 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 benefits. These benefits 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 vulnerability and water scarcity are intensified by skewed development processes, rapid and unplanned urbanization, economic disparity, poor water management and water governance, and institutional inefficiency. Cities in Africa face converging challenges that heighten the risk of urban drought: rapid urbanization (that is unplanned and unprepared for, leading to slum growth) rising climate threats, and skyrocketing demand for increasingly constrained water resources, increasing strain on existing, often inefficient water infrastructure and resulting in disproportionate impacts on the urban poor. Urban droughts can lead to wide-ranging and cascading impacts and compounding risks, such as health risks, unemployment and food insecurity, migration, social and political instability, and conflict**.**

The Urban Drought Risk Management Framework (UDRMF) builds on international best practice, with a strong emphasis on integrated, proactive, comprehensive, and people-centered risk management. The Framework aims to mitigate and prepare for the current and likely future impacts of urban droughts, 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 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.

This approach can help mitigate urban drought risk and strengthen resilience by addressing multiple components of urban drought management, including urban and disaster risk management, climate change adaptation, and water management. As urban droughts are not merely natural hazards, the UDRMF is cognizant of 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 urban drought mitigation, preparedness, and response actions to address the root causes of current and future impacts and compounding risks. The assessment data should enhance communication and collaboration across sectors and levels of government.

The framework's three-pillar approach is centered around interconnected, multidisciplinary, and multi-institutional activities directed at 1) monitoring and early warning systems; (2) impact and vulnerability (risk) assessment; and (3) drought mitigation, preparedness, and response.

This toolkit thus provides a conceptual framework, guidelines, methodologies, tools, and data sources to assist task team leaders (TTLs) and task teams. Jointly this should help TTLs and teams in identifying and supporting necessary—and tailored—measures, investments, policy reforms, and analytical work needed to improve urban drought risk management and disaster resilience in the SADC region.

The Toolkit aims to strengthen and enhance cross-sectoral knowledge and understanding. Mainstreaming the concept through ongoing or future World Bank projects in these major areas in the SADC region will provide and enhance the climate resilience of water utilities and cities. Such a comprehensive investment portfolio of resilient measures linked to thorough drought policy enforcement is both viable and much needed in the region. It is **structured around six sections**: (1) a general overview and guide on how to use the Toolkit; (2) a conceptual framework on urban drought and its challenges in the SADC; (3) details of how to strengthen urban drought risk management policy development and legal, planning, and management frameworks; (4) an introduction to the guiding principles for integrated drought management practices, including urban drought monitoring and early warning systems, urban drought impact and vulnerability assessment, and mitigation, preparedness, and response; (5) discussion of the benefits of urban drought risk management; and (6) guiding principles for monitoring and evaluation. The final section summarizes key points and recommendations.

To further assist TTLs and task teams, a Workbook (Microsoft Excel) complements the Toolkit. The Workbook provides additional tools, data sources, and relevant case studies to help enhance urban drought monitoring and early warning systems; develop rapid urban drought impact and vulnerability assessments for the main cities; and identify and develop urban drought mitigation, preparedness, and response (policies, plans, and measures).

The UDRMF aims to improve understanding of the multifaceted nature of exposure and vulnerability, to inform the design and implementation of effective drought risk management strategies, including policy recommendations and resilient investments. Such strategies will help mitigate risk and ensure continued service provision, and may trigger positive economic, environmental, and social cobenefits.

The UDRMF is aligned with and aims to complement recent work developed by the World Bank.

Abbreviations

ESG	environmental, social, and governance
FEWS NET	Famine Early Warning System Network
GWP	Global Water Partnership
IDMP	Integrated Drought Management Programme
IWI	International Wealth Index
NDMC	National Drought Mitigation Center (University of Nebraska, United States)
NRW	non-revenue water
PRONACOSE	National Program against Drought (Programa Nacional contra la Sequía), Mexico
PMPMS	Drought Prevention and Mitigation Measures Programs (Programas de Medidas Preventivas y de Mitigación a la Sequía), Mexico
SADC	Southern African Development Community
SADRI	Southern Africa Drought Resilience Initiative
SHDI	Subnational Human Development Index
TTL	task team leader
UDRMF	Urban Drought Risk Management Framework
UNCCD	United Nations Convention to Combat Desertification
UNICEF	United Nations Children's Fund
VI	Vulnerability Index
WMO	World Meteorological Organization

1 Introduction

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 management will not only reduce losses and damages but can also trigger positive economic, environmental, and social benefits. These benefits include increased productivity and economic growth; improved access and reduced disruptions to essential services and reduced failures in public water supply; increased disaster resilience; reduced inequalities, poverty, health risks, social instability, and conflict; and the development of prosperous and resilient cities. Such proactive drought management requires strengthened and sustained coordination and governance, and long- and medium-term policy and development planning.

Droughts pose a complex hazard, with wide-ranging and cascading impacts. **Drought events affect agricultural production, public water supply, energy production, transportation, tourism, human health, biodiversity, and natural ecosystems, among other aspects**. Often such impacts evolve slowly and indirectly and can linger for long periods after a main drought incident. While the impacts result in severe economic losses, environmental damage, and human suffering, they are generally less visible than the impacts of other natural hazards (floods, earthquakes, and so on) that cause more immediate and structural damages that can be clearly linked to the hazard and quantified in economic terms. But the ultimate impacts of drought events are no less severe, and often cascade into a chain of consequences that can trigger secondary or indirect socioeconomic impacts and compounding risk at city, regional, and national scales—well beyond the origin and immediate location of the hazard—thereby increasing vulnerability and challenging coping capacity (UNDRR 2019). Analytical and institutional foundations are needed to catalyze national and regional investment in integrated drought resilience.

Most of Southern Africa's rapidly urbanizing cities experience water scarcity and droughts—and their frequency is increasing. This exacerbates the economic vulnerabilities of cities, curbing livelihoods, and reducing a city's ability to deal with crises such as COVID-19 and waterborne diseases, especially when the extent of the existing water supply and sanitation infrastructure lags behind population growth.

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, and with financial support from the Cooperation in International Waters in Africa partnership, the Southern Africa Drought Resilience Initiative (SADRI) aims to build the analytical and institutional foundations to catalyze national and regional investment in integrated drought resilience.[1]

The Urban Drought Risk Management Framework (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 interactions and feedback loops 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

[1] For an overview of the Cooperation in International Waters in Africa partnership, see the World Bank website at https://www.worldbank.org/en/programs/cooperation-in-international-waters-in-africa. For more details about SADRI, see the Africa Press news story at https://www.africa-press.net/tanzania/files/world-bank-launches-a-drought-resilience-initiative-in-support-of-sadc.

inclusion, fostering partnerships, and enhancing cross-sectoral coordination (mainly urbanization, disaster risk reduction, and water) at all levels to enhance coherence across climate and disaster risks, water management, land use, poverty reduction, and development policies.

The SADRI initiative was launched In February 2021, **with financial support from the Cooperation in International Waters in Africa partnership (CIWA)**. Its objective is to build the analytical and institutional foundations to catalyze national and regional investment in integrated drought resilience. Under the SADRI Cities pillar, two publications were developed: the *Urban Drought Risk Management Framework: A Regional Guidance Note for the Southern African Development Community* and the *Urban Drought Risk Management Toolkit for Task Team Leaders in the Southern African Development Community*.

1.1 How to Use the Toolkit

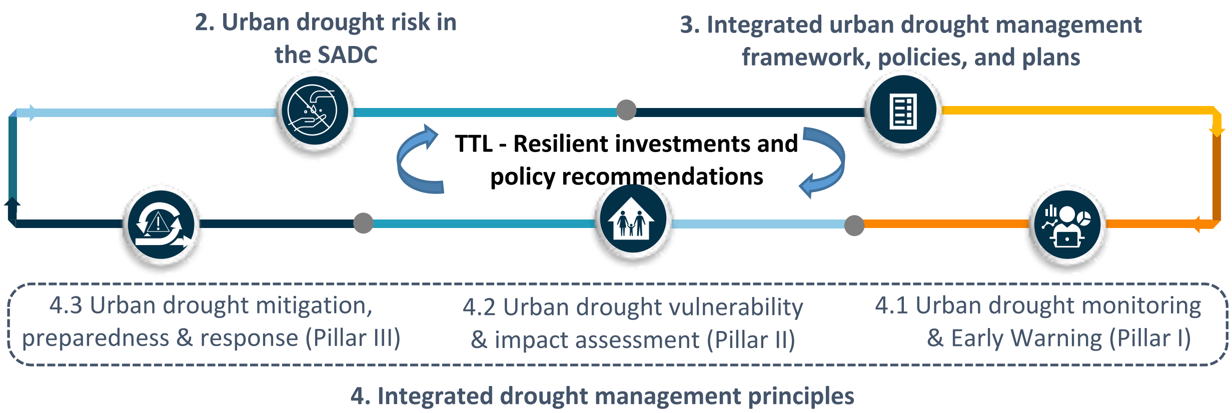
Building on international best practices and SADC case studies, this Toolkit provides guidance on how to address and mitigate urban drought risk. The Toolkit is structured around the step-wise policy development processes established by the Integrated Drought Management Programme (IDMP) and the Drought Initiative, which are linked to the three planning pillars of: (1) drought monitoring and early warning systems; (2) impact and vulnerability (risk) assessment; and (3) mitigation, preparedness, and response.[2] Highly adaptable, the Toolkit offers a set of tools and resources that provides a conceptual framework, guidelines, methodologies, tools, data sources, and case studies that task teams can leverage to improve urban drought risk management and disaster risk resilience in SADC countries though policy actions and investment.

The Toolkit is structured around six sections, offering: (1) a general overview and guide on how to use the Toolkit; (2) a conceptual framework on urban drought risk and its challenges in the SADC; (3) details of how to strengthen urban drought policy development and legal, planning, and management frameworks; (4) an introduction to the guiding principles for integrated drought management practices, including urban drought monitoring and early warning systems, urban drought impact and vulnerability assessment, and mitigation, preparedness, and response; (5) discussion of the benefits of urban drought risk management; and (6) guiding principles for monitoring and evaluation. The final section summarizes key points and recommendations (Figure 1.1).

The Toolkit aims to strengthen the links among urban drought risk management, urbanization, water resources management, and disaster risk management. Mainstreaming the concept through ongoing or future World Bank projects in these major areas in the SADC will provide and enhance the climate resilience of water utilities and cities. Such a comprehensive investment portfolio of resilient measures linked to thorough drought policy enforcement is both viable and much needed in the SADC.

[2] For an overview of the IDMP, see the program's dedicated website at https://www.droughtmanagement.info. For more details about the Drought Initiative, see the UNCCD website at https://www.unccd.int/actions/drought-initiative.

Figure 1.1. Structure of the Toolkit



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To further assist TTLs and task teams, a Workbook (Microsoft Excel) complements the Toolkit. It provides additional tools, data sources, and relevant case studies to help enhance urban drought monitoring and early warning systems; develop rapid urban drought impact and vulnerability assessment for the main cities; and identify and develop urban drought mitigation, preparedness, and response policies, plans, and measures.

The Toolkit is presented as a 'living' document that can be adjusted and scaled up over time to include more resources and information. The World Bank invites all TTLs and task teams to share tools, case studies, and experiences so that others can learn from past or ongoing experiences.

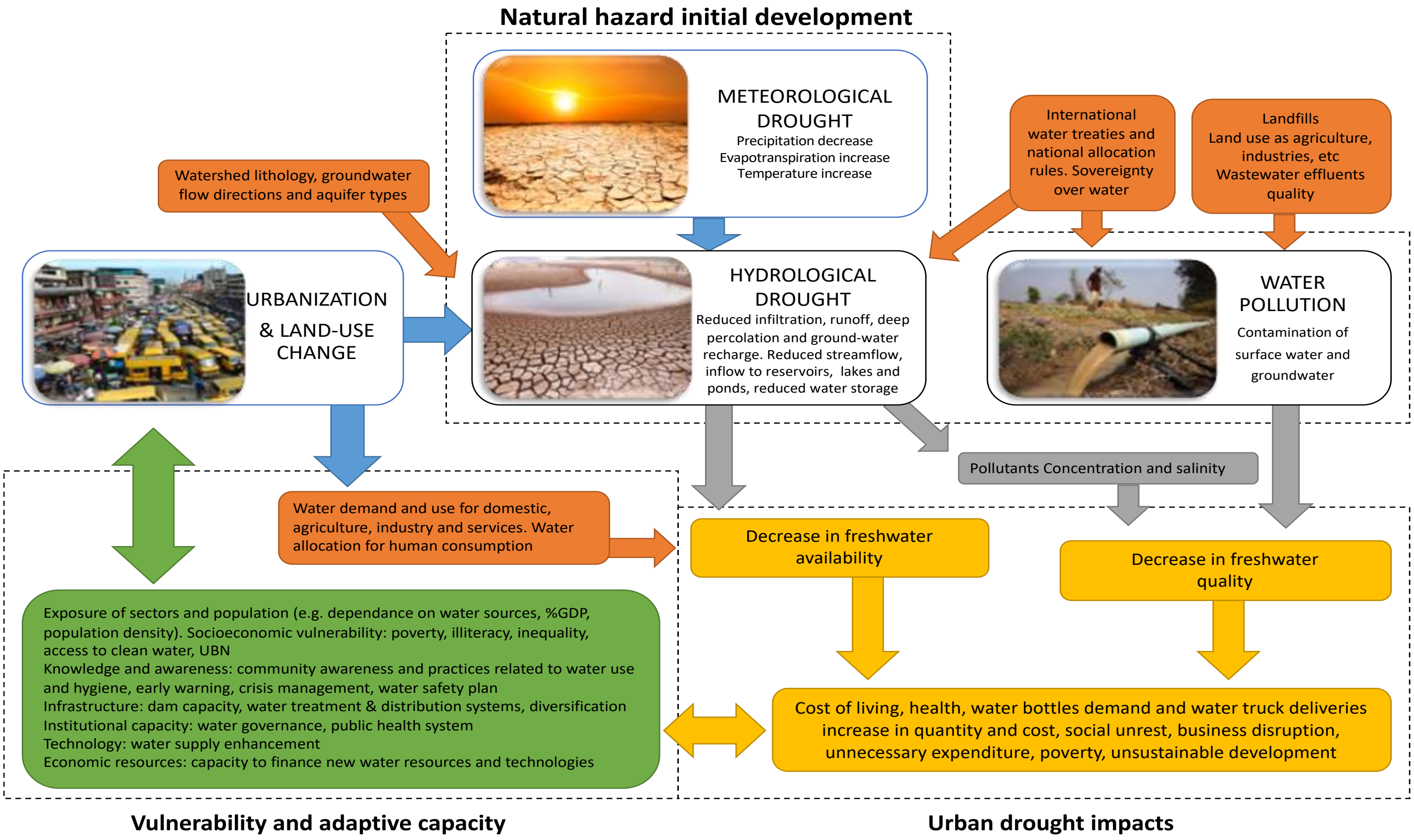
2 Urban Drought in the Southern African Development Community

2.1 Understand Urban Drought and Possible Impacts

Four types of droughts are commonly recognized in drought management literature and practice: meteorological, hydrological, agricultural, and socioeconomic (Wilhite and Glantz 1985). The latter deals with drought in terms of supply and demand, and the effects of water shortfall on socioeconomic systems. The four types of droughts reflect progression in intensity and time, according to the duration of lack of precipitation, increases in temperature and evapotranspiration, and the intensity of each of those climatic indicators measured in terms of dryness levels according to the local features.

Owing to the concentration of people in urban areas, urban drought tends to have severe socioeconomic impacts (Wang et al. 2019; Zhang et al. 2019). Hence, urban drought is 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 (Figure 2.1).

Figure 2.1. Urban Drought



Source: Original figure for this publication.

Unplanned urban development and human activity may increase urban drought risk by reducing freshwater availability and quality in several ways. 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).

2.2 Urban Drought Challenges in the Southern African Development Community

In many African cities, the converging challenges of rapid population growth, rapid urbanization (and slum growth), rising climate threats, and skyrocketing demand for increasingly constrained water resources threaten economies, livelihoods, and the health and well-being of billions of people. On average, by 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).

The adverse environmental consequences of these infrastructural inadequacies threaten the sustainability of urban water systems and intensify economic disparity, poor water management, and water governance issues, as well as institutional inefficiency. '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 temporary water stress or change in balance between supply and demand, whereas water scarcity is generally considered a long-term problem (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, weak governance, and scarcity of livelihood options for the poor (high confidence)" (Cardona et al. 2012, pp 67).[3]**.**

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). Informal settlements or slums mostly experience some combination of overcrowding, low-quality housing, and inadequate access to safe water and sanitation, increasing the vulnerability of these settings, and their inhabitants, to drought and other natural disasters (Lall, Henderson, and Venables 2017).

The 2015–18 Cape Town water crisis drew new international attention to urban drought, but it was not the first case of its kind. Barcelona (Spain), Mexico City (Mexico), Los Angeles (United States), Sao Paulo (Brazil), and other cities have also faced severe water supply problems due to drought events. In South Africa, the metropolitan municipalities of Johannesburg, eThekwini, and Nelson Mandela Bay, and many smaller municipalities in the past decade experienced stress points on their water supply sources. Seven of the eight metropolitan municipalities in South Africa implemented water restrictions before the Cape Town event began in 2015 owing to low dam and rainfall levels. Cape Town is just one example of how towns and

[3] 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).

cities in the Southern African Development Community (SADC) and other semiarid regions can be affected by water stress due to drought and climate change (Ziervogel 2019).

Rural, urban, and peri-urban areas are becoming increasingly interconnected, raising the potential for intersectoral conflict over shared water resources. Within this context, managing water resources during drought and 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, domestic 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). The "Southern Africa: Seasonal Overview and Drought Hotspot Analysis (2019/2020)" identified over 38.8 million people affected by drought out of the more than 91.3 million people exposed to drought in the SADC region (WFP 2020). **Box 2.1** emphasizes the disaster, fragility, and conflict nexus, and the urgent need to invest in more resilient water services, while Box 2.2 highlights the cascading effects of severe droughts and rising urban drought challenges.

Box 2.1 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, 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 often also a conflict-compounding factor, due to limited and inequitable access, which increasingly the case in Southern Africa (Maunganidze, Greve, and Kurnoth 2021).

While cities can bring many benefits, they can also exacerbate risks of marginalization, poverty, climate shocks, and conflict. Africa's fast pace of urbanization—with much of urban expansion occurring in urban slums—poses a complex conversion of disaster, fragility, conflict, violence, and climate risks. 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).

With population growth projected to add more than 1 billion people in Sub-Saharan Africa between 2019 and 2050, the region could account for more than half of world's population growth during this period, and the region's population is projected to continue growing through the end of the century (UN DESA 2018).[4] On average, by 2030, about 70 percent of the population of Southern Africa will be urban (UN DESA 2018), but there are significant differences within and between countries. While 76.8 percent and 72.1 percent of people from Botswana and South Africa respectively will live in urban areas, only 20.9 percent and 26.5 percent of people from Malawi and Eswatini (UN DESA 2018).

[4] A billion is 1,000 million.

Box 2.2 Urban Drought Challenges in Southern Madagascar

Severe droughts in southern Madagascar have affected millions of people in recent decades. The region is experiencing the most acute drought since 1981, and drier than normal rainy seasons for the past several years (US DOS HIU 2021). By December 2021, more than 1.5 million people were classified under the Integrated Food Security Phase Classification Acute Food Insecurity classification as being in Crisis (Phase 3) or in Emergency (Phase 4). The most-affected districts—classified as Emergency contexts—include Amboasary-Atsimo, Ambovombe-Androy, Ampanihy, and Tsihombe, which together host nearly 300,000 of the 400,000 people experiencing these Emergency conditions (IPC 2022).

Toliara city is one of the preferred destinations for migrants seeking refuge from droughts in the southern part of the country. Rural-to-urban migration in Madagascar push factors drive people out of rural areas and include climate impacts (mainly drought in the south), environmental degradation, resource shortages, and actual or perceived insecure land rights. Populations affected by the recent severe drought in southern Madagascar migrate to urban areas, seeking alternative sources of income, changing their food consumption, and selling household goods (USAID 2018). Mass migration recently has led to the proliferation of urban slums and increased pressure on the already limited urban water infrastructure (USAID 2018).

Southern Madagascar has the country's lowest water supply coverage and is highly vulnerable to droughts. Access to potable drinking water is a major challenge for the local population (Serele 2019). In this 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.

Table 2.1 summarizes the urbanization prospects of the SADC region—albeit based on varying definitions of 'urban population' used by different national statistical offices.[5]

Table 2.1 Urbanization Prospects: Predicted Growth of Urban Populations

	TOTAL POPULATION (THOUSANDS)	URBAN POPULATION (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS (%)	ANNUAL URBAN POPULATION AT MIDYEAR BY 2030 (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS BY 2030 (%)	ANNUAL URBAN POPULATION AT MIDYEAR BY 2050 (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS BY 2050 (%)
CONGO, DEM. REP.	84,004.99	37,348.94	44.46	62,343	51.76	125,931	63.79
TANZANIA	59,091.39	19,958.55	33.78	35,529	42.45	76,542	55.43
ANGOLA	30,774.21	20,161.54	65.51	32,437	72.55	61,132	80.39
ZAMBIA	17,609.18	7,663.68	43.52	12,549	50.48	25,577	62.38
MALAWI	19,164.73	3,245.93	16.94	5,551	20.89	13,360	32.04
MOZAMBIQUE	30,528.67	10,986.62	35.99	18,195	42.87	37,473	55.29
NAMIBIA	2,587.80	1,294.74	50.03	1,972	60.76	3,116	71.81
BOTSWANA	2,333.20	1,620.33	69.45	2,151	76.82	2,871	83.91
ZIMBABWE	16,913.26	5,447.51	32.21	7,370	34.24	13,627	45.95
SOUTH AFRICA	57,398.42	38,086.77	66.36	46,457	72.07	58,057	79.80

[5] Because national definitions of urban and rural areas differ significantly from one country to the next, it is difficult to compare these types of areas across national borders. To facilitate international comparisons, a coalition of six international organizations developed a new global definition of cities, towns and semi-dense areas, and rural areas. On March 5, 2020, the United Nations Statistical Commission endorsed the Degree of Urbanization as a recommended method for international comparisons (Dijkstra et al. 2020). The Degree of Urbanization identifies three types of settlements: (1) cities—which have a population of at least 50,000 inhabitants in contiguous dense grid cells (more than 1,500 inhabitants per square kilometer); (2) towns and semi-dense areas—which have a population of at least 5,000 inhabitants in contiguous grid cells (with a density of at least 300 inhabitants per square kilometer); and (3) rural areas—which consist mostly of low-density grid cells.

	TOTAL POPULATION (THOUSANDS)	URBAN POPULATION (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS (%)	ANNUAL URBAN POPULATION AT MIDYEAR BY 2030 (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS BY 2030 (%)	ANNUAL URBAN POPULATION AT MIDYEAR BY 2050 (THOUSANDS)	PROPORTION OF TOTAL POPULATION IN URBAN AREAS BY 2050 (%)
LESOTHO	2,263.01	637.10	28.15	887	34.00	1,485	46.35
ESWATINI	1,391.39	331.14	23.80	442	26.54	703	33.78
MADAGASCAR	26,262.81	9,767.29	37.19	16,102	45.24	31,158	57.91
MAURITIUS	1,268.32	517.39	40.79	539	41.85	604	49.50
COMOROS	832.35	241.09	28.97	345	32.52	599	40.95
SEYCHELLES	95.24	53.99	56.69	61	61.75	67	69.59

Source: UN DESA (2018).

3 Benefits of Urban Drought Risk Management

Resilient investments can become a real source of savings for countries: 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. Failure to invest in urban resilience can have significant adverse impacts on the urban poor. Disasters and the effects of climate change, such as increased food prices, could reverse many development gains.

Climate change 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.

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 co-benefits. **For example, such investments can**:

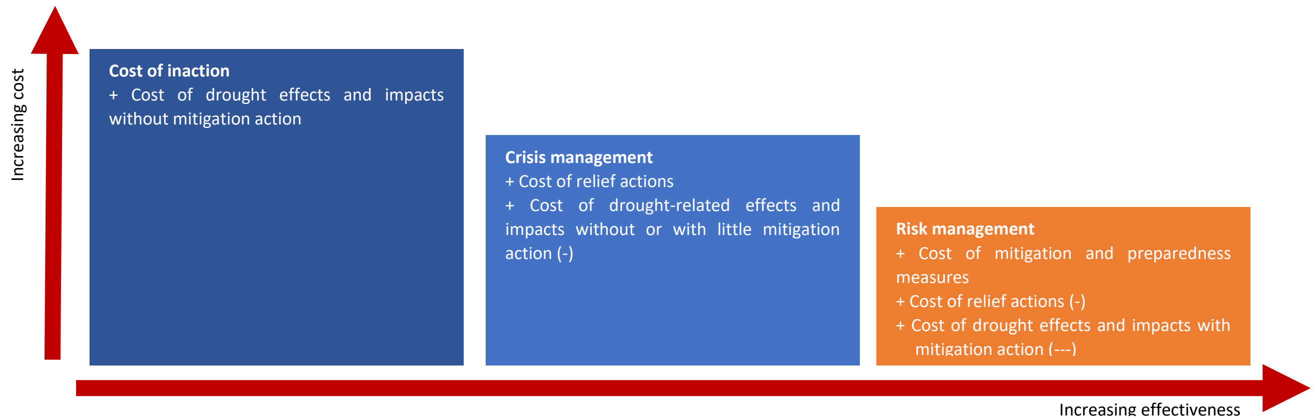
- Increase productivity, drive innovation, reduce or avoid environmental degradation, and improve access to basic services (Vorhies and Wilkinson 2016)
- Reduce the impacts of extreme hydro-meteorological events and increase resilience. This translates into the reduction of losses and damage, of cascading impacts, and of 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 rehabilitation and care after disasters.
- 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. Owing to the disproportionate impacts of natural disasters on the poor (Hallegatte et al. 2017), investing in resilient mitigation and preparedness measures will provide a backbone to poverty reduction strategies
- Reduce disruptions to essential services, reduce the impacts of disasters on vulnerable populations, and prevent more people from falling into poverty as a result of disasters.

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 ex ante urban drought risk management actions are higher than those of investing in ex post 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 3.1**Error! Reference source not found.**).

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 risk 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.

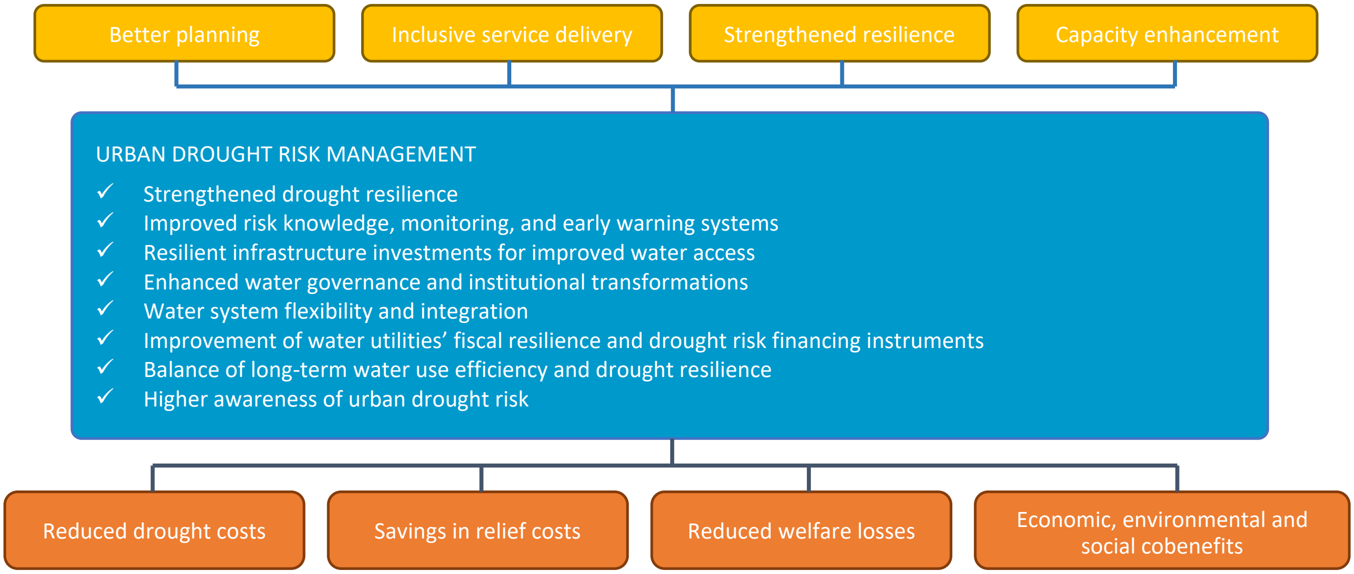
Figure 3.1. Costs of Drought under Different Action Scenarios



Source: Adapted from Gerber and Mirzabaev (2017).

Preventive management strategies have a far wider appeal than simply the capacity to mitigate urban drought risks, in that they bring about substantial socioeconomic co-benefits. Many urban drought risk management measures not only build resilience to droughts but also to additional socioeconomic and environmental shocks. Thus, several approaches to urban drought risk management are 'low- and no-regrets' options: their application makes sense as a precautionary measure to prevent the negative impacts of many of the direct costs of droughts and, especially, the indirect costs—about which we know very little. The benefits of adopting urban drought risk management approaches include reduced drought costs and lower drought relief costs, as well as substantial socioeconomic co-benefits (Figure 3.2).

Figure 3.2. 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. Low- and no-regrets options provide benefits across a wide 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 help create 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 co-benefits (Field et al. 2012).

4 Urban Drought Risk Management Framework

The section aims to help task team leaders (TTLs) understand the Urban Drought Risk Management Framework (UDRMF) and its planning process, identify progress already made in the Southern African Development Community (SADC) on urban drought risk management policy and plans, tailor an ad hoc implementation strategy to the context, and identify gaps and needs in capacity building and research (Figure 4.1). It provides information and guidelines to assist TTLs in identifying key steps, relevant institutions, and stakeholders to assess, develop, or strengthen urban drought risk management policies and plans (Figure 4.2).

The Framework is based on the three-pillar approach supported by the Integrated Drought Management Programme (IDMP), 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).

Figure 4.1. Process to Develop Policies and Plans for Urban Drought Risk Management

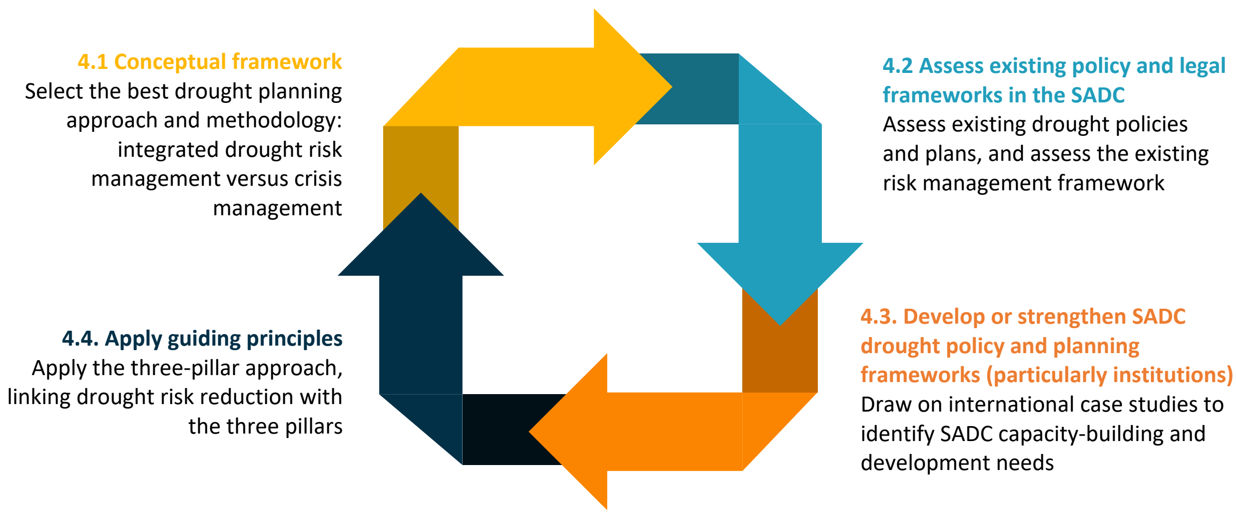


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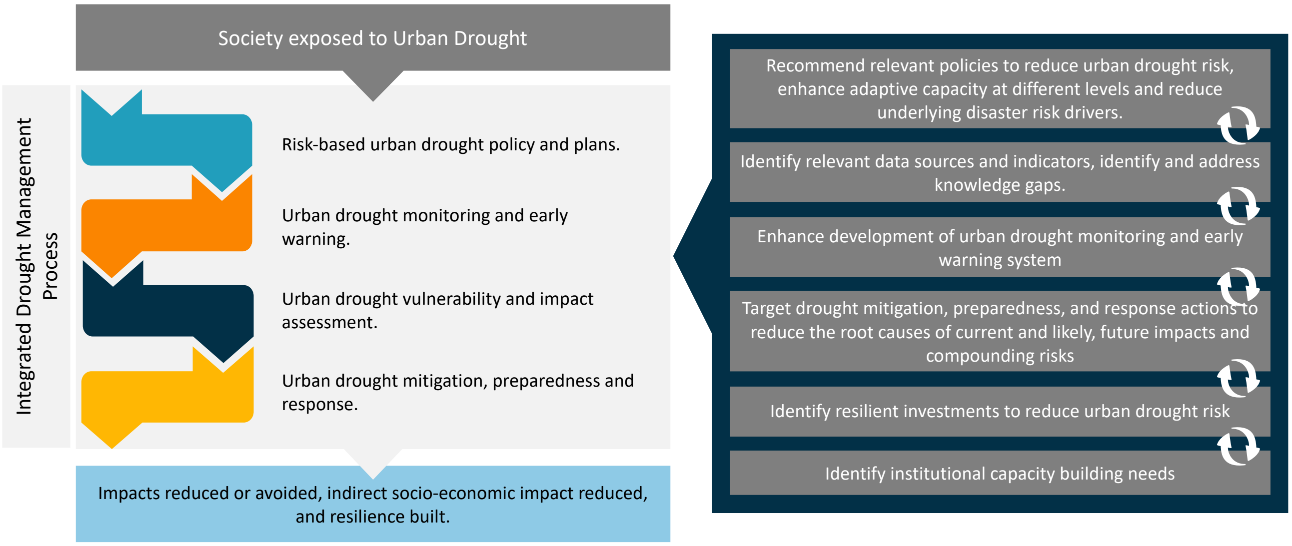
Figure 4.2. What the UDRMF Policy and Plans Section Can Help Address



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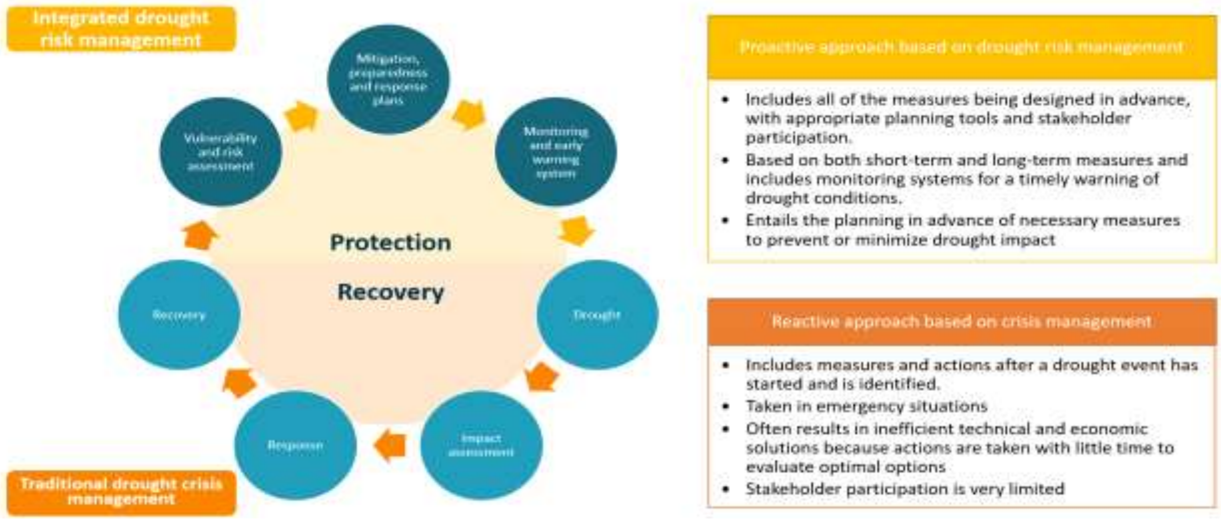
4.1 Conceptual Framework for Drought Planning

A *national* and *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. 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. The 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).

Most countries and cities still address droughts through crisis management. Adopting this approach has generally proven untimely and ineffective, and drought relief measures have been poorly targeted and have done little to reduce vulnerability to the next drought. In fact, in many cases, drought relief actually increases vulnerability to future events by reducing the level of self-reliance and increasing dependence on external assistance (Hayes, Knutson, and Wilhite 2005; Wilhite and Knutson 2008).

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 4.3).

Figure 4.3. Planning Approaches: Integrated Drought Risk Management versus Drought Crisis Management



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4.2 Assess Existing Drought Policy and Legal Frameworks in the SADC

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. The alternative to using drought risk mitigation measures would be to develop 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. But such schemes come with a range of social, economic, environmental, and political implications, which could complicate their establishment and implementation.

Other relevant hydrological factors in the region include the following (Malzbender and Earle 2007):

- The high number of transboundary rivers, and their national and regional importance: Five of the 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.
- High reliance on groundwater, often shared among countries. At present, very little is known about the region's aquifers. As most of them do not coincide with the major river basins, they effectively form a stock of fossil groundwater. The flow characteristics, recharge rates, permeability, and transmissivity of these bodies of water are not well understood.

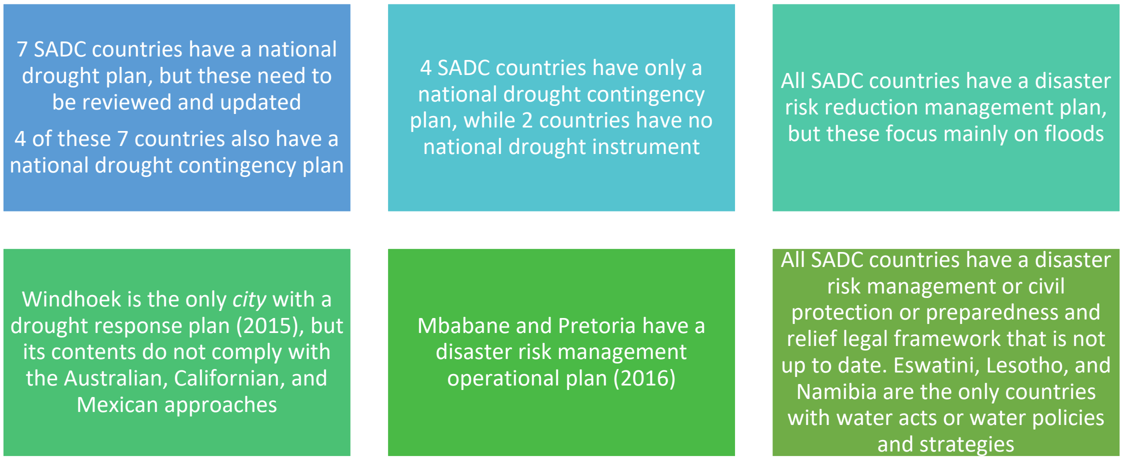
Therefore, the SADC Protocol on Shared Watercourses—the legal instrument governing transboundary water resources management in the region—is crucial. "The Protocol does not regulate the specifics of basin management in the respective basins of the region. Rather, it is a framework that contains the accepted key elements of international water law and makes transboundary water resources management mandatory in the SADC region. These elements include equitable and reasonable use, a duty not to cause significant harm, and the obligation to give prior notice of planned developments" (Malzbender and Earle 2007, 15 pp). These agreements are fundamental to consider when developing supply-side measures that focus on mitigating drought impacts and on strengthening water management institutions when dealing with shared and transboundary rivers.

There is not yet a consistent policy position and operational approach among SADC countries for water and drought risk management. 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. For urban drought risk management policy implementation, water agencies at the national level are the natural leadership. Most national water agencies already have a department of water affairs, with a hydrology section or division, that can provide reservoir and groundwater information and take the lead in the technical aspects of drought monitoring and early warning. All SADC countries have a national meteorological service, but their capabilities need to be enhanced to improve meteorological and hydrological drought monitoring and early warning. 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. 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 resource related or any other potential internal or external shock (Kingdom, 2022).

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 (Figure 4.4). National and urban drought planning instruments identified within the SADC region are presented in the Workbook.

It is important to note that various studies conclude that drought planning suffers when done in isolation, as it often is, from other development and environmental decision-making processes. Confusion in the way that drought is understood and measured by different stakeholders can also complicate drought planning. National and local capacities to participate effectively in drought planning are highly variable and are undermined by reduced state budgets and human resources. Participatory local processes can build capacities and empower communities to respond to droughts. Central authorities, however, often take control during crises, disempowering local actors. These issues should be avoided in the development and implementation of the urban drought risk management plan (Hayes, Knutson, and Wilhite 2005; Kallis 2008; State of California 2008; Wilhite and Knutson 2008).

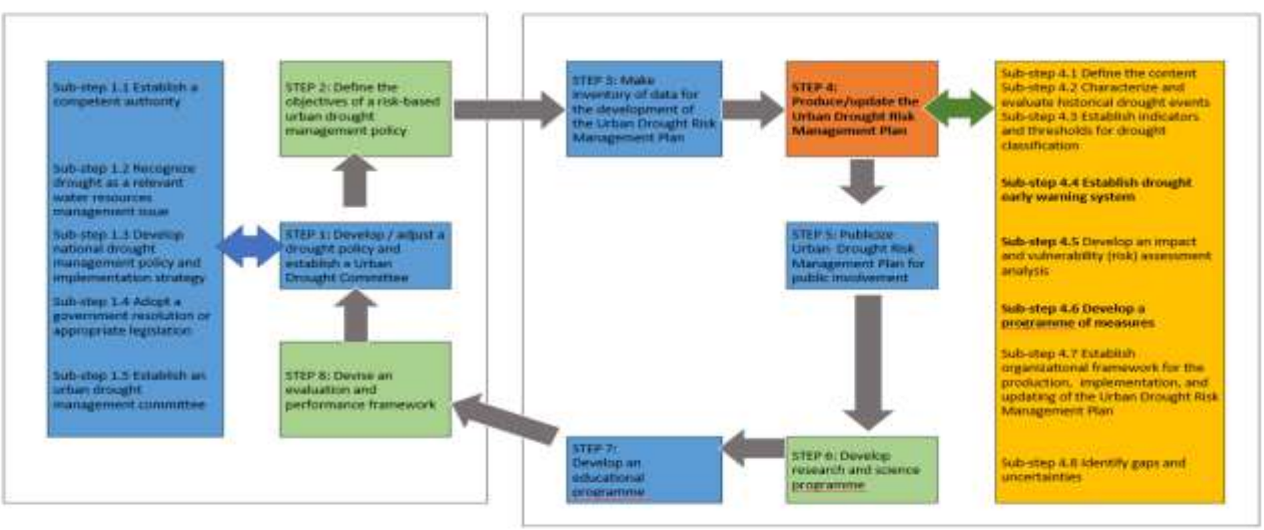
Figure 4.4. SADRI sketch of the existing Drought Policy and Legal Framework in the SADC



4.3 Develop or Strengthen SADC Urban Drought Policy and Plan Development: Policy and Planning Processes

Drought plans at national, regional, and local (urban) levels should help reduce drought vulnerability. Drought planning, particularly for cities, as presented in the previous section, includes proactive measures (for example, conservation and reallocations) and contingency provisions, that is, establishing 'drought-stage triggers' and defining the measures to be implemented during each stage (for example, rationing, use of lower-quality water, water transfers). Collaboration between agencies and stakeholders is important. Controversial measures, like interbasin water transfers and the temporary or permanent curtailment or purchase of agricultural water rights, and cooperative actions are better if agreed upon before a crisis (Kallis 2008). Figure 4.5 depicts two linked, but distinct processes: policy development vis-à-vis planning. The entry point (step) in each process will depend on existing policy and plans in a country.

Figure 4.5. Urban Drought Risk Management Policy and Plan Development Processes



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Box 4.1 describes examples of processes used in various world regions to develop drought management policy and plans. The examples described have a lot in common and have been tested in multiple countries and cities globally, where they have performed with variable effectiveness in creating, or setting the scene for, a risk-based public policy on drought management and its corresponding implementation in appropriate plans and programs. Successful policy implementation is always closely linked to the political recognition of drought management as a priority of the highest order, supported by other relevant factors, such as communication, training, and financing.

Among the SADC countries, there are drought policy and plan development experiences that need to be reviewed and updated—benchmarking them against similar international case studies—to identify, assess, and overcome potential gaps and weaknesses. It is important to highlight that even when existing methodologies for developing and implementing drought management plans (not exclusively for urban drought but for all types of droughts) focus mainly on the national or regional level, their principles, concepts, and steps are entirely applicable and adaptable to the city (urban) level, as demonstrated by the case studies from California (United States) and Mexico.

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). Particularly for urban drought, some cities have been mandated by law (mainly disaster risk reduction laws) to develop and implement a drought contingency plan or a water shortage contingency plan, or the city's drought plan is contained in its water plan, as in Lima and Arequipa (Peru), some Mediterranean countries, and the Californian (United States) and Australian cases discussed in this Toolkit (Groves et al. 2019; Iglesias et al. n.d.-a, n.d.-b; SEDAPAR 2015; State of California 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 determine their duties in the drought risk management system (Fatulová et al. 2015). Across the guidelines presented, every initial step concerns the establishment of a drought committee, which begins with the identification/confirmation of the competent authority for drought risk management.

Institutional arrangements and a supporting legal framework that establish clear roles 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 the Cape Town (South Africa) case study regarding water governance make clear the need to strengthen transversal management between municipal departments; build systems and relationships of mutual accountability for effective water management between spheres of government; strengthen leadership and the capacity to enable flexible, adaptive decision-making; and invest in partnerships beyond the city government (Ziervogel 2019). Also, the cases from California (United States), Australia, and Mexico highlight the importance of strengthening institutions, leadership, roles, (binding) laws, and data sharing and communication throughout the 'drought life cycle'.

Box 4.1 **Existing Drought Management Initiatives: Policy and Planning Processes**

The Integrated Drought Management Program and the Drought Initiative

'Integrated drought management' mitigates drought risk and builds drought resilience by addressing multiple components of drought management, including disaster risk reduction, climate change adaptation strategies, and national water policies. In 2013, the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) launched the Integrated Drought Management Programme (IDMP) to address drought issues more effectively (for more details, see the website at https://gfcs.wmo.int/idmp).

The United Nations Convention to Combat Desertification (UNCCD) established the Drought Initiative in 2018 to focus on promoting regional efforts in drought preparedness to reduce drought risk and vulnerability and a toolbox to boost the resilience of people and ecosystems to drought.[a] Through the Drought Initiative, the UNCCD has made available comprehensive national plans of action ready to be activated well before drought strikes.

These two global initiatives share the same principles and guidelines of the three-pillar approach to address drought hazards as are set out in the Sendai Framework for Disaster Risk Reduction (UNDRR 2015) and the Hyogo Framework for Action, 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). The three-pillar approach applies to all types of droughts since it encompasses the full drought life cycle, as defined by the WMO.

Recognized planning methodologies exist to develop and implement a drought policy and preparedness plan. These include the 10-step approach of the IDMP and the 8-step approach of the Drought Initiative (Fatulová et al. 2015; Hayes, Knutson, and Wilhite 2005; Rossi, Castiglione, and Bonaccorso 2007; State of California 2008; Wilhite 2014; Wilhite and Knutson 2008). Both the 10- and 8-step processes can be easily adapted 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 (Table 4.1).

[a] For more details about the Drought Initiative, see the UNCCD website at https://www.unccd.int/actions/drought-initiative.

Table 4.1. Comparison of Processes for Development of a Drought Policy and Preparedness Plan

Integrated Drought Management Programme (WMO-GWP)	Drought Initiative (UNCCD)
The 10-step drought policy and preparedness plan process are 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 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 7: Communicate the national drought plan and educate stakeholders on its use
Step 10: Evaluate and revise national drought management policy and supporting preparedness plans	Step 8: Evaluate the national drought plan

Adapted IDMP Approach for the European Union

For the European Union, the Central and Eastern European branch of the GWP—on the recommendation of its constituent countries—adapted the IDMP approach to respect the principles of European legislation, water policy, and drought policy. A step-by-step approach sets out the process for developing drought policy; this condenses the 10 steps of the IDMP approach into a 7-step process, reflecting the context of the Water Framework Directive.

The eight principles of integrated drought management in the context of the Water Framework Directive (and the Flood Directive) are as follows (Fatulová et al. 2015):

- Principle 1: Drought policy is based on a proactive approach, with an emphasis on drought risk management. It is associated with developing a preparedness plan with the aim to prevent or minimize drought impacts.
- Principle 2: A drought management plan is an administrative tool for the enforcement of mitigation measures (preventive and responsive) to achieve a reduction in drought impacts on the economy, environment, and society.
- Principle 3: The Water Framework Directive provides the legislative framework for the development of drought management plans focused on the reduction of drought impacts in affected areas and the enhancement of resilience against droughts.
- Principle 4: A drought management plan is an additional planning document that supplements a river basin management plan developed as a part of planning cycles in accordance with the Water Framework Directive (article 13.5). According to the United Nations Convention to Combat Desertification (chapter 10), the relevant chapters of a drought management plan are included in the national action plan to combat desertification.
- Principle 5: The development of drought policy and the production of the drought management plan are consistent with policy documents issued by the European Commission and other technical and methodological documents developed and adopted within the process of the Common Implementation Strategy for the Water Framework Directive. Links should be ensured between the drought management plan and national and local development strategies, plans, and programs.
- Principle 6: Professional experiences and scientific knowledge on drought risk management from other regions should be drawn upon and used.
- Principle 7: Three main elements are crucial for effective drought management: drought indicators and thresholds for the classification of drought stages (that is, normal, pre-alert, alert, and emergency) and a drought early warning system; mitigation measures to achieve specific objectives in each drought stage; and an organizational framework to deal with drought.
- Principle 8: A key factor for establishing effective and integrated drought management is ensuring the involvement of key sectors, decision-makers, professionals, stakeholders from impacted sectors, and the public in the process of developing and implementing a drought management plan.

“The development of drought policy and production of the drought management plan are dynamic and iterative processes that need to be regularly reviewed and updated according to appropriate indicators. A periodic process of postdrought evaluation and updating of the drought management plan, based on a review of steps 2 to 7, should link with the six-year cycle of the river basin management plan planning process. Postdrought evaluations establish a baseline for the revision of drought policy and updating of the drought management plan and include an analysis of climate, social, and environmental aspects, as well as an evaluation of the effectiveness and weaknesses of the drought policy and the mitigation measures implemented” (Fatulová et al. 2015, 19 pp).

Drought Contingency Plans at the City Level

Examples of drought contingency plans (employed when drought is already present) at the city level come from Lima and Arequipa (Peru) and California (United States), which employs a 7-step process in its *Urban Drought Guidebook* (State of California 2008). The California process for developing a drought contingency plan is equivalent in principles, concepts, and implementation to the 10-step (IDMP), 8-step (Drought Initiative), or 7-step (European

Union) processes—and three-pillar approach—used to develop the broader drought policy and preparedness plans (Table .1.2).

Table 4.2. Californian Development and Implementation Process for a Drought Contingency Plan

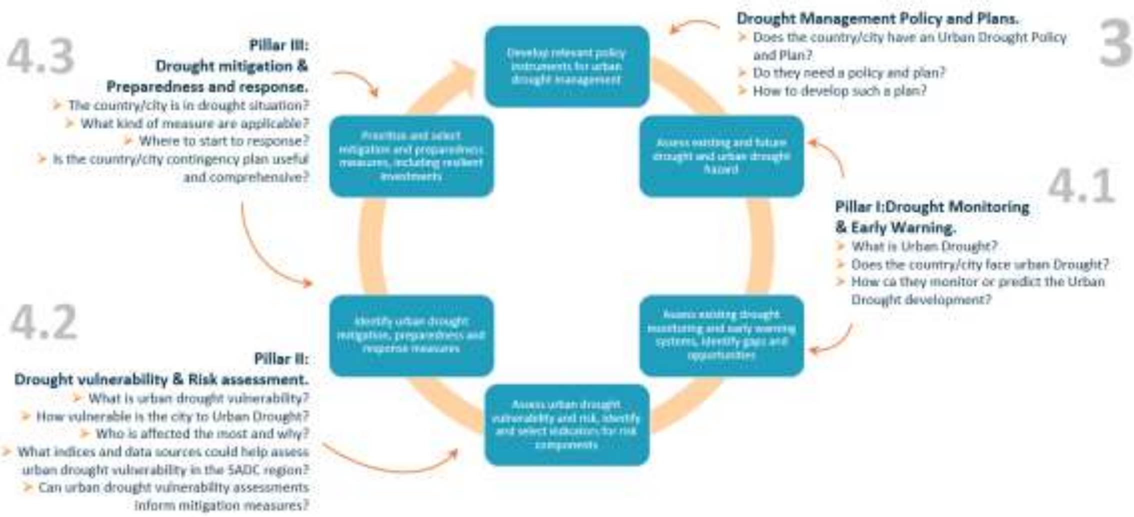
Step 1	Calls for the formation of a water shortage response team with a leader to spearhead the effort and involve the various units in the organization.
Step 2	Calls for water utilities to collect supply and demand data. These data are needed as a basis for planning and estimating how much water of acceptable quality will be available under various shortage conditions, including multiyear shortages. Pumping and pipeline capacity are also considered. Calculating projected demand, including increases because of population growth and reduced precipitation, will be balanced against projected supply. The best time to initiate this process is before a shortage occurs.
Step 3	Examines not only the quantity of water available owing to various supply augmentation and demand reduction options, but also any problems or constraints resulting from the use of such sources.
Step 4	Identifies trigger mechanisms to react to shortage severity. (Steps 3 and 4 involve assessing shortage mitigation options and setting drought-stage triggers. These can be parallel efforts that support the final selection of water shortage contingency plan elements in step 5.)
Step 5	Represents the synthesis of information from previous steps. Groups of water-saving measures are associated with progressive levels of supply shortage. The key element in this step is the involvement of customers, to create a program that the community understands, contributes to, and supports.
Step 6	Develops a budget and presents the draft plan to the public for review and revision. Formal establishment of the ordinances and interagency agreements that underlie the plan occurs before the plan is adopted.
Step 7	Considers the fine details of how to implement the plan. Procedural issues, staffing needs, and budget and funding considerations must be resolved. Preparation and implementation of a plan calls for many complex actions, and it is recommended that the water utility begins planning at least six months before water rationing could start.

Source: Urban Drought Guidebook (State of California 2008)

4.4 Apply the Guiding Principles of the Urban Drought Risk Management Framework

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) (Figure 4.6).

Figure 4.6. The Interconnected Three Pillars for Effective Integrated Drought Management



Source: Original figure for this publication, based on IDMP WMO-GWP (2013).

Pillar 1 (see section 4.1). An urban drought monitoring and early warning system is the foundation of effective proactive urban drought policy. Governments maintain drought early warning systems to alert their citizens (urban and rural) about impending drought conditions. Reliable information must be communicated in a timely manner, and through appropriate communication channels, to government officials, water managers, policymakers, and the public. 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. In addition, monitoring the impacts (using social indicators) that are occurring on the ground as a drought develops helps calibrate assessments of severity for local areas (see pillar 3, below).

Pillar 2 (see section 4.2)*.* Impact and vulnerability assessment aims to determine the historic, current, and likely future impacts associated with urban drought and assess vulnerability to these. Drought impact and vulnerability assessment aims to improve understanding of both the natural and human processes associated with droughts, and the impacts that occur. The outcome of the impact and vulnerability assessment is a depiction of who and what is at risk, and why. The assessment considers social, economic, and environmental factors to determine a community's susceptibility to drought hazards. An archive of information on historic drought impacts does not exist for most countries. Anecdotal information on recent and historic droughts may, however, be available from local authorities and tribal populations, and using such information to assess historic drought impacts is nevertheless valuable.

Pillar 3 (see section 4.3). The appropriate urban drought mitigation, preparedness, and response measures aim to reduce risk and vulnerability based on the specific context. The selection of measures involves the identification of appropriate triggers to phase in and phase out mitigation actions, particularly short-term actions, during urban drought onset and termination. It also involves the identification of national and local (city) institutions, agencies, or organizations responsible for developing and implementing an urban drought risk management plan. Triggers are defined as specific values of an indicator or index that initiate and/or terminate mitigation or response actions by decision-makers based upon existing guidelines or preparedness plans. Reducing the impacts of urban droughts involves both structural measures (that is, engineering projects) and nonstructural measures (that is, policies, public awareness, and a legal framework) (pillar 2).

The 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 a national-level 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 are implemented if a severe urban drought occurs, with a view to responding to the affected population's basic needs (mainly water supply), while contributing to long-term development.

Whilst drought crisis management focuses solely on response and interventions following disaster onset, integrated urban drought risk management—as put forth in the 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).

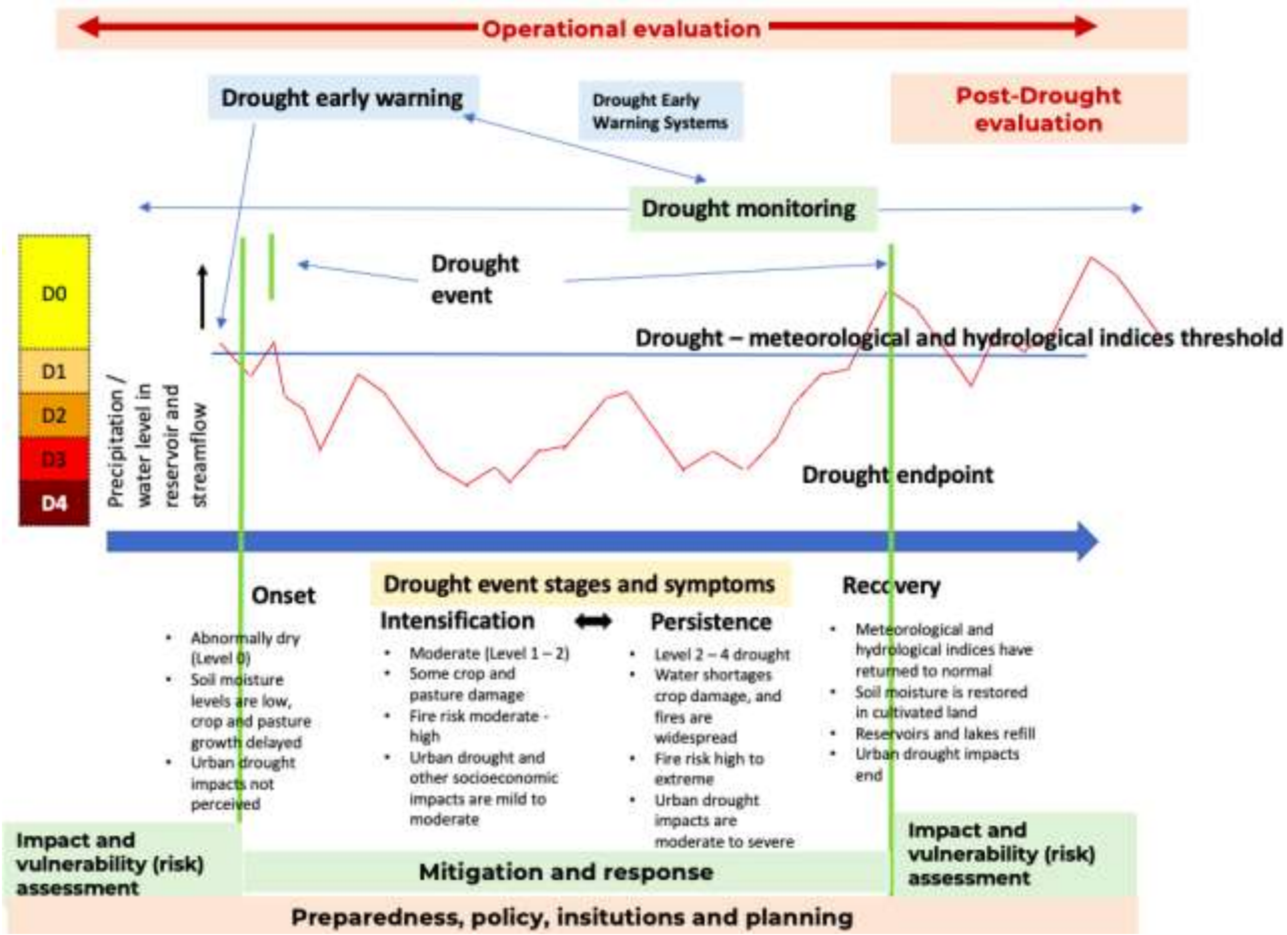
This approach is also applicable to urban areas, and can enable governments to address urban droughts proactively, by reducing the root causes of urban drought risk. It is imperative that cities adopt the new paradigm for urban drought risk management based on the three pillars. To build more resilient cities, the three pillars must be included in an urban drought risk management policy based on the UDRMF. Policy development is guided by a step-by-step process (the 10-step IDMP process or 8-step Drought Initiative process) that SADC countries can follow to develop the overarching principles of a national-level drought policy and plan aimed at urban risk reduction (Wilhite 2014).

The UDRMF is aligned with complementary to recent World Bank work, such as the iEPIC Response Framework for drought and flood actions. Compared to EPIC, the UDRMF offers more extensive emphasis on social inclusion and to identify and respond to the most vulnerable to drought within an urban community. Additional work is the City Resilience Program and the Utility of the Future Program, and recommendations from recent reports (including World Bank reports ***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; Ebb and Flow Volume 1: Water, Migration and Development***). Some of these recommend constructing new water storage and management infrastructure paired with policies that control the demand for water and describe in detail the Windhoek applied measures[6].

Ultimately, efforts to characterize a drought life cycle are essential to increase the temporal understanding of the hazard and to improve the linkages between drought stages—which are linked to the monitoring and early warning systems—and the implementation of risk-informed mitigation, preparedness, and response actions (Figure 4.7).

[6] 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.

Figure 4.7. Drought Life Cycle and Three-Pillar Approach



Source: Adapted from WMO (2019).

5 Urban Drought Risk Management Principles

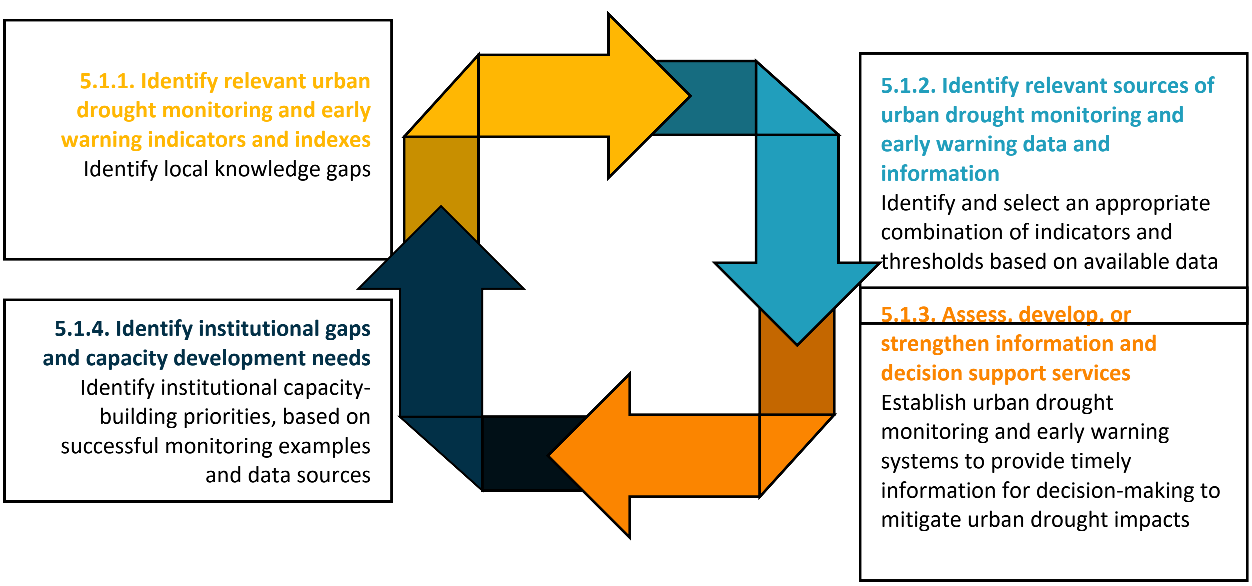
5.1 Pillar 1: Urban Drought Monitoring and Early Warning Systems

Drought early warning systems that are linked to predefined mitigation, preparedness, and response actions are key to the effective management of drought risk. The starting point is drought monitoring, which involves the continuous assessment of the natural indicators of drought severity, spatial extent, and impacts. Using that information to elicit an appropriate response represents an early warning.

Risk management in drought response includes monitoring, prediction, and early warning to reduce the impacts of drought both now and in the future. Drought monitoring makes it possible to track the severity and location of drought, and in this risk-based paradigm, it serves a critical role, improving the ability to provide relevant and timely drought information to decision-makers as part of an early warning service. Many drought monitoring efforts to date have emphasized climate-based and hydrological indicators and indexes that track changes in the hydrological cycle, using data derived primarily from point-based, in situ observations (Hayes et al. 2012). Together, these elements from a feedback loop in which better drought management drives the need for improved drought monitoring and, in turn, improved drought monitoring encourages more effective drought management (Hayes et al. 2012).

This section offers guidance on urban drought monitoring and early warning indicators and indexes, on identifying local knowledge gaps, on the selection of relevant data and information sources, and on identifying institutional capacity-building priorities (Figure 5.1). This should assist task team leaders (TTLs) in assessing technical, technological, and institutional capacity development needs to strengthen urban drought monitoring and early warning systems.

Figure 5.1. Process for Drought Monitoring and Early Warning



Source: Original figure for this publication.

5.1.1 Identify Urban Drought Monitoring and Early Warning Indicators and Indexes

Drought indicators and indexes are used to describe the physical characteristics of the severity, spatial extent, and duration of drought. Although it is incorrect to do so, the terms 'indicator' and 'index' are often used interchangeably. According to Hayes et al. (2012), "Indicator is a broader term that, in this context, covers parameters such as precipitation, temperature, streamflow, groundwater and reservoir levels, and soil moisture. In contrast, indexes can simplify complex relationships and serve as useful communication tools for diverse audiences and users, including the public. An index, in this context, is typically a computed numerical representation of a drought's severity or magnitude, using combinations of the climatic or hydrometeorological indicators listed above. Both indicators and indexes can be used to measure the qualitative state of droughts on the landscape for a given time, and an index is technically also an indicator. Climatic monitoring at various timescales allows the identification of short-term wet periods within long-term droughts, and short-term dry spells within long-term wet periods".

Indexes are also used for quantitative assessment of the severity, location, timing, and duration of drought events. Severity refers to the divergence from the 'normal' of an index. A threshold for severity can be described in terms of when a drought begins and ends, and the extent of the affected geographic area. The timing and duration of a drought event are determined by the approximate dates of its onset and termination.

The timing of a drought may be as significant as its severity in determining impacts and outcomes (Svoboda and Fuchs 2016). The impacts are determined by the interaction of the hazard event and the exposed people, agricultural areas, reservoirs, or water supplies, and their vulnerabilities to drought**.** Vulnerabilities can be exacerbated by previous droughts, which, may have triggered the sale of productive assets to meet immediate needs.

Mostly, it is best to use a combination of indicators when monitoring drought. No single indicator or index can represent the diversity and complexity of drought conditions across the spatial and temporal dimensions affected by drought. A 'composite' index is the recommended option to fully capture the multiscale, multi-impact nature of drought in all its complexity. A composite index combines many parameters, indicators, and/or indexes into a single product. A single map of drought information, with a simple classification system, is preferred over multiple maps depicting various indicators with various classification schemes. The IDMP carried out a comprehensive collection and analysis of the drought indicators and indexes most frequently used across drought-prone regions (Svoboda and Fuchs 2016).

The indicators and indexes covered in the World Meteorological Organization (WMO)/Global Water Partnership (GWP) *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 indicators and indexes are listed by ease of use: Their suitability to a particular application is determined by user knowledge, needs, data availability, and the computer resources available for its implementation. It is relevant to reiterate that the simplest indicator/index is not necessarily the best one to use (Svoboda and Fuchs 2016).

The *Handbook of Drought Indicators and Indices* describes indicators and indexes of the hydrometeorological characteristics of droughts. The handbook does not cover socioeconomic and environmental indicators such as those that may be needed to assess and anticipate drought-related impacts and outcomes (Svoboda and Fuchs 2016).

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. It involves 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.

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).

5.1.2 Identify Relevant Sources of Urban Drought Monitoring and Early Warning Data and Information

Use of satellite information and data interpretation can be a good alternative to the monitoring of drought indicators, especially in areas where meteorological and hydrological data are scarce. This type of monitoring is especially beneficial in regions such as Sub-Saharan Africa, where 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).

Remote sensing approaches (satellite drought monitoring) complement climate and hydrological data derived from point-based, in situ observations. Hayes et al. (2012), as well as many recent publications and workshops, recommend the use of spaceborne sensors that provide synoptic, repeat coverage of spatially continuous spectral measurements collected in a consistent, systematic, and objective manner. Usage of remote sensing is increasing filling the gaps or supplementing data from existing networks, even in regions with abundant point-based data.

Sub-Saharan Africa's meteorological services do not meet WMO recommendations for a minimal sampling density requirement for meteorological station placing. When on-site observations are limited, a combination of real-time and long-term satellite observations can be used to analyze and detect droughts. This highlights the potential application of remote sensing for regional to global drought monitoring, especially over remote and/or ungauged regions, as well as for monitoring operational drought with multivariate drought indexes (AghaKouchak 2015; AghaKouchak and Nakhjiri 2012; Asadi Zarch, Sivakumar, and Sharma 2015; Awange et al. 2013; Carrão, Naumann, and Barbosa 2016; Hao and Singh 2015; Touma et al. 2015; Vicente-Serrano et al. 2015). Global drought monitoring sources for Africa are highlighted in Workbook.

Over the past decade, efforts have been made to advance virtual global monitoring of droughts. The National Drought Mitigation Center (NDMC) of the University of Nebraska (United States), led by Hayes et al. (2012), has been an advocate of such approach. The initial concept was that, collectively, global, regional, and national partnerships would enhance the sharing and leveraging of resources, information, and experiences through a series of continent-based virtual regional networks, starting with the North American Drought Monitor and expanding to Australasia, Europe, South America, Africa, and Asia.

Many attempts to scale up drought monitoring in Africa are research projects, which have not been periodically updated. There have been continental approaches aimed at helping African countries to monitor drought, but local or country monitors for the Southern African Development Community (SADC) need to be strengthened.

Since there are no specific urban drought monitoring and early warning frameworks, the alternative is to use a watershed-scale drought monitoring or locally based monitoring framework. The most prominent monitors are the recent NDMC-World Bank Southern Africa Drought Resilience Initiative (SADRI) monitor, the SADC Climate Services Centre monitor, and the United States Geological Survey's Famine Early Warning System Network (FEWS NET) monitor. The SADRI monitor is the most reliable in terms of spatial resolution, continuous and timely satellite data collection, type of data, and periodic reporting. **Box 5.1** highlights a recent local monitoring system operated by the United Nations Children's Fund (UNICEF) in the Grand Sud region of Madagascar.

Box 5.1 Drought Monitoring System in Grand Sud (Madagascar)

Madagascar is subject to recurrent droughts. In the semiarid area of southern Madagascar, the phenomenon is cyclical. To better understand and predict the risk of droughts, the United Nations Children's Fund (UNICEF) installed a groundwater early warning system in this area to monitor groundwater and predict droughts.

The primary goal of the UNICEF Aquifer Monitoring in Southern Madagascar Project was to install a groundwater early warning system to monitor groundwater availability and quality in eight drought-prone districts in three regions of southern Madagascar. The project has also linked the groundwater early warning system to a drought monitoring and alert system to improve drought emergency responses in southern Madagascar (Toliara city included).

Initiated in 2017/18, the project was initially funded by Directorate-General for European Civil Protection and Humanitarian Aid Operations. It has been supported by the European Commission's Joint Research Centre as part of the Disaster Risk Reduction, Preparedness, and Resilience Building in Madagascar proposal. Implemented in collaboration with the Regional Directorates of Water, Sanitation, and Hygiene in the three most drought-affected regions (namely Androy, Anosy, and Atsimo-Andrefana), the project is still ongoing, thanks to UNICEF funding.

Since the project was implemented, the groundwater early warning system has been used to inform a monthly drought monitoring bulletin for the Grand Sud region. This publication focuses on meteorological and agricultural droughts, as well as the impacts of drought on groundwater resources—the main source of water supply for southern Madagascar's cities and towns.

Recently, the NDMC has been aiding the World Bank, within the context of SADRI, by developing a drought monitor for each country of the SADC. Each monitor uses satellite data (four indicators to develop the Composite Drought Index at 5-kilometer resolution) on a regional and national scale, which are updated monthly.[7] The process is fully automated and does not require manual authoring, as the US Drought Monitor and North American Drought Monitor, and drought monitors for Brazil and Mexico do. The NDMC

[7] 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.

produces the SADRI drought monitor in-house and is working to transfer operational capacity to the individual countries themselves; plans are farthest along with Botswana and Eswatini, and the two countries were expected to assume full operational control of their respective monitors in 2021.

The SADRI Drought Monitor is operational on a regional and national scale, with data updated monthly. Improvement is in progress, with the NDMC currently looking at using some preliminary data for a couple of the input sources, enabling maps to be released earlier in the month. Latency is an issue, due to timely data availability and the processing time needed to produce an updated map. Additional scenarios (outlook) are implemented to analyze the future behavior of the drought (Box 5.2)

Box 5.2 Drought Outlook

(Kallis (2008) state that "Meteorological droughts result from many complex, often synergistic, atmospheric causes. A breakthrough in drought forecasting has been the discovery of strong teleconnections between sea surface temperature phenomena, such as the El Niño/Southern Oscillation, and hydroclimatic anomalies[a] This has significantly improved forecasting capabilities, especially in regions where associations are strong. For example, in areas with a strong El Niño/Southern Oscillation influence, prediction accuracy is approximately 60 to 70 percent for years affected by the phenomenon, though it is substantially less accurate overall because the El Niño/Southern Oscillation is active in only half of the years".

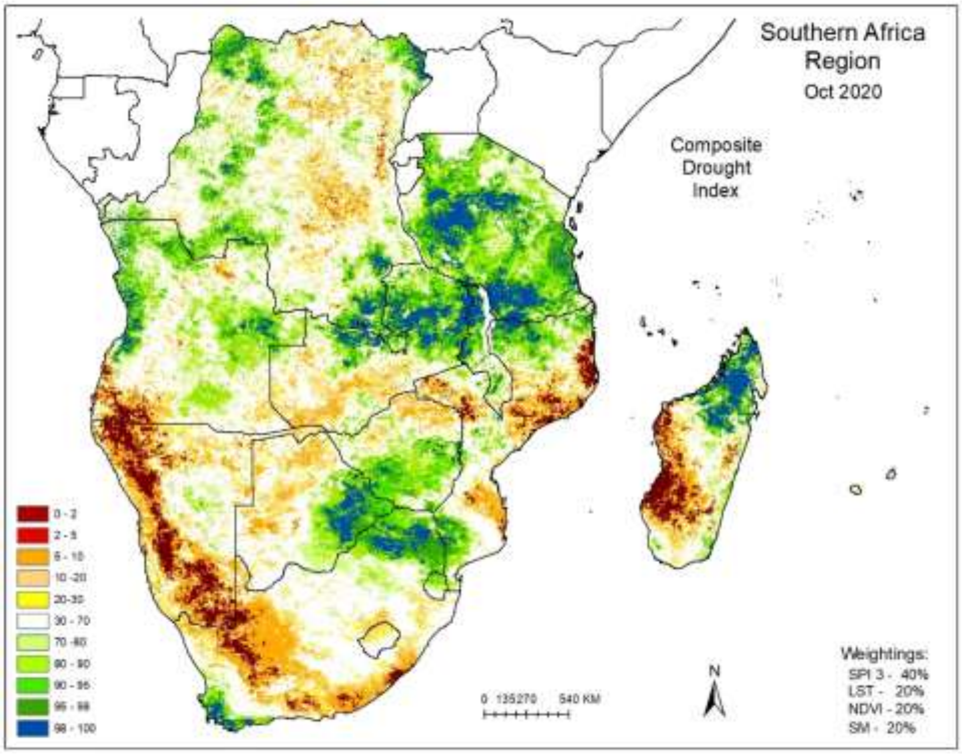
Also "global temperature predictions are reasonably robust; there is less agreement concerning regional changes. Precipitation is much more poorly modeled than temperature. Global circulation models do not systematically analyze drought-relevant parameters such as changes in the number of days with rain, rainfall intensity, variability in water balance variables, and large-scale disturbances (like the El Niño/Southern Oscillation)" (Kallis 2008, 10 pp). There is very high confidence that Southern Africa is one region of the world that will experience increasingly drier conditions by the end of the century, with precipitation declining by 10 to 30 percent. Also, there is high confidence that precipitation variability and associated drought risk will increase. It is expected that in summer, drought-affected areas will increase in size over low latitudes and midlatitudes of continental interiors. Thus, the likelihood of water supply droughts will increase (urban droughts) (Kallis 2008).

At the catchment or supply system level, drought assessments tend to be explorative, identifying worst case, rather than likely, scenarios. This limits their use for planning purposes. Water managers plan for climate change in terms of changes in average supply and demand, typically adding a safety factor to design estimates (Kallis 2008).

[a] Teleconnections are correlations between rainfall at specific locations and surface pressure values over much of the globe.

Composite Drought Index categories are based on the same percentile classes (30/20/10/5/2 percentiles) as the US Drought Monitor and North American Drought Monitor. In addition, the SADRI Drought Monitor provides the same analysis for the drought classes (20/10/5/2/0 percentiles) as for the wet classes (98/95/90/80/70 percentiles) to help emergency management agencies and hydrometeorological services understand both climate extremes (Figure 5.2).

Figure 5.2. SADRI Drought Monitor: Composite Drought Index for October 2020



Source: National Drought Mitigation Center (2020)

The Intergovernmental Authority on Development's Climate Prediction and Applications Center and SADC Climate Services Centre use parts of the Combined Drought Indicator tripod, along with the 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 FEWS NET provides access to geospatial data, satellite image products, 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.[8] The aim is to provide countries with alerts on water levels and reductions that may affect crop and livestock production (and water supply systems)[9].

The most common and recommended drought indicator for 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. It can also be used for assessment within a drought watch system in river basins with significant storage works (Nalbantis 2008). Other similar indicators and indexes for use in monitoring hydrological drought are described in the

[8] For an overview of data relating to the African continent available on the US Geological Survey FEWS NET Data Portal, see the FEWS Net website at https://earlywarning.usgs.gov/fews/search/Africa.
[9] For an overview of the US Geological Survey FEWS NET Data Portal, see the FEWS Net website at https://earlywarning.usgs.gov/fews.

literature (Svoboda and Fuchs 2016). A recently launched predictive and operational drought monitoring tool is the Forecast-Informed Reservoir Operations, which could be an alternative resource to test. Forecast-Informed Reservoir Operations is a proposed management strategy that uses data from watershed monitoring and modern weather and water forecasting to help water managers selectively retain or release water from reservoirs in a manner that reflects current and forecast conditions. This new tool is currently being tested in the United States.[10]

Assuming sufficient periodicity of the products, the potential benefits of using the various satellite-based monitors are enormous. What is crucial, however, is that monitor use is coupled to an early warning system or drought risk reduction protocol that triggers the implementation of a proper action plan.

5.1.3 Assess, Develop, or Strengthen Information and Decision Support Services

An analysis of precipitation patterns for SADC capital cities shows differences pertinent to mitigation measures. **Four precipitation groups are clearly defined, among which Windhoek (Namibia), Luanda (Angola), Gaborone (Botswana), and Dodoma (Tanzania) have the lowest annual precipitation**. May to September is the dry season and, in some cases, precipitation is entirely absent. There have been several urban drought incidents in the region in October and November. Lusaka (Zambia), Maseru (Lesotho), and Gaborone (Botswana) have suffered the most drought events of the SADC capitals, and almost all the capital cities were affected by the 2015–16 drought event caused by the El Niño/Southern Oscillation phenomenon (for further information, see the Workbook). In terms of magnitude and impact, the 2015–16 El Niño drought is the most significant drought event on record for the SADC region. Donors provided significant resources toward the humanitarian response (at least 77 percent of the total reported funding), with national governments providing considerably less funding (Botha, Nkoka, and Mwumvaneza 2018).

But no drought monitoring and early warning framework exists—globally or in the SADC—exclusively for urban drought. In most cases, monitoring and early warning for drought occur through the Sendai Framework for Disaster Risk Reduction, as with any other natural hazard (City of Cape Town 2015). While a couple of the SADC countries issue general drought bulletins through their national meteorological service, these are not urban drought-focused:

- South Africa (CSIR 2014) has some drought early warning systems managed by national research institutes like the Institute for Soil, Climate, and Water—funded by the Department of Agriculture, Land Reform, and Rural Development—which oversees the Umlindi Early Warning System focused on agricultural drought.
- Madagascar has a groundwater early warning system to monitor groundwater availability and quality for the Grand Sud region. Implemented by a UNICEF project in 2017/18, this system focuses on multiple objectives, including urban drought.

Of the SADC countries, only Madagascar (in the Grand Sud region) and South Africa issue specific drought bulletins and drought emergency alerts.[11] The alerts are based on precipitation data (Standardized

[10] For more details about Forecast-Informed Reservoir Operations, see the Drought.gov website at https://www.drought.gov/news/forecast-informed-reservoir-operations-firo-overcoming-barriers-and-realizing-benefits#:~:text=Forecast%2Dinformed%20reservoir%20operations%20(FIRO)%20is%20a%20reservoir%2D,benefits%20and%20to%20enhance%20flood.

[11] For an example of a monthly drought bulletin, see the South African Weather Service website at https://www.weathersa.co.za/Documents/Climate/nr_drought.pdf.

Precipitation Index) and may also refer to the Vegetation Condition Index and Temperature Condition Index, as well as national dam levels (storage). The remaining SADC countries develop the traditional daily, weekly, and seasonal forecasts based on precipitation and temperature. Some countries issue agricultural bulletins that draw on precipitation and vegetation condition data (Normalized Difference Vegetation Index). The adoption of a drought monitor framework is highly recommended (see Workbook).

5.1.4 Identify Institutional Gaps and Capacity Development Needs

Across the SADC region, installed capacity for drought and urban drought monitoring and early warning is very limited. Table 5.1 summarizes the capabilities of the national meteorological services in relation to drought monitoring and early warning (see detail in Workbook).

Table 5.1 Drought Monitoring and Early Warning Capabilities of National Meteorological Services in 12 Countries of the SADC

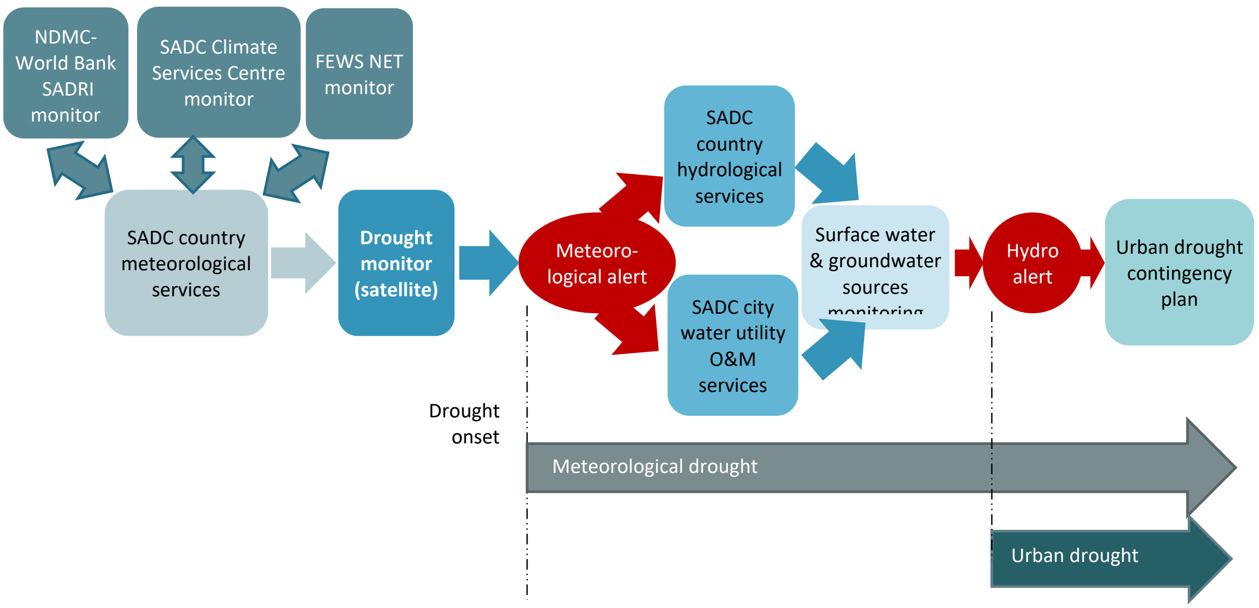
COUNTRY	DROUGHT BULLETIN	PERIODICITY	INDICATORS
BOTSWANA	forecast update	Daily	Rainfall and temperature five-day forecast
ESWATINI	Weather forecast update	Daily, monthly, and seasonal bulletins	Rainfall, temperature, Vegetation Condition Index
LESOTHO	Weather forecast update	Daily, weekly, and monthly bulletins	Rainfall and temperature five-day forecast
NAMIBIA	Weather forecast update	Daily	Rainfall and temperature five-day forecast
SOUTH AFRICA	South African Weather Service Drought Bulletin	Monthly	Short-term (one month) to medium-term (three to six months) precipitation (Standardized Precipitation Index and Standardized Precipitation Evapotranspiration Index; Vegetation Condition Index and Temperature Condition Index, and dam levels (storage)
ANGOLA	Agrometeorological Bulletin; daily weather forecast	Every four months	
MALAWI	Agrometeorological Bulletin; daily weather forecast	Monthly (suspended since 2019); daily	Rainfall and temperature forecast
MOZAMBIQUE	Drought Bulletin	Monthly	Short-term (one month) to medium-term (three to six months) precipitation; Vegetation Condition Index

COUNTRY	DROUGHT BULLETIN	PERIODICITY	INDICATORS
			(Normalized Difference Vegetation Index), surface temperature
TANZANIA	Agrometeorological Bulletin; daily weather forecast	Monthly; daily	Rainfall and temperature five-day forecast
ZAMBIA	Weather forecast update	Daily, weekly, and monthly bulletins	Rainfall and temperature forecast
ZIMBABWE	Weather forecast update	Daily, weekly, and monthly bulletins	Rainfall and temperature forecast
MADAGASCAR	Weather forecast update	Daily, weekly, and monthly bulletins	Rainfall and temperature forecast

Source: Original table for this publication.

Since the SADC has local installed capacity for neither drought monitoring/early warning nor urban drought monitoring/early warning, the UDRMF should rely on (established) drought monitoring capabilities and tools, such as global drought monitors, coupled with hydrometeorological data (dam and stream measurements) and piezometric observations (Figure 5.3). The reason this is so important is that most cities rely on surface water stored in dams and few have supplementary groundwater as water supply (slums typically have wells and boreholes as their primary water supply source). Only one SADC capital city (Dodoma) relies entirely on groundwater. The example of the Madagascar groundwater early warning system is useful to follow as a framework, but its sustainability must be improved and secured. Relevant examples of drought monitoring and early warning systems for benchmarking for the SADC region are provided in the Workbook, and drought intensities or degrees of severity equivalences are given for the three recommended drought monitors.

Figure 5.3. 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.

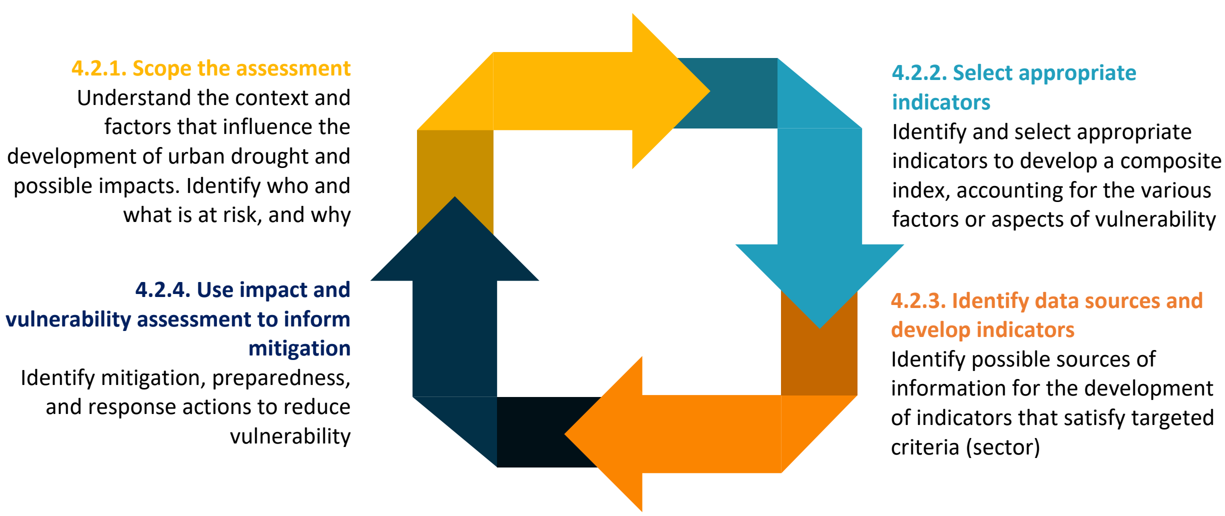
Another SADC feature to highlight is that six of the region's capital cities share the same river basin for water supply, which may affect water availability during a drought. Transboundary cooperation and coordination tools, including to share monitoring data, should be agreed in advance to address and mitigate possible water conflicts (see Workbook for further information).

5.2 Pillar 2: Impact and Vulnerability (Risk) Assessment

This section provides relevant information to help guide the urban drought impact and vulnerability (risk) assessment for countries and cities of the SADC region. It sets out critical factors that need to be addressed, provides guidance on the identification and selection of proper indicators for risk components, offers example indexes and data sources to help assess urban drought vulnerability in the SADC, and discusses how impact and vulnerability assessments can inform mitigation, preparedness, and response (Figure 5.4).

By identifying who and what is at risk, and why, urban drought impact and vulnerability assessments aim to inform targeted drought mitigation, preparedness, and response actions to address the root causes of current and likely future impacts and compounding risks. At the same time, the assessment data support enhanced communication and collaboration across sectors and levels of government, as well as resilient investments and the building of more resilient cities.

Figure 5.4. Process for Drought Impact and Vulnerability Assessment



Source: Original figure for this publication.

5.2.1 Scope the Assessment

Urban areas in drought-prone regions face serious water shortages affecting their citizens, businesses, and industries. The greater frequency of droughts and more erratic nature of rains in many countries, combined with underlying economic, environmental, and social vulnerabilities, results in increasing impacts to at-risk populations (World Bank 2019). The magnitude of the impacts of a drought depends on the vulnerability of the exposed assets and sectors, or in other words, on the predisposition of assets or sectors to suffer adverse effects when exposed to a drought event. The level of vulnerability to a drought (of a specific type) is determined by the intrinsic characteristics of the asset or sector, and not all assets and sectors are equally vulnerable to all types of droughts (World Bank 2019).

Urban drought vulnerability can be defined as the extent to which the balance of urban water demand and supply is disrupted by drought, leaving the city unable to cope (Wang et al. 2020). Based on urban characteristics, socioeconomic factors (including water infrastructure) are key to understanding the drought vulnerability of urban systems, as distinct from the agricultural scale. A society's overall vulnerability to a disastrous outcome begins with the economic, political, and social structures and ideologies that shape the distribution of human, physical, political, and social capital in that society (Wang et al. 2020). Figure 5.5 illustrates the context and factors that influence the development of urban drought and possible impacts in the SADC region.

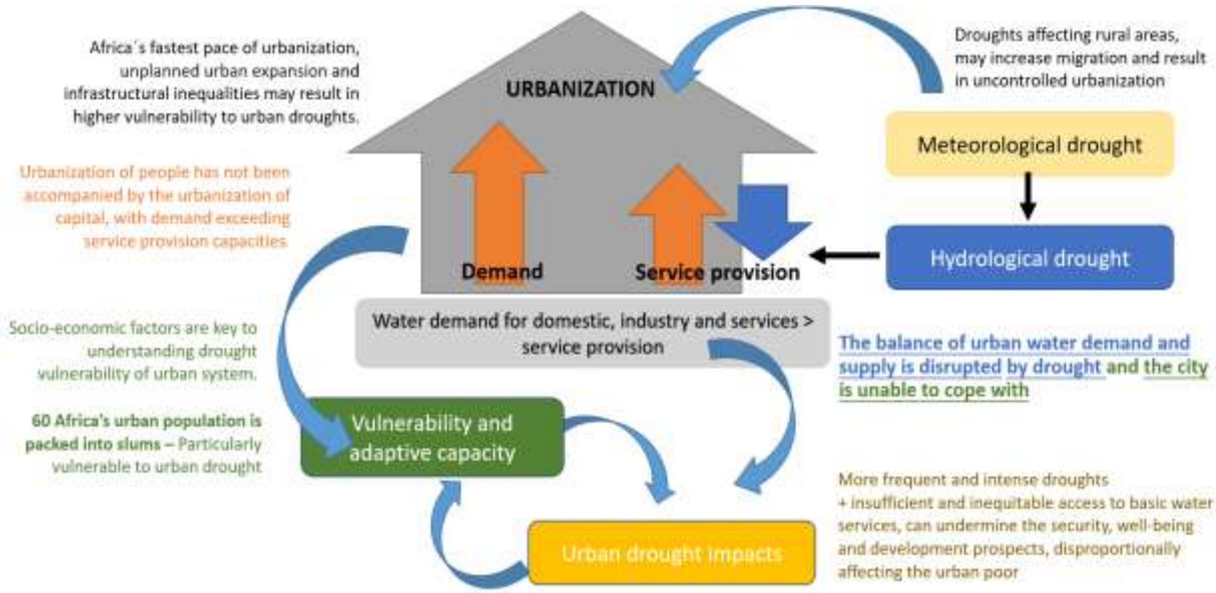
The impacts of a drought vary according to the city sector affected and the drought phase (Szalińska, Otop, and Tokarczyk 2018). Studies of drought vulnerability focused on the urban scale will explicitly provide decision-makers with the theoretical basis to reduce urban drought vulnerability and mitigate urban drought risk and urban drought impacts (Wang et al. 20120). But ultimately, reducing urban drought risk and vulnerability requires coherent actions from both city and water managers (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 inequalities may result in higher vulnerability to urban droughts. Water shortages may result from the current and likely future climatic conditions in the region and infrastructure limitations in terms of guaranteeing water availability and distribution. 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).

The risk associated with drought for any region or group is a product of the exposure to the natural hazard and the vulnerability of the society to the event. Drought hazard varies regionally and over time, and there is little, if anything, that can be done to alter its occurrence. 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. Therefore, the vulnerability profile is a cornerstone of drought risk reduction planning (UNDRR 2009).

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). Rapid and uncontrolled urbanization on the African continent had already resulted in 200 million people living in slums by 2014. On average, 60 percent of Africa's urban population lives in informal settlements—a far larger share than the average 34 percent seen in other low- and lower-middle-income countries (Lall, Henderson, and Venables 2017). 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).

Figure 5.5. Context and factors that Influence urban drought and impacts in SADC



Source: Original figure for this publication.

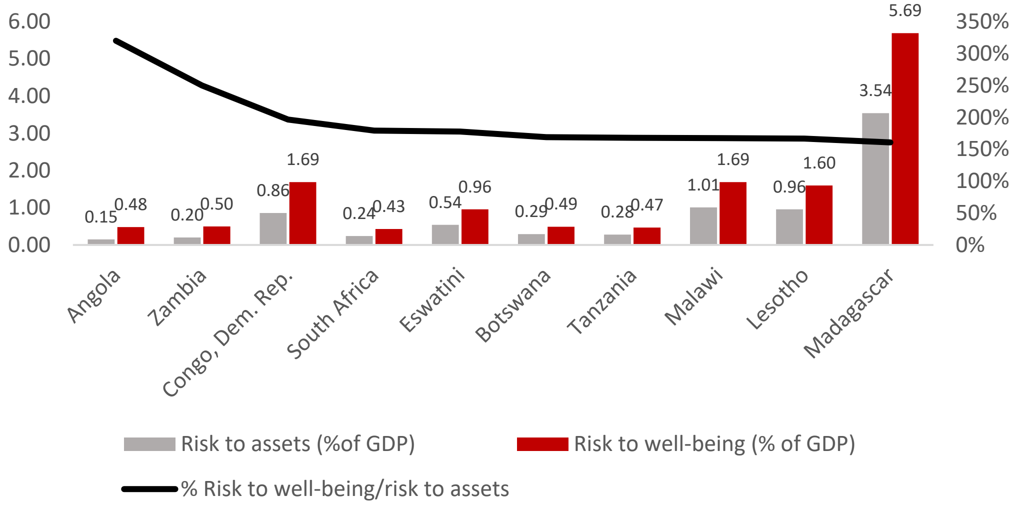
The Intergovernmental Panel on Climate Change report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* highlights exposure and vulnerability as determinants of risk (Cardona et al. 2012). The authors stress: "The severity of the impacts of weather and climate events 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, weak governance, and scarcity of livelihood options for the poor (high confidence)" (Cardona et al. 2012, 67 pp)**.**[12]

Poor people are disproportionately affected by natural hazards and disasters. Poor people tend to lose a larger fraction of their wealth and socioeconomic resilience when a disaster strikes and are unable to recover. Hallegatte et al. (2017) also found that based on estimates of socioeconomic resilience—and including in the analysis how poverty and lack of capacity to cope with disasters magnify losses in well-being—the effects of natural disasters lead to well-being losses that are 60 percent greater than the widely reported asset losses. They identified that in the SADC, the well-being to asset loss ratio ranged from 150 to 350 percent (Figure 5.6). Disaster risk management policy and risk mitigation plan designs should not stop at reflecting asset losses; in low- and lower-middle-income countries, disaster risk management can also be considered a means of poverty reduction (Hallegatte et al. 2017).

Urban drought vulnerability is understudied: "Drought vulnerability studies focus mainly on rural contexts (agriculture) where dependency to water (rainfall) is direct. The few studies that do refer to urban vulnerability conceive it as the risk of water supply drought. The unit of analysis is the water supply system, not the household" (Kallis 2008, 18 and 19 pp).

[12] 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).

Figure 5.6. Risk to Assets and Well-Being Losses in the SADC



Source: Original figure based on data from Hallegatte et al. (2017).

Urban droughts can have various types of impacts affecting citizens, businesses, and industries. Together, the increasing frequency of droughts and more erratic nature of rains in many countries—combined with underlying economic, environmental, and social vulnerabilities—results in greater impacts for at-risk populations (World Bank 2019) (Box 5.3).

Box 5.3 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

Poor people are faced with unequal opportunities to cope with shocks, being deprived of access to water services and having their needs inequitably ignored.

There is unequal exposure of women and children to extreme weather-related water insecurity. 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 the impacts of weather extremes 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 bear higher levels of poverty and lower levels of literacy than men (Maunganidze, Greve, and Kurnoth 2021). A gender analysis helps ensure that impact and vulnerability assessments consider women and men's different needs, roles, benefits, impacts, risks, and access to/control over resources (**Box 5.4**).

Box 5.4 Gender Analysis

The assessments also include considerations of intersecting categories of identity, such as age, social status, ethnicity, and marital status, to avoid reinforcing existing imbalances. This focus helps ensure that appropriate measures are taken to address these imbalances and to advance gender equality.

A gender analysis can reveal linkages between inequalities at different levels of society and possible conflict dynamics, as well as proximate or intermediate factors associated with a conflict (for example, gender-based violence). Such an analysis helps ensure that women and men have equal opportunities to participate in, contribute to, and benefit from interventions, and it can provide concrete approaches to address gender inequalities and identify strategies to advance women's empowerment.

A review of sex- and age-disaggregated data, national gender statistics, time-use surveys, national action plans, and qualitative data generated through policy and academic research and participation assessments should be used to inform the analysis. Information from stakeholder consultations and interviews should be incorporated into the analysis.

Source: United Nations et al. (2017).

Research and outreach activities have not yet focused on the features of vulnerable groups in these low- and lower-middle-income world (mega)cities and the structure of their vulnerability. Even in upper-middle- and high-income cities 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). The different vulnerabilities of various population groups should be further assessed, considering the diverse impacts of both the droughts themselves and of the mitigation and coping strategies.

Common elements of urban drought vulnerability in the SADC are rapid urbanization and increasing water demand, rising climate threats and increasingly constrained water resources, increasing strain on existing inefficient water infrastructure, institutional inefficiency and financial instability of water utilities, economic disparity, and inequalities in access to services that lead to disproportionate impacts on the urban poor. From large cities like Dar es Salaam (Tanzania) to small urban centers like Toliara (Madagascar), urban areas are experiencing rising urban drought challenges. Box 5.5 provides a brief glance at urban drought vulnerability in the SADC, elaborating on the situation in some of the region's main cities through case studies.

Box 5.5 A Brief Glance at Urban Drought Vulnerability in the SADC 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 2017a).
- 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 the preferred destination 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

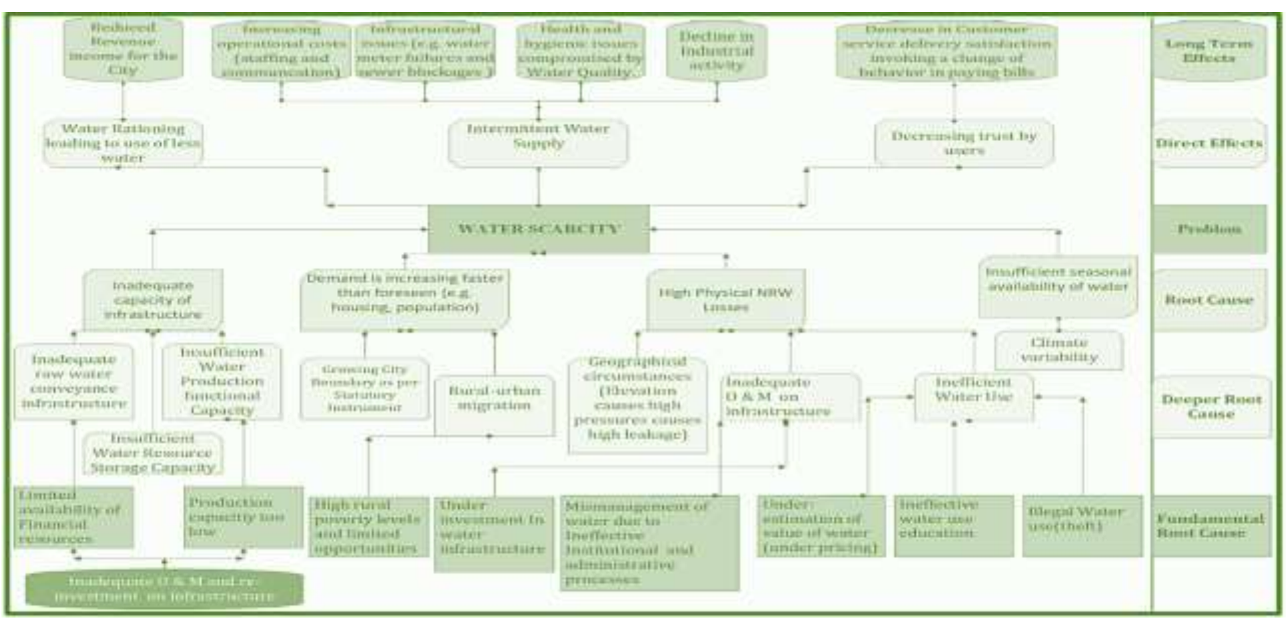
- Namibia is the most arid country in Sub-Saharan Africa, with a generally hot and dry climate marked by sparse and erratic rainfall. The country has perennial rivers only on its very northern and very southern borders, which are 750 kilometers and 900 kilometers from Windhoek respectively.
- Windhoek 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.

Figure 5.6 presents Bulawayo's water scarcity problem tree, developed by the Zimbabwean city's water utility to help assess future water supply improvements.

Figure 5.6. Bulawayo's Water Scarcity Problem Tree

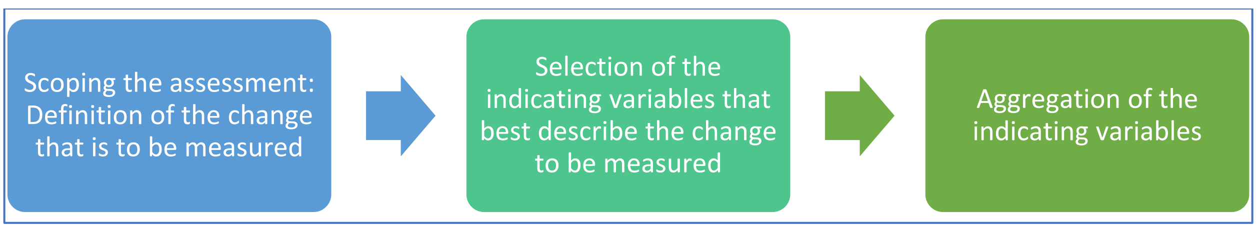


Source: (*Kwanele G. Sibanda, Bulawayo City Council, personal communication (December 21, 2021)*)

5.2.2 Select Appropriate Indicators

Indicators and indexes can be valuable tools for assessing urban drought impacts and vulnerability, because of their capacity to synthesize complex conditions and developments. Generally, vulnerability is assessed using a composite index that aggregates proxy indicators, thereby accounting for the various factors or aspects of vulnerability. As indicators serve the purpose of solving a problem, their potential can only be discussed adequately considering the specific problem in question. The purpose of impact and vulnerability assessments is to inform policy and decision-making (Hinkel 2011; Patt et al. 2009). 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). 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 variables that best describe the change to be measured; and (3) aggregation of the variables (Figure 5.7).

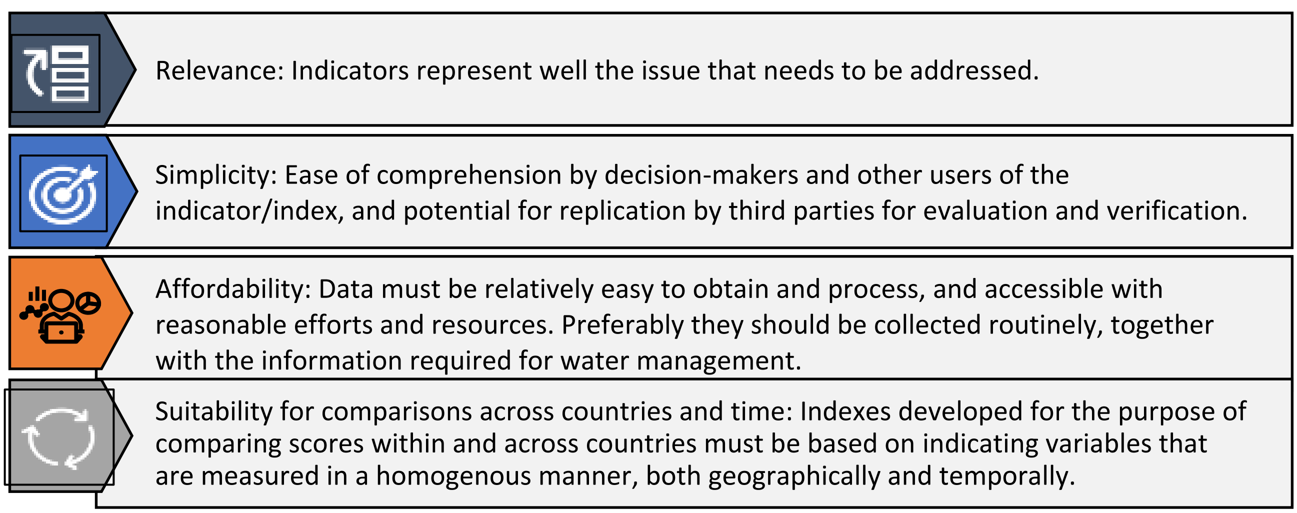
Figure 5.7. Steps Involved in the Development of Indicators



Source: Original figure for this publication.

Figure 5.8 describes a number of criteria that indicators must satisfy to receive support and be operational (Cap-Net UNDP 2020; GIZ, Eurac Research, and UNU-EHS 2018).

Figure 5.8. Criteria for Indicators to Receive Support and Be Operational



Source: Original figure for this publication.

Impact and vulnerability (risk) assessment methods range from global and national quantitative assessments to local qualitative participatory approaches. The appropriateness of a specific method depends on the adaptation or risk management issue to be addressed, including, for instance, the time and geographic scale involved, the number and type of actors, and economic and governance aspects (Cardona et al. 2012). Drought vulnerability assessments tend to be informed by the experiences of past droughts—particularly when it comes to economic assessments which often refer to specific costs associated with the impacts of past droughts. Economic activities and settlement patterns are, however, changing rapidly in many low- and lower-middle-income countries, creating a need to anticipate new, different types.

Indicators, indexes, and probabilistic metrics are important measures and techniques for risk and vulnerability analysis. *Quantitative vulnerability assessment must, however, be complemented with qualitative understanding of the complexity and the tangible and intangible aspects and dimensions of vulnerability. The selection of impact and vulnerability evaluation approaches depends on the decision-making context (Cardona et al. 2012). Indicators to assess urban drought vulnerability must address the root causes of the real and likely impacts of urban drought. Water supply is influenced, first by factors upon which water availability depends, like institutional capacity for water resources management, water storage capacity, diversification of water sources, international water treaties, and national allocation rules. But supply also hinges on the drivers of water distribution, like production efficiency, technology, distribution systems, and institutional capacity of water utilities or water departments. The effects of a water shortage will depend, however, on socioeconomic factors such as urbanization and poverty levels, the proportion of people living in slums, access to clean water, inequality, and unmet basic needs (*
Figure 5.9).

Figure 5.9. Categories of Urban Drought Vulnerability Indicators

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). Relevant drought and urban drought vulnerability assessment studies are summarized in Box 5.6.

Box 5.6 Relevant Studies and Methodologies on Drought and Urban Drought Vulnerability Assessment

Study: Urban Drought Vulnerability Assessment: A Framework to Integrate Socioeconomic, Physical, and Policy Index in a Vulnerability Contribution Analysis (Wang et al. 2020)

Study area: Beijing-Tianjin-Hebei, China

Methodology: Based on physical, socioeconomic, and political indicators, the study evaluated and analyzed urban drought vulnerability in the Beijing-Tianjin-Hebei region using spatial-temporal analysis and contribution analysis. Results indicate that economic factors were considered the main factors contributing to high drought vulnerability, while public budget expenditure, gross domestic product, and indicators related to education significantly contributed to urban drought vulnerability.

Study: Urban Drought (Szalińska, Otop, and Tokarczyk 2018)

Study area: Wroclaw, Poland

Methodology: In the city of Wroclaw, the highest vulnerability values in relation to drought and drought-related hazards were assigned to water supply, energy, industry, transportation, green areas, and a sensitive population. Vulnerability levels for the analyzed city components were estimated for extreme hot days, cooling degree days, heat waves, and meteorological drought hazards, as well as for long-term dry spells, dry spells with a high temperature, low flows, and hydrological drought hazards.

Study: Developing Water Security Index for Urban Areas (Ray and Shaw 2019)

Study area: Asia

Summary: This study proposes parameters and indicators to assess water security in urban areas and resilience in the urban water system to gauge sustainable development. Indicators have been used as a tool to describe the physical, socioeconomic, and institutional dimensions of urban water security. An indicator translates a complicated measurement into a simple one that is easy to understand, and which highlights the main characteristics of the system. The importance of indicators lies in their ability to communicate relevant information and facilitate decision-making. Apart from physical water scarcity, cities around the world also suffer from water insecurity, often magnified by improper water management. Hence, in the listing of indicators, greater emphasis has been placed on institutional dimensions of urban water security.

Study: Drought Vulnerability Indicators for Global-Scale Drought Risk Assessments: Global Expert Survey Results Report (Meza et al. 2019)

Study area: Global

Summary: An expert survey was conducted to weigh drought vulnerability indicators according to their relevance to agricultural systems and domestic water supply. Indicators originate from multiple dimensions (social, economic, infrastructure, crime and conflict, environmental, and farming practices) and are grouped into four subcategories: social susceptibility, environmental susceptibility, lack of coping capacity, and lack of adaptive capacity. The findings underline that the relevance of indicators strongly varies depending on the sector that is susceptible to the negative impacts of drought. Hence, the most relevant indicators for agricultural systems differ significantly from those for domestic water supply. The Globe Drought project uses the results of the study to include expert judgment in its vulnerability assessments.

Study: Exploring Drought Vulnerability in Africa: An Indicator Based Analysis To Be Used in Early Warning Systems (Naumann et al. 2014)

Study area: Africa

Summary: The authors propose a composite drought vulnerability index that reflects various aspects of drought vulnerability evaluated at Pan-African level for four components: renewable natural capital, economic capacity, human and civic resources, and infrastructure and technology. The selection of variables and weights reflects the assumption that a society with institutional capacity and coordination—as well as mechanisms for public participation—is less vulnerable to drought. Agriculture is considered by the researchers to be just one of many sectors affected by drought. The study includes three steps that aim to provide a transparent rundown of the construction of the composite drought vulnerability index and assist in the interpretation of results.

Study: Multi-Dimensional Assessment of Drought Vulnerability in Africa: 1960–2100 (Ahmadalipour and Moradkhani 2018)

Study area: Africa

Summary: In this study, a multidimensional modeling framework was implemented to investigate drought vulnerability at a national level across the African continent. Data for 28 factors across six components (that is, economy, energy and infrastructure, health, land use, society, and water resources) were collected for 46 African countries during the period 1960–2015, and a composite drought vulnerability index was calculated for each country.

Various analyses were conducted to assess the reliability and accuracy of each proposed drought vulnerability index, and the indexes were evaluated against historic observed drought impacts. Regression models were then fitted to the historic time series of the drought vulnerability index for each country and the models extrapolated for the period 2020–2100. This provided three future scenarios of drought vulnerability index projection (low, medium, and high) based on historic variations and trends. The future index projections indicate that the difference between the least and most vulnerable countries will increase in future, with most of the (least vulnerable) southern and northern African countries becoming less vulnerable to drought, whereas most of the (most vulnerable) central African countries indicate increasing drought vulnerability. The projected drought vulnerability indexes can be used for long-term drought risk analysis as well as strategic adaptation planning purposes.

The drought vulnerability assessment of this study was performed in seven steps: (1) data selection, preprocessing, and reformatting; (2) normalizing factors and calculation of vulnerability for each factor; (3) multicollinearity test and elimination of redundant factors; (4) weighting and averaging to calculate each drought vulnerability index; (5) cluster analysis and categorization of countries based on their vulnerability to drought; (6) change-point analysis and diagnosis of any substantial changes in historic drought vulnerability index; and (7) regression analysis and future drought vulnerability index projections.

5.2.3 Identify Data Sources and Develop Indicators

Given their capacity to synthesize complex conditions and developments, indicators and indexes can be valuable tools to assess urban drought impacts and vulnerability. In this example, three families of indicators are recommended for use in constructing an urban drought vulnerability index for each of the main cities of the SADC: (1) water availability; (2) water distribution systems; and (3) population exposure and socioeconomic vulnerability.

A practical tool to help TTLs estimate an urban drought vulnerability index for the main cities of the SADC is provided in the Workbook. The Workbook application results also help inform opportunities or needs for mitigation measures, policy recommendations, and resilient investments. 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 difference of the evaluation effect. For each indicator, the Workbook provides a description, explains its relevance, and gives example data sources.

Limited access or lack of data at the subnational and city level has been a constraint in the development of the urban drought vulnerability assessment tool, and the information provided reflects these limitations. It is suggested that users of the tool review indexes and update or gather information with greater spatial resolution at the city or water utility level, as appropriate or subject to availability.

At present, the selection of indicators and the assignment of their relative importance (within and across families) rely on expert knowledge and experience. For a more comprehensive urban drought vulnerability assessment, more data would be needed to select indicators and assign weights. Expert surveys and impact assessments from historic urban droughts in the SADC could help inform the factors or root causes that influence the risk of drought impacts in the region.

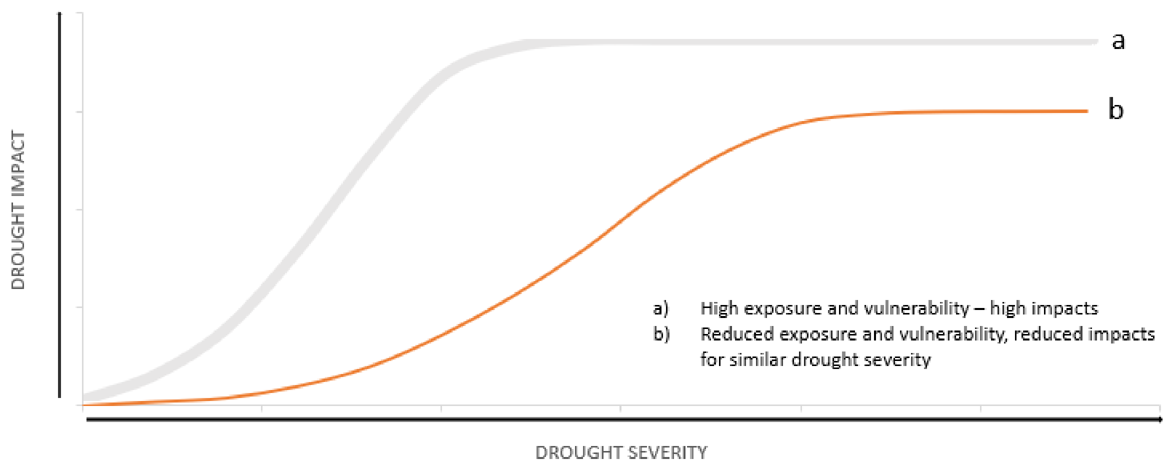
5.2.4 Use Impact and Vulnerability Assessment to Inform Mitigation

Impact and vulnerability assessments aim to inform appropriate drought mitigation, preparedness, and response (pillar 3). This includes policy recommendations to reduce urban drought vulnerability, enhance adaptive capacity, and reduce underlying disaster risk drivers, and the promotion of resilient investments to mitigate risk and ensure service provision.

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 likely 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.

Exposure and vulnerability are factors that can mediate the impacts that droughts will have on society at different levels of severity. 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 2019). Progress toward reducing or modifying vulnerability factors could then be measured and a clear economic case presented for such interventions (Figure 5.10).

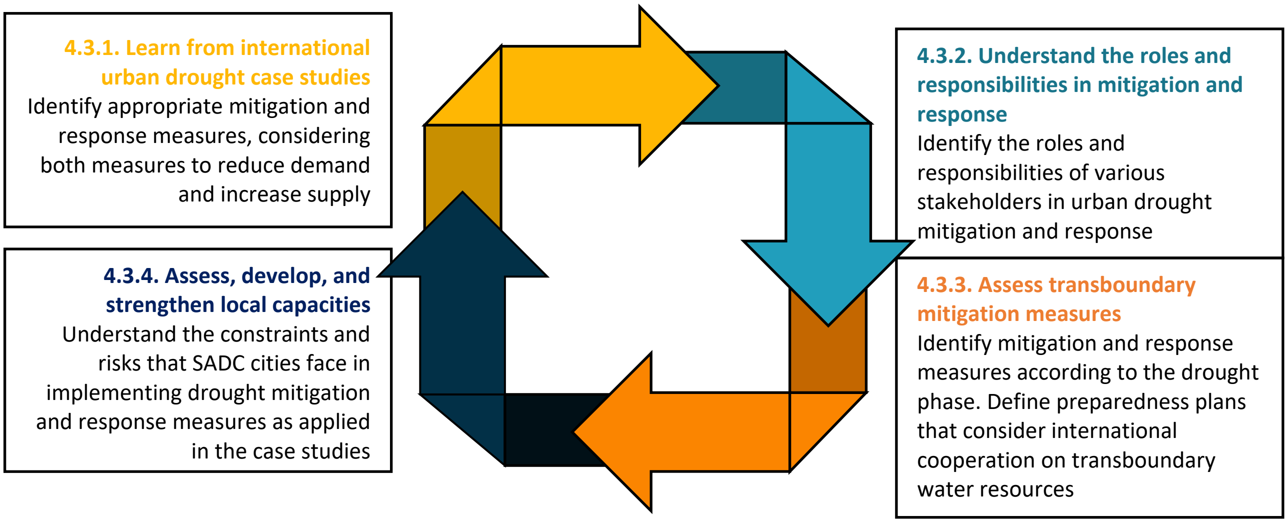
Figure 5.10. Assessment of Drought Impact and Vulnerability



5.3 Pillar 3: Urban Drought Mitigation, Preparedness, and Response

This section provides relevant information on urban drought mitigation, preparedness, and response. It helps identify relevant measures and gaps and recommends preparedness and response plans as applied in the case studies from around the world. These plans, in turn, suggest the prioritization and implementation of resilient investments, as shown in (Figure 5.11.

Figure 5.11. Mitigation, Preparedness, and Response Process



Source: Original figure for this publication.

5.3.1 Learn from International Urban Drought Case Studies

The costs of urban droughts will continue to grow—owing to climate change and expanding urbanization—and are magnified by relatively higher levels of returns from urban water use compared with agricultural water use. Drought mitigation and preparedness efforts in urban areas are therefore particularly important (Gerber and Mirzabaev 2017).

Urban droughts have been experienced in almost every world region in recent years and all the affected cities considered in their drought mitigation and preparedness plans the following measures:

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

Several ways to increase urban drought resilience and ensure droughtproof (resilient) urban areas have been suggested. Related to demand management, water conservation measures may include non-market and market mechanisms. Non-market mechanisms usually involve water conservation education and explicit restrictions on specific water uses, while market mechanisms involve increasing water prices during droughts. All such measures have significant transaction costs to enforce compliance, as well as loss of revenue for water utilities. On the other hand, increasing the price of water during periods of drought may pose challenges in terms of social equity in access to water—a human right. Beyond their immediate and short-term direct impacts, droughts may also have longer-term indirect impacts on urban economies and livelihoods. For example, a move toward more water-efficient home appliances may be prompted by water pricing and water conservation measures (Gerber and Mirzabaev 2017).

Urban droughts call for action from water managers to avoid a potential water shortage or to manage a shortage that has already begun. For maximum effectiveness, a risk-based approach to drought management is advocated. This should be based on estimation of drought hazards and drought impacts to identify and apply measures to counteract drought and drought-related impacts through mitigation, preparedness, and response/recovery planning. Drought mitigation relies on an effective water management system with a special emphasis on rainwater collection, storage, and treatment. Additionally, ensuring a sustainable city design, with open green spaces, and the protection of ecological corridors can help mitigate the impacts of drought-related heat waves (Szalińska, Otop, and Tokarczyk 2018).

Relevant countries with cities that have recently experienced severe drought impacts and from which lessons can be drawn include Australia, Brazil, China, Singapore, South Africa, and the United States (California). Zhang et al. (2019) summarize four representative and recent urban droughts and the actions taken and lessons learned (Box 5.7). Additional case studies of cities around the world that have coped with urban drought are found in the Workbook.

Box 5.7 *Lessons Learned from International Case Studies*

Durban/eThekwini, South Africa

A decade ago, the South African city of Durban suffered severe water shortages. Water storage levels in dam reservoirs were decreasing at an alarming rate, falling to as much as 20 percent lower than average. At least one in four residents were already living in water-stressed informal settlements. Municipal capacity was unable to keep pace with the rapid rate at which the city was expanding, and service backlogs and proliferating slums seemed to be entrenching poverty. Durban has been able to identify, target, and mitigate the root causes of the monumental water-related challenges for its 3 million residents. A regional approach was taken, with investment in participatory processes.

Durban has addressed these challenges with system-wide solutions that reach its informal settlements and avoid the use of costly materials. The regional approach was essential to reduce the pollution, waste, and erosion from forest degradation in upstream areas of the (Umgeni River) catchment. The effect was a reduction in negative impacts on water supplies and ecosystems downstream. The extensive community engagement processes identified system-wide levers for change. An additional benefit was the acquisition of a long-term vision for systemic, transformative change. The shared vision was developed with a wide range of groups (including the urban poor in informal settlements) who can then challenge the status quo, develop alternative solutions, and refine what resilience means in the specific context of the city of Durban (Kim et al. 2021).

Australian Cities

From late 1996 to mid-2010, much of southern Australia (except parts of central Western Australia) experienced the Millennium Drought or the Big Dry (which officially ended in 2012). The drought conditions were particularly extreme in the more densely populated southeast and southwest areas of the country and severely affected the Murray-Darling Basin and virtually all the southern cropping zones. During the Millennium Drought, Adelaide, Brisbane, Canberra, Hobart, Melbourne, Perth, and Sydney were all affected by persistent or periodic drought episodes. Addressing the severe drought required both supply-side and demand-side mitigation measures. [A]

The Millennium Drought demonstrated leading innovation and exceptional examples of water planning and management driven by crisis, as well as examples of missed opportunities, and initiatives and decisions that did not work out well (Turner et al. 2016). Useful lessons originally targeted at helping California's water authorities address the drought that started in 2012 and lasted until 2017 remain applicable for other cities facing similar situations of persistent drought (Table 5.1).

[a] For more information see http://www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.html

Table 5.1. Lessons Learned from the Millennium Drought in Australia

1. MANAGING CRISIS AND OPPORTUNITY	"The drought is both a crisis and an opportunity to innovate—to roll out new water-saving initiatives and incentives at scale, and to leverage community and political will to make the necessary policy and regulatory changes. Also, politicized and crisis-driven decision-making resulted in costly overinvestment".
2. WORKING TOGETHER	"Strong partnerships, knowledge sharing, and coordination between organizations—state governments and agencies, water utilities, research institutions, and industry—supported successful mitigation and response during the Millennium Drought. Following an emergency, such collaborations can dissolve, and the Australian governments and water utilities faced the challenge of retaining the knowledge and savings that these partnerships made possible". During the drought years, the partnerships stimulated a multimillion-dollar water efficiency industry.
3. SPEAKING AND LISTENING	Public communication and engagement on water-saving programs and "the water scarcity situation were essential to the success of all water-saving initiatives". In many places, "however, state governments and water utilities failed to grasp the opportunity to undertake best practice community engagement and water supply decision-making".
4. GETTING THE RULES RIGHT	"Governments need to implement best practice policy settings and regulatory arrangements to enable investment in cost- effective water supply measures including water efficiency measures". "It is crucial to have best practice regulations that encourage water utilities to invest in water efficiencies" among final users.
5. PICKING THE LOW-HANGING FRUIT	"During a drought, it is essential to consider all supply- and demand-side mitigation measures, and to prioritize implementation of 'no-regrets' least-cost options. To cope with the uncertainty of the drought in terms of length and severity, real options planning, and the concept of 'readiness to implement' enable decision-makers to prioritize options". Measures not previously implemented in the regions, like rebates for water-efficient washing machines in Western Australia and "cost-effective water-saving, were rolled out across states and cities. A permanent transformation of the industry and the market" resulted from this innovation.

Source: Taken and adapted from Turner et al. (2016).

In the Australian cities, in contrast to the other cities covered in the Toolkit case studies, most urban water suppliers were reluctant to purchase water from irrigators to augment their supply. "For example, Sydney pursued desalination, recycling, and a dam-raising project ahead of purchasing cheaper water from irrigators using the Tantangara Dam system. For many Australia's cities the agricultural water transfers were feasible and, in many cases, are cheaper and more environmentally friendly than the alternatives, but various government policies discourage the measures. Other reasons put forth for the disinclination to purchase water from irrigators include Australians' sympathy for farmers and the reluctance of politicians to disrupt the status quo in the absence of a strong demand from the electorate" (Heberger 2012, 114 pp).

Mexico's Main Cities

Mexico's National Program against Drought (Programa Nacional contra la Sequía; PRONACOSE) was launched in 2013 and favors preventive actions over reactive ones—which had been the previous approach—to address droughts and their effects. This proactive stance is in accordance with international best practice as promoted by the United Nations Educational, Scientific and Cultural Organization, United Nations Convention to Combat Desertification, Global Water Partnership, and World Meteorological Organization.

Within the PRONACOSE framework, 40 drought prevention and mitigation measures programs (Programas de Medidas Preventivas y de Mitigación a la Sequía; PMPMS) were integrated at the river basin level and for Mexico's main cities. The intention was to put in place, in advance, programs and actions that would be applied before, during, and after eventual situations of drought, with the aim of minimizing economic, environmental, and social impacts.

Between 2013 and 2015, 26 PMPMS at the river basin level were prepared, presented, and approved by the river basin councils (there is one council for each river basin in the country)[b].The objective was for the PMPMS to be appropriated by the governments and local institutions or delegations of the federal agencies, as well as by interested local actors that are integrated in the river basin councils. Along the same lines, PMPMS for Mexico's 22 main cities were also prepared within the framework of the river basin councils and the water and sanitation utilities following a common outline[c]. Both this effort and the previous work of program formulation were coordinated by university institutions funded by Mexico's national water authority, Comisión Nacional del Aqua.

Strategic, tactical, and emergency measures were also distinguished as alternatives for action for the cities. Strategic measures are long-term actions of an institutional and infrastructural nature, which are part of hydrological planning (storage and regulation structures, regulations, and use management). They require a long implementation period, large budgets, political negotiation, social acceptance, and—eventually—legislative modifications.

Tactical measures are short-term actions planned and validated in advance within the framework of the drought risk management plan. They are activated in the pre-alert and alert phases of drought. These types of measures are based on historic situations and are adopted once the pre-alert phase of drought has been verified through the system of indicators.

Emergency measures are adopted well into the drought and vary depending on the severity of the drought and its extent or degree of impact on the river basin (see the Monterrey city case study in the Workbook).

[b] For more details about the PMPMS, see the Government of Mexico website at https://www.gob.mx/conagua/acciones-y-programas/programas-de-medidas-preventivas-y-de- mitigacion-a-la-sequia-pmpms-por-consejo-de-cuenca.
[c] For more details on urban drought plans see the Government of Mexico website at https://www.gob.mx/conagua/acciones-y-programas/programa-nacional-contra-la-sequia-pronacose-programas-de-medidas-preventivas-y-de-mitigacion-a-la-sequia-pmpms-para-ciudades.

US Cities

An analysis of current policies to combat urban drought in the United States—to build climate adaptation capacity—showed that drought responses overall are seen as successful in reducing water demand and helping maintain system reliability, but they can also reduce flexibility and introduce other limitations. Among the findings on drought response options that played a dominant role were public perception, the multipurpose nature of water, revenue structures, expectations, and other social factors. Also, some urban water utilities faced challenges in measuring the effectiveness of demand reduction strategies. Demand reduction was the most popular overarching category of drought responses, compared with augmentation of water supply. Public communication was also identified as a relevant drought response strategy. Most water utilities, however, rely on several strategies and the engagement of multiple actors (Dilling et al. 2019).

Barcelona's Urban Drought in 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 Euro, 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 5.2 summarizes the total annualized costs of the drought and provides an indication 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. Notably, crisis management measures are far more costly, and typically involve the transportation of water. Demand reduction actions were significantly more cost-efficient than supply augmentation measures. .

Table 5.2. 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[14]
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: Table based on data from Martin-Ortega and Markandya (2009).

5.3.2 Understand the Roles and Responsibilities in Mitigation and Response

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 the Cape Town (South Africa) case study regarding governance make clear the need to strengthen transversal management between municipal departments; build systems and relationships of mutual accountability for effective water management between spheres of government; strengthen leadership and the capacity to enable flexible, adaptive decision-making; and invest in partnerships beyond the city government (Ziervogel 2019). Also, the cases from California (United States), Australia, and Mexico highlight the importance of strengthening institutions, leadership, roles, (binding) laws, and data sharing and communication throughout the 'drought life cycle'.

The experience of US cities shows that managing drought locally in an urban context relies on a complex web of relationships between water utility decision-makers, elected officials, organized civic groups, domestic customers, commercial and industrial users, and regulating legal institutions. Concerns about public perception and participation can also have a great influence on decision-making by water utilities in response to drought (Dilling et al. 2019).

The case study of the US cities also shows the importance of mapping the relevant actors and their roles in mitigation and response and of including this rundown of roles in the preparedness plan (Box 5.8).

A comprehensive compilation of urban drought risk mitigation measures from all over the world is included in the Workbook. This also includes the recommended time frame for implementation of the measures and identifies the vulnerability factors that can be addressed for risk reduction.

Box 5.8 International Case Studies on Roles and Responsibilities in Mitigation and Response

California's *Urban Drought Guidebook*

[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.
[14] 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.

The State of California (United States) has led the way in addressing water shortages since the 1990s and is one of the most advanced American states in this area today. California published the first *Urban Drought Guidebook* in 1988, updating it in 1991. An upgrade followed in 2008, owing to several situations and challenges facing California water managers, including the fact that each successive year was being declared the hottest and driest year on record; urban growth and water demand were both increasing; and the reliability of water deliveries was diminishing with the rising uncertainty and variability in demand.

The aim of the *Urban Drought Guidebook* is to provide a 7-step process to anticipate and respond to water shortages due to drought. The guide discusses water shortage management programs that belong in water shortage contingency plans (State of California 2008).

Since 1983, the State of California requires every urban water supplier that either provides water to 3,000 or more customers or provides more than 3.7 million cubic meters (3,000 acre-feet) of water annually to develop and implement an urban water management plan (California Water Code, sections 10610–10657). Water suppliers must update this plan every five years. The Urban Water Management Planning Act (1984) describes the contents of an urban water management plan as well as how urban water suppliers should adopt and implement such a plan (State of California 2008).

An important requirement is that each water supplier must prepare an urban water contingency analysis (California Water Code, section 10632). The analysis includes six components: (1) a description of the steps of action an agency will take in response to water shortages; (2) an estimate of supply for three consecutive dry years; (3) a plan for dealing with a catastrophic supply interruption; (4) a list of the prohibitions, penalties, and consumption reduction methods to be used; (5) an analysis of expected revenue effects of reduced sales during shortages and proposed measures to overcome those effects; and (6) details of how the water supplier will monitor and document water cutbacks.

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 (see the Workbook). Tasks are not necessarily in the order that a particular water supplier will follow, and some tasks can be carried out simultaneously. Combined with the information provided in the 7-step process, the checklist can help form the foundation of a water supplier’s water shortage contingency plan and actions (State of California 2008). The contingency plan serves as a useful responsive tool when urban drought is present.

What is worth noting is that the mitigation measures at the urban level look to the watershed as an indicator of the reliability of water supply sources. Another relevant aspect is that the guide features many case studies of cities. Chapters include “Manchester, Connecticut, Drought Contingency Plan”; “City of Denver, May 2004 Drought Response Plan – Early Versus Delayed Implementation”; “Programs Adopted by Retail Water Suppliers during California Drought 1976–77”; and “City of Denver, May 2004 Drought Response Plan – Stage Criteria”. There is also a box entitled “Communications Plan Key in Denver Drought Plan”.

As with any other urban drought risk mitigation measures and response plan, California’s *Urban Drought Guidebook* addresses the natural hazard in two ways: supply augmentation measures and demand reduction measures. The guide points out, however, with widespread use of the internet—which allows for information sharing and communication at a level unimagined in previous decades—comes the more efficient use of water, enabled by new technologies ranging from commercial cooling towers to smart irrigation controllers. Regional alliances have been established, often on a formal basis, to coordinate water supply and demand management efforts (State of California 2008).

California released a new Water Supply Strategy: Adapting to a Hotter, Drier Future which (August 2022) which takes up the concepts of the Guidebook improving water conservation to stretch water supply and enable water suppliers to become more resilient to current and future droughts supporting them with 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.

Lima and Arequipa Contingency Plans

In the cases of Lima and Arequipa (Peru), as in the California example, the water utilities are mandated by law (Law No. 28551, that Establishes the Obligation to Prepare and Present Contingency Plans) to prepare, present, update, and implement contingency plans for various hazards, including drought.

Most of the mitigation measures are on the supply side, to secure water sources and water quality. For Lima and Arequipa, wells are the main sources of water—whether using or adding new depth to old wells or drilling new wells—if the dams go empty (ANDINA 2014). In both cases, the distribution of water to informal settlements by truck is common and, in drought contingency efforts, this plays a crucial role. In either city, water rationing and public communication are the demand-side mitigation measures most often presented. Roles and responsibilities for the mitigation measures are established in the contingency plans, as mandated by law.

The specific protocol for triggering the mitigation measures in each city is established in its contingency plan (as per the law) and is linked to the National Meteorology and Hydrology Service.

Source: ANDINA (2014); SEDAPAR (2015).

Relevant cross-cutting lessons from the SADC city case studies to mitigate drought risk is shown in Box 5.9.

Box 5.9 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 historic divisions, especially considering preexisting inequalities in access to water. For example:
    a. The impact of water shortages is disproportionately felt by the urban poor.
    b. Restrictions that limit water consumption can also lead to significant impacts on other sectors, affecting the economies of both the city and the country at large.
    c. Prioritizing human consumption of water is not always possible in a low-income country context. Balancing competing pressures on water use—such as for 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.
    d. Demand reduction measures challenge the fiscal stability of the water utilities and, in turn, their commercial viability; financial models must allow and account for reduced direct income.
2. Crisis management approaches have been ineffective in reducing urban drought vulnerability and have enhanced the high dependence on external assistance and humanitarian aid. Urban water services face complex and demanding challenges due to growing urban populations, continuing infrastructural decay, limited fiscal and institutional capacity, and inadequate water governance.
3. Water supply in the Southern African Development Community (SADC) region 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 the limited data available, which minimizes the ability to forecast severe drought conditions. Monitoring and early warning 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, considering both demand reduction and supply augmentation measures.
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. Establishing clear, credible communication about the drought situation and response is paramount to the engagement of public participation and support.
8. Multimodal outreach approaches to promotion, education, and communication can span information about water savings, water storage levels, incentives to reduce water use, requirements and expectations about drought, and planned supply options.
9. Water governance is the cornerstone of effective urban drought risk management. Good water governance includes systems and relationships between spheres of government and between national government agencies, decentralized water utilities and/or municipal departments and entities, stakeholder sectors, and communities at risk. Institutional arrangements and a supporting legal framework need to establish clear roles and coordination mechanisms for the institutions and organizations at national, regional, and city level. Enhancing cross-sectoral knowledge and understanding among climate, water, disaster risk, and urban decision-makers and professionals is crucial for sound urban drought risk management.
10. 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) are needed. 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.
11. Water infrastructure investments need to be complemented by policy reform to enhance water governance, improve 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/inequality reduction strategies, improve the urban drought management capacities and fiscal resilience of water utilities and cities, and enable drought risk financing instruments.
12. Implementing a water-sensitive, resilient, and equitable city vision is necessary to reduce urban drought risk, mitigate the potential impacts of urban droughts—especially on poor and marginalized populations—and build more resilient cities.

City specific lessons from the case studies are outlined in Box 5.10.

Box 5.10 SADC cities urban drought key 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) have inadequate capacity to forecast reliable drought (urban drought) due to drought's distinctive characteristics as compared to others natural disasters. Knowledge, skills, and tools are urgently required for national and city institutions involved in drought monitoring and early warning systems to improve on managing urban drought. The LWB is developing a climate change strategy based on recent experiences on drought response (2015/2016). This instrument consider strengthening the limited monitoring and warning capacity of the phenomenon and improve the skills of the human resources of the utility and focuses on reducing the water deficit.

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, the 40 years of experience in Windhoek shows that with persistent, well-designed, and targeted communication to the public, this perception can be changed. Windhoek has made significant advancements in building urban drought resilience in a water scarce context by applying integrated drought and water management. The city has developed drought response and water management plans at city level, that include both demand reduction and supply augmentation and 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 might have helped citizens to understand the importance of restrictions, as well as the reasons behind the City's interventions.

5.3.3 Assess Transboundary Mitigation Measures

International case studies show that to set sound drought risk mitigation measures, the entire river basin must be considered. Today, the Colorado River is experiencing a megadrought, the impact and negative effects of which have badly hit the urban water systems of the western United States and northwestern Mexico, where more than 40 million people rely on the Colorado River as the main water supply source.

The 1944 Water Treaty between Mexico and the United States, concerning water distribution and allocation, set rules for sharing water from the Colorado River and Rio Bravo/Grande. Among those complex and differentiated rules for each river basin, the concept of 'extraordinary drought' is introduced 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.[15]

Many African cities rely on shared water sources in transboundary river basins and aquifers. 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 countries have water agreements but not all river basins and countries are covered by clear water distribution rules in case of drought. The Jordanian case can be very enlightning for the SADC in the sense of integration of the transboundary dimension into the national drought plans and policies (Box 5.11)

Box 5.11 Lessons from a Transboundary Case Study: Jordanian Drought Risk Management System

A Jordanian case study for the water sector (not only water and sanitation) investigated drought impacts on groundwater basins based on measurements of the probability and severity of drought occurrence, and of drought exposure for the entire country. Impacts were computed by means of a combined drought index that included Jordan's Precipitation Drought Index, Temperature Drought Index, and Vegetation Drought Index for 1980 to 2017.

Drought in Jordan is characterized by temporal and spatial variability in terms of probability of occurrence and severity. The study showed that the most prolonged drought events ranged from mild to moderate severity, with long periods of exposure that extended for up to 13 consecutive years. In the Jordan context, the high sensitivity of groundwater basins and low adaptive capacity make the groundwater systems fragile and highly vulnerable to drought impacts, resulting in a reduction in water quantity and/or deterioration in water quality over time (Al Adaileh et al. 2019).

The recommended drought risk management system included proactive and contingency plans enabled by national-level policies and legal frameworks to ensure sustainable water resilience and governance. For appropriate engagement in drought risk management, present water planners should consider the following:

- Building willingness among decision-makers by recognizing the importance of cooperation and collaboration
- Strengthening the current means of communication, and making all plans in coordination with the water sector representative on any national climate action committee
- Ensuring consistency between water sector policies and climate action/drought policies by encouraging each sector to participate in the planning for the other sectors
- Clarifying accountability and follow-up and ensuring transparency to achieve objectives that depend on external factors such as climate variability and social unrest due to security issues
- Ensuring that climate action and drought planners continue to be aware of the importance of water managers' participation in all activities, including capacity-building programs.

[15] For more details about the transboundary water sharing between Mexico and the United States, see the International Boundary and Water Commission website at https://www.ibwc.gov/home.html.

The Jordanian case study recommends that drought risk management is mainstreamed into all the country's development policies, plans, and programs. Drought awareness at all levels of society is crucial, including by facilitating the dissemination—by printed, audiovisual, and other appropriate means—of environmental policies, strategies, regulations, and standards.

Although this case study suggests several drought risk management measures for the water sector, drought adaptation plans should be institutionalized as an integral part of the development planning process. Promotion and support are also needed 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).

5.3.4 Assess, Develop, and Strengthen Local Capacities

The impact and vulnerability (risk) assessment outlined in section 4.2 informs the selection/prioritization of recommended mitigation, preparedness, and response measures. The analysis identifies the weaknesses and gaps to be filled for each of the following broad components: water availability, distribution systems, and population exposure and vulnerability. The preceding subsections of section 4.3 (and the Workbook) provide mitigation, preparedness, and response measure options to address the improvement needs of each component.

There is no one-size-fits-all set of mitigation, preparedness, and response measures. The selection should aim to focus more on resilience measures based on the context of the water utility and city. A sufficiently high spatial resolution and comprehensive impact and vulnerability assessment is crucial to understand what measures are relevant for the specific water utility, city, or country.

Consideration of Regional Context

Although not all SADC cities have the same resources as the drought-exposed cities in the international case studies, the mitigation measures and contingency plans discussed are still useful in terms of options to consider, adapt, and implement. The case studies address urban drought through a combination of supply- and demand-side mitigation measures. The governance (transboundary surface and groundwater), as well as the water quantity and quality for the supply-side are relevant topics for the SADC context. As regards of the demand-side the unplanned growth and the reliability of the water supply services are crucial themes to consider:

- The 12 mainland African states of the SADC are linked by 18 river basins that cross international political boundaries.[16] 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.

[16] The 18 river basins are: Buzi, Congo, Cuvelai, Incomati, Kunene, Limpopo, Maputo, Maputo-Usutu-Pongola, Nile, Okavango, Orange, Orange-Senqu, Pungwe, Ruvuma, Sabi (Save), Umbeluzi, Umbilici, and the Zambezi.

- 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.

Also, before selecting demand-side measures, it is important to consider regional features that differentiate the SADC context from other regional contexts:

- 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) (see the Workbook).
- 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.

Additional Recommendations on the Selection of Measures and Investment Decisions

Even with the differences in regional context, the Australian case study offers key messages and lessons that can be adapted to the SADC context to support the selection of mitigation measures and prioritization of investments to respond to urban drought (Table 5.2). Detailed descriptions of the criteria for investment and of the lessons learned are given in the Workbook.

Table 5.2 Key Messages and Lessons Learned from the Millennium Drought, Australia

	Lessons learned				
Decision criteria areas	1. Managing crisis and opportunity	2. Working together	3. Speaking and listening	4. Getting the rules right	5. Picking the low-hanging fruit (the ready prepared measures)
Combination of different strategies	**X**	**X**			
Financial decision	**X**				**X**

Powerful demand-side programs		X		X	
Effective supply-side strategy				X	X
Communication	X		X		
Measurement				X	X
Water and services pricing	X		X		

Source: Original table for this publication.

A World Resources Institute report (Workalemahu Habtemariam et al. 2021) highlights four priority pathways for African cities to drive transformation toward water resilience to face drought and other related challenges:

- *Plan for water*. Mainstream risk-informed land management and water-sensitive urban development.
- *Prioritize the most vulnerable*. Increase equitable access to safe water and sanitation.
- *Create change at scale*. Develop innovative institutions and pursue partnerships for water resilience.
- *Get finance right*. Increase and align water-resilient investments across sectors.

Once the local capacities and experiences of SADC cities/water utilities in relation to drought mitigation and preparedness have been assessed and existing resources identified, the selected and implemented measures should be benchmarked against the experiences of cities featured in international case studies. This will serve to not only assess implementation progress and identify any required improvements, but also to learn from the mistakes of other cities prior to further implementation of the urban drought risk management policy and plans.

It is highly recommended that task team leaders (TTLs) analyze the rapid urban drought risk management assessments for Blantyre (Malawi) and Dar es Salaam (Tanzania) using the simplified urban drought vulnerability assessment (Box 5.12, and appendix B). TTLs should also review the initial data basic collection questionnaire, the Bulawayo (Zimbabwe) and Toliara (Madagascar) case studies, and the international case studies and mitigation, preparedness, and response measures, all of which are contained in the Workbook.

Box 5.12 Blantyre, Malawi: Rapid Urban Drought Vulnerability Assessment

Blantyre is Malawi's second largest city by population (800,264 inhabitants in 2018) and size, covering an area of 240 square kilometers. It is Malawi's main commercial city and hosts most of the private sector headquarters in the country (Mawenda, Watanabe, and Avtar 2020).

Malawi has inadequate capacity to forecast drought reliably and at a high spatial resolution. Knowledge, skills, and tools are urgently required for institutions and individuals involved in drought monitoring and early warning systems. In Malawi, two types of drought monitoring and early warning systems are used: scientific and traditional (Malawi Government 2013). Scientific systems are based on indicators derived from variables such as climate, soil moisture, and streamflow. Traditional systems use the behavior of plants or animals. Blantyre city has no early warning systems (World Bank et al. 2017).

Considering the interactions between the social, economic, and physical subsystems in Blantyre, and by assessing the conditions that make the city and its population susceptible to adverse effects when affected by droughts, some vulnerability factors can be identified (for the full rapid urban drought vulnerability assessment, see appendix C; for a simplified version, see appendix B). Blantyre's vulnerability factors include the following:

- Blantyre is producing insufficient water to meet current demand, and demand will likely increase in future as the city's population grows (National Planning Commission 2021).

- Water supply coverage is low (73.8 percent of the population) and even more so for household connections (45.86 percent of households). Network density in Blantyre is among the lowest of cities in the Southern African Development Community (SADC) region, at 27.37 connections per kilometer. This is almost half that of Cape Town (South Africa): 60.62 connections per kilometer; or Antananarivo (Madagascar): 67.05 connections per kilometer (IBNET 2021).
- Non-revenue water losses are estimated to be as high as 46 percent of non-revenue water, equivalent to 23.3 cubic meters per kilometer per day (IBNET 2021).
- There are inequalities in access to water, with informal settlements receiving less than 5 percent of supplied water despite accounting for 1.5 times the number of people as domestic households (National Planning Commission 2021).
- Competing pressures on water use: Blantyre's economy (and that of Malawi) relies on the commercial and industrial sectors.
- The city is highly dependent on surface water and on the Walker's Ferry offtake.
- The water utility is under strain in terms of its capacity, and it is financially unsustainable (Kalulu and Hoko 2010).
- The energy required to pump water from Walker's Ferry to Blantyre contributes to the cost of electricity accounting for 40 percent of the water utility's total operating costs. Frequent blackouts (Kalulu and Hoko 2010) continue to negatively affect the delivery of water.
- Water consumption is relatively low, compared with other cities in the region. Blantyre's consumption is estimated at 62.98 liters per person per day (compared with Cape Town's consumption of 216 liters per person per day) (IBNET 2021).
- Blantyre scores 41.2 on the International Wealth Index, which measures the economic situation of households based on their ownership of assets, housing quality, and access to public services. The International Wealth Index runs from 0 to 100, with 0 representing nil assets, the lowest quality of housing, and no access to services, and 100 representing all assets, the highest quality of housing, and full access to services.
- An estimated 65 percent of households in Blantyre are poor—that is, they have an International Wealth Index score of less than 50.
- The city scores 0.56 on the Subnational Human Development Index, which considers the dimensions of education, health, and standard of living.

Based on the Urban Drought Risk Management Framework (UDRMF) rapid impact and vulnerability (risk) analysis, four key findings are highlighted for Blantyre:

- There is no reliable urban drought monitoring, and early warning systems are not in place.
- Insufficient and aging water and sanitation infrastructure and high energy demand lead to unmet water demand and the financial instability of the water utility.
- Population growth, particularly in informal settlements, puts additional strain on the city's already inadequate water provision capabilities.
- No preventive or contingency plan or strategy for urban drought is available, and there is only weak urban drought governance (as part of disaster risk reduction).

According to the UDRMF, two groups of measures are recommended based on the key findings of the vulnerability and risk analysis developed for Blantyre. All measures that feature in the UDRMF apply, and some of the measures should be used regardless of the drought phase. The two groups of measures recommended for Blantyre are:

- Necessary preventive measures to minimize drought impacts in advance (including predefined measures for optimal response and recovery).
- Contingency (responsive) measures to reduce impacts of an existing urban drought.

Five key policy and investment opportunities are identified:

- Establishment of an early warning system coupled with a disaster risk management plan for the city as part of the ongoing World Bank Malawi Resilience and Disaster Risk Management Project (previously known as the Malawi Drought Recovery and Resilience Project) (UDRMF pillar 1: monitoring and early warning).

- Immediate implementation of a long-standing program to minimize non-revenue water or not-accounted-for water through the replacement of aging infrastructure and the construction of a new pipeline network; and roll out of a contingency program to set up automated water kiosks (more water supplied to kiosks, reducing wastage, water operating costs, and waiting times) to increase water availability and accessibility for the population (UDRMF pillar 2: impact and vulnerability assessment—infrastructure dimension; and pillar 3: mitigation, preparedness, and response).
- Development of a new water source (project identified by Blantyre Water Board, to target the Shire River Basin); construction of emergency boreholes, including rehabilitation of existing boreholes; and development of secure and sufficient hydroelectric generation (UDRMF pillar 3: mitigation, preparedness, and response).
- Support for and enforcement of resilient urbanization programs for informal settlement areas (for example, a national slum upgrading project) (UDRMF pillar 2: impact and vulnerability—social dimension; and pillar 3: mitigation, preparedness, and response).
- Drastic strengthening of preventive and emergency mitigation, preparedness, and response, while contingency plans need to be updated, reviewed, exercised, and better aligned to the budget cycle (especially the Shire River Basin and Blantyre City drought risk management plans from the World Bank project). This drought risk management planning must be mainstreamed in development strategies and programs and be supported by adequate (that is, more comprehensive, preventive, and enforced) institutional and legal frameworks (pillar 3: mitigation, preparedness, and response—governance).

6 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 and responsiveness to water utility needs.[17]

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. The operational evaluation program is proposed to help keep the drought assessment and response system current and responsive to the changing needs of society. Following the initial establishment of the urban drought risk management plan, 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 overall scope of the operational evaluation program is represented by four segments: impact, effectiveness, efficiency, and appropriateness. Each segment represents the activities that will be pursued through lines of enquiry (Figure 6.1). 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.

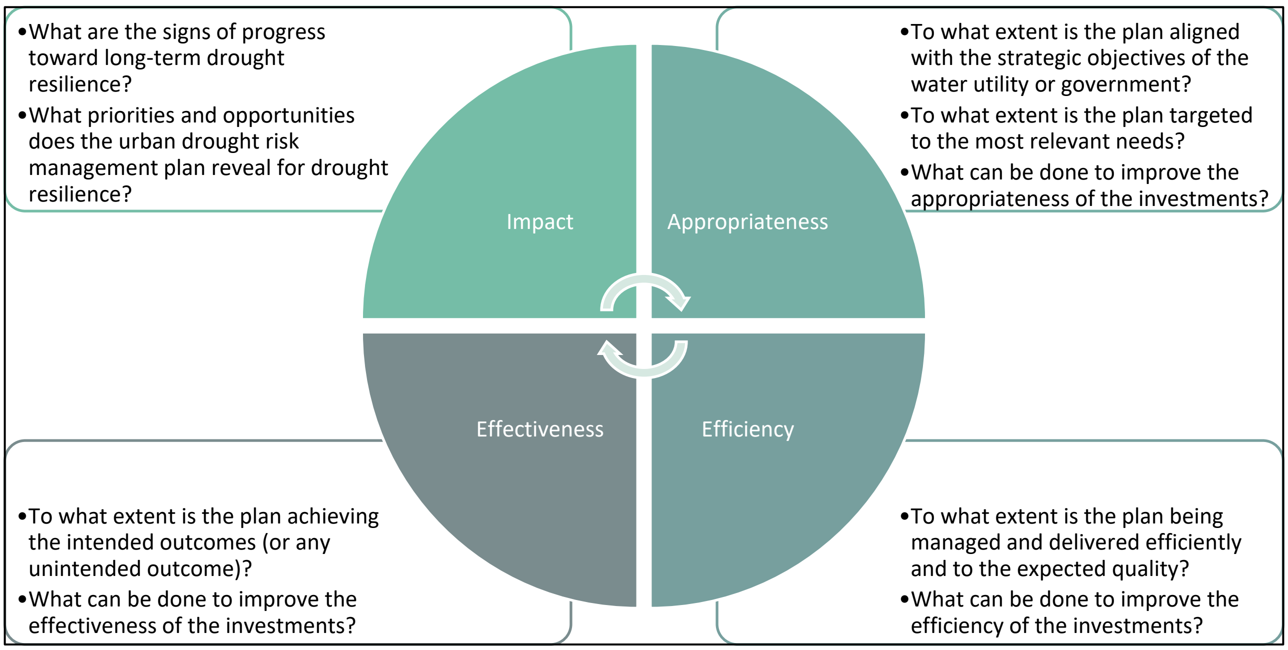
Progress toward the desired outcomes in an urban drought risk management plan is best measured using two types of indicators:
1. High-level drought resilience indicators, to monitor patterns in drought resilience over time as the plan is implemented, and to refine the measures or support the development of new interventions.
2. Measures-level indicators, to track how each measure contributes to 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, the natural attrition of people in primary leadership positions, and the destruction of critical documentation of events and actions taken.

[17] *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 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.

Post-drought evaluation should analysis of the physical aspects of a drought: its impacts on soil, groundwater, plants, and animals; its economic and social consequences; and the extent to which predrought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post drought recovery. Evaluations should not only focus on failure of coping mechanisms, but also pay attention to drought-coping mechanisms that worked, and where communities showed resilience. Provision must be made to implement the recommendations from evaluation. Drawing on evaluations of previous responses to drought is recommended as a planning aid to inform both technical and relief actions. To ensure unbiased appraisals, water utilities or governments should preferably commission independent evaluators. (UNEP 1992; Wilhite 1991) (Box 6.1).

Figure 6.1. Scope of the Operational Evaluation Program



Source: Original figure for this publication.

Box 6.1 Post drought Evaluation: Key Questions

The post drought evaluation review team should ask the following questions:

- Was the urban drought risk management plan followed? If not, why not?
- Were the actions and preventive measures effective in mitigating drought impacts? Which actions were not effective?
- 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 such 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, and what role did they play in the emergency?

7 Conclusion and Final Remarks

The *Urban Drought Toolkit for Task Team Leaders in SADC* provides a conceptual framework, guidelines, methodologies, tools, and data sources to assist task team leaders (TTLs) and task teams in identifying necessary—and tailored—measures, investments, policy reforms, and analytical work to improve urban drought risk management and disaster risk resilience . Through this work, TTLs and teams can support engagement with clients, complement ongoing initiatives and operations, and enable new ones.

Countries of Southern Africa experience differences in precipitation—highly seasonal in most countries—between the tropical climates in the north of the SADC region and the arid and semiarid southern and central areas. Drought influences water availability, alongside other factors that may heighten scarcity, including population growth, migration, and climate change. Competing pressures on water use often affect water quality: in some cases, water may be available but not fit for human consumption or domestic use.

Droughts are common in SADC, and while they account for less than 20 percent of natural disasters in the region, they may also contribute the severity of other natural disasters (UNDRR 2009). Yet, urban drought is understudied and underestimated in the SADC. Drought monitoring and early warning, even at the national level, are generally limited, in part due to weak monitoring networks and lack of access to information and technology. This prevents the development of local systems and leads to low institutional capacity and a lack of national policy on urban drought prevention and mitigation.

For a sound assessment of urban drought risk management in SADC, the data collection to apply the three pillars approach is crucial and must consider the following, and the questionnaire in appendix A):

- **Due to the limited resources to monitor drought and alert the population, remote sensing (satellite drought monitoring) is a particularly promising source of information on drought in the SADC**. It is possible to measure every component of the hydrological cycle at the land surface, as well as the state of natural vegetation and agriculture, often at a very high spatial resolution (less than 1 kilometer) and in near-real time. Monitoring the drought conditions (meteorological and hydrological droughts) at watersheds, where urban populations in the SADC have water sources, is key. This Toolkit provides a monitoring scheme that can be adapted to the specific context.

- **Climate impact and vulnerability (risk) assessment regarding urban drought requires ground data (global data sets are an option, but resolution could be an issue) to be developed and updated periodically, given the rapid rate of urbanization (high growth rate of slums or unplanned settlements) in SADC capital cities**. Consider that urban drought usually surpasses a water utility's capacity to provide water and sanitation services. Drought impact and vulnerability assessment of urban drought must consider periodically available data to evaluate progress in reducing urban drought risk and vulnerability. The Toolkit covers several methodologies, but none have been systematically applied in SADC capitals or other cities using benchmarks for urban drought risk and vulnerability.

- **Drought risk mitigation measures and preparedness at the national and municipal level are mostly linked to disaster risk reduction plans in the SADC region, and hence often not a priority for national policy**. With drought at country level often underestimated, urban drought often is even less prioritized, although high profile cases like Cape Town and Nelson Mandela Bay in South Africa, and Dar es Salaam in Tanzania have sparked renewed interest in the issue. Similar examples in other parts of the world – such as Australia, Mexico, and the United States (California) – provide lessons for innovation in impact and vulnerability assessment to inform in preventive and mitigation measures.

The Australian concept of 'readiness to implement', used to prioritize mitigation measures, may be of use for SADC water utilities.

Experience shows that adaptation and policy intervention in cities to deal with more recurrent and intense droughts must be context-specific and consider and respect local complexities. The urban drought risk management policies and plans reflected in the international case studies in this report, are adaptable to the SADC context, but timely implementation and evaluation hinge on political will at the highest level.

Governance for drought risk management is closely linked to disaster risk reduction, but often treated as a highly relevant threat, hence not receiving specific attention from either water agencies or disaster risk reduction institutions. And in most water utilities, the management of urban drought has not been institutionalized. To reverse this trend requires defining and institutionalizing clear roles and coordination mechanisms, guided by sound drought risk management policy—even more so in the SADC region, given the extent of transboundary surface and groundwater sharing.

There are multiple windows of opportunity to explore and improve how to address urban drought in SADC, and to invest in doing so. The full drought life cycle must be measured; impact and vulnerability (risk) assessment methodologies used to establish baselines; mitigation measures logically prioritized with a 'readiness to implement' approach; drought risk management plans developed; and local legislation updated accordingly. This requires robust data production, collection and sharing, effective use of internet technology, and capacity building of water utilities and national and city institutions for effective urban drought risk management planning.

Urban drought risk management should be tightly linked to the management of urbanization, urban governance and service delivery, and water resources, and disaster risk management. Mainstreaming the concept through World Bank projects in the SADC region could enhance the climate resilience of water utilities and cities significantly. Linking such a comprehensive investment portfolio of resilient measures to robust drought policy enforcement is both viable and much needed in the SADC region.

From a World Bank perspective, it is worth highlighting that the Urban Drought Risk Management Framework is aligned with other corporate initiatives, including the overarching EPIC Response Framework, and the City Resilience and Utility of the Future Program. Notably it aligns well with key recommendations from recent World Bank reports, such as *High and Dry: Climate Change, Water, and the Economy*).

The Urban Drought Risk Management Framework has been applied to two SADC case studies (Blantyre and Dar es Salaam) through a rapid impact and vulnerability assessment (see Annex C), and to three additional SADC case studies (Tulear city, Lilongwe and Bulwayo) via a comprehensive diagnostic assessment, which identified the vulnerability factors and monitoring gaps that need to be filled. As a next step for the featured cities, ultimate decisions regarding options for resilient investments and policy recommendations (mitigation, preparedness, and response measures) should be discussed with the TTLs of the ongoing World Bank urbanization, water, and disaster risk reduction projects, and later, with each respective city and its water utility.

Appendix A: Basic Data Collection Questionnaire

Target: National water agencies, water utilities/cities in charge of water supply and sanitation, and disaster risk reduction institutions

General:

- Is the city susceptible to urban droughts? Are urban droughts common?
- What challenges does the city face given the urbanization trends, population growth, and water services? What other challenges does the water utility face?

Urban drought monitoring and early warning:

- Who is responsible for urban drought monitoring and early warning? Which institutions are involved in the process? What are their roles and responsibilities?
- Does the water utility have a monitoring and early warning framework? Which indicators or indexes does it consider?
- For any urban drought event that the city has faced, were early warnings issued? Were the early warnings timely?

Urban drought impact and vulnerability assessment:

- Has the city been affected by urban droughts in the past?
- Which sectors or population groups have suffered the most? Why (root causes)?
- Has urban drought vulnerability or urban drought risk been assessed? Which urban drought vulnerability indicators or indexes have been used? Which indexes and data sources could help assess urban drought vulnerability and risk?
- What are the challenges for the city in terms of (1) water availability, (2) distribution systems, and (3) socioeconomic factors?

Urban drought mitigation, preparedness, and response:

- What type of mitigation and response measures have been carried out during past urban drought events?
- What were the demand measures, and the water supply measures, implemented to mitigate and respond to urban droughts?
- Were the roles and responsibilities of stakeholders clear in the contingency plans?
- Was the timing of implementation of the response measures appropriate?
- Was international cooperation in transboundary water sources part of the mitigation and response?
- What were the constraints and risks that the city faced while implementing the drought mitigation and response measures?
- What lessons have been learned from past events?

Urban drought risk management policy and plans (institutions):

- Did the city have any type of drought plan (preventive or contingency)?
- Did the water utility or country have any urban drought policy?
- Which national institutions participated in response to the urban drought?
- Has the urban drought been documented and are reports available?

Benefits of action and costs of inaction:

- Have urban drought impacts been assessed in terms of costs?
- Have post disaster assessments been conducted in the past for urban droughts (for example, damage and loss assessments, post-disaster needs assessments)?
- What was the cost of the different mitigation or response actions during past urban drought events? (Cost of action)
- Has cost-effectiveness been assessed to identify the best mitigation and response actions?
- For any other necessary mitigation or preparedness actions (actions needed), have costs been estimated?

Governance:
- What institutions are involved in disaster risk management at country and city level?
- What institutions are involved in water management at country and city level?
- What institutions are involved in the development of climate change policies and in climate change mitigation and adaptation?
- How are disaster risk management, climate change, and water management policies and practices integrated? What are the challenges?
- Is transboundary water governance an issue? How so?

Economic, environmental, and social effects and cobenefits:
- What have been the economic, environmental, and social impacts of urban droughts?
- What are likely poverty and social effects of urban drought mitigation measures (positive or negative)?
- What are the possible economic cobenefits of urban drought mitigation measures?
- What are the possible climate cobenefits of urban drought mitigation measures (climate change mitigation or adaptation)?

Appendix B: Simplified Urban Drought Vulnerability Assessment

The vulnerability profile is a cornerstone of drought risk reduction planning (UNDRR 2009). The impacts of a drought differ depending on the city sector and the 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 mitigate urban drought and decrease urban drought vulnerability (Wang et al. 2020). Reducing urban drought vulnerability and risk requires coherent actions from both city and water managers (Szalińska, Otop, and Tokarczyk 2018).

Using the Vulnerability Assessment Workbook developed as part of the *Urban Drought Risk Management Toolkit for Task Team Leaders in the Southern African Development Community*, a simplified urban drought vulnerability assessment is conducted for Dar es Salaam, Tanzania, and Blantyre, Malawi. The Excel Workbook application results are intended to inform opportunities or needs for mitigation measures, policy recommendations, and resilient investments.

The Toolkit and Workbook offer guidance on the process 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 of vulnerability.

Given their capacity to synthesize complex conditions and developments, indicators and indexes can be valuable tools to assess urban drought impacts and vulnerability. In this example, three families of indicators are proposed for use in constructing an urban drought vulnerability index for each of the main cities of the Southern African Development Community (SADC): (1) water availability; (2) water distribution systems; and (3) population exposure and socioeconomic vulnerability (for more details, see Table B.1). 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. For each indicator, the Workbook provides a description, explains its relevance, and gives example data sources.

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 difference of the evaluation effect.

Positive and negative indexes are standardized using the following equations
$x_{ij}' = (x_j - x_{min})/(x_{max} - x_{min})$; $x_{ij}' = (x_{max} - x_j)/(x_{max} - x_{min})$

The values x_{max} and x_{min} are determined either by the selected indicator limits (if applicable) or by the maximum or minimum values identified within the region.

<u>Limitations</u>

Limited access or lack of data at subnational and city level has been a constraint in the development of the urban drought vulnerability assessment tool, and the information provided reflects these limitations. It is suggested that users of the tool review indexes and update or gather information with greater spatial resolution at the city or water utility level, as appropriate or subject to availability.

At present, the selection of indicators and the assignment of their relative importance (within and across families) rely on expert knowledge and experience. For a more comprehensive urban drought vulnerability assessment, more data would be needed to select indicators and assign weights. Expert surveys and impact assessments from historic urban droughts in the SADC could help inform the factors or root causes that influence the risk of drought impacts in the region (Table B.1).

Table B.1 Vulnerability assessment indicators and existing data sources

Indicator	Family	Description/relevance	Possible sources of information
Baseline water stress	Water availability	Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies reflect the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users.	https://www.wri.org/data
Interannual variability		Interannual variability measures the average between-year variability of available water supplies, including both renewable surface water and groundwater supplies. Higher values indicate wider variations in the available supply from year to year.	https://www.wri.org/data
Seasonal variability		Seasonal variability measures the average within-year variability of available water supplies, including both renewable surface water and groundwater supplies. Higher values indicate wider variations in the available supply within a year.	https://www.wri.org/data
Surface water dependency (% of water supply from surface water)		Surface countries that rely on a single water source may face more problems if affected by drought.	Information from water utilities
Average annual precipitation		Average annual precipitation (millimeters per year) in city basin.	Aquastat; Global Precipitation Climatology Centre
City dam capacity (subnational/city)		Cumulative storage capacity of all dams that supply the city. The value indicates the sum of the theoretical initial capacities of all dams.	http://www.fao.org/aquastat/en/databases/dams
Per capita dam capacity (subnational/city)		Total dam storage capacity per capita. Calculation criteria: [Dam capacity per capita] = 1000000*[Total dam capacity]/[population]	
Water coverage (%)	Distribution systems	Population with access to water services (either with direct service connection or within reach of a public water point) as a proportion of the total population under the water utility's nominal responsibility.	https://database.ib-net.org/DefaultNew.aspx
Water coverage (household connections)		Population with access to water services (with household connection) as a proportion of the total population under the water utility's nominal responsibility.	https://database.ib-net.org/DefaultNew.aspx
Network density (connections/km)		Density of service connections per kilometer.	https://database.ib-net.org/DefaultNew.aspx
Continuity of service (hours/day)		Average hours of service per day for water supply. The period of uninterrupted water distribution to customers divided by the maximum possible period (24 hours per day).	https://database.ib-net.org/DefaultNew.aspx
Water production (liters/person/day)		Total annual water supplied to the distribution system (including purchased water, if any) expressed by daily amount of water in liters that a person uses.	https://database.ib-net.org/DefaultNew.aspx
Non-revenue water		Non-revenue water (NRW) is water that has been produced and is 'lost' before it reaches the customer. NRW can occur through physical losses from leaking and broken pipes, which are caused by poor operations and maintenance; lack of active leakage control; and poor quality underground assets. NRW can also arise from commercial losses caused by the under-registration of customer meters,	https://database.ib-net.org/DefaultNew.aspx

Indicator	Family	Description/relevance	Possible sources of information
		data handling errors, illegal connections, and theft. Another cause of NRW is unbilled authorized consumption, which includes water used by utilities for operational purposes, water used for firefighting, and water provided for free to certain consumer groups. Reducing NRW can significantly improve the performance of public water utilities in low- and lower-middle-income countries.	
Households with piped water (%)		Proportion of households in the city with piped water.	https://globaldatalab.org
Population in urban areas (habitations)	Socioeconomic	Population living in urban areas. When the population living in urban areas is not available, the city population is used.	https://www.oecd.org; https://globaldatalab.org ; http://www.demographia.com/db-worldua.pdf; https://data.un.org; https://populationstat.com
Built-up area (km^2)		Area with a high population density and infrastructure of the built environment.	https://stats.oecd.org; http://www.demographia.com/db-worldua.pdf
Population density in urban areas (habitations/km^2)		Population density in urban areas. Calculation criteria: [Population density in urban areas] = [Population living in urban areas]/[built-up areas]	https://www.oecd.org; https://globaldatalab.org ; http://www.demographia.com/db-worldua.pdf; https://data.un.org; https://populationstat.com
Population living in slums* (only available at national level)		Ideally, use city data, but usually only national-level data are available. United Nations agencies may have specific city data (for example, Dar es Salaam: 70 percent).	https://urban-data-guo-un-habitat.hub.arcgis.com/datasets/urban-population-living-in-slums-by-country-or-area-1990-2018-thousands/explore
International Wealth Index score		The International Wealth Index (IWI) is an asset-based index that measures the economic situation of households in low- and middle-income countries on the basis of their ownership of assets, housing quality, and access to public services. IWI runs from 0 to 100, with 0 representing nil assets, the lowest quality of housing, and no access to services and 100 representing all assets, the highest quality of housing, and full access to services (Smits and Steendijk 2015).	https://globaldatalab.org
Subnational Human Development Index score		The Subnational Human Development Index is an average of the subnational scores for three dimensions: education, health, and standard of living.	https://globaldatalab.org
Poverty (% with IWI < 50)		Proportion of poorer households (households with an IWI score below 50).	https://globaldatalab.org
Total water consumption (liters/person/day)		Total annual water sold, expressed as population served per day.	https://database.ib-net.org/DefaultNew.aspx
Unimproved/no drinking water		Unimproved/no drinking water reflects the proportion of the population collecting drinking water from an unprotected dug well or spring, or directly from a river, dam, lake, pond, stream, canal, or irrigation canal (WHO and UNICEF 2017). Specifically, the indicator aligns with the unimproved and surface water categories set by the Joint Monitoring Programme—that is, the lowest tiers of	https://www.wri.org/data

Indicator	Family	Description/relevance	Possible sources of information
		drinking water services. Higher values indicate areas where people have less access to safe drinking water supplies.	
The Peak RepRisk Country ESG Risk Index		The Peak RepRisk Country ESG Risk Index quantifies business conduct risk exposure related to environmental, social, and governance (ESG) issues in the corresponding country. The index provides insights into potential financial, reputational, and compliance risks, such as human rights violations and environmental destruction. RepRisk is a leading business intelligence provider that specializes in ESG and business conduct risk research for companies, projects, sectors, countries, nongovernmental organizations, and more, by leveraging artificial intelligence and human analysis in 20 languages. The World Resources Institute has elected to include the Peak RepRisk Country ESG Risk Index in its Aqueduct platform to reflect the broader regulatory and reputational risks that may threaten water quantity, quality, and access. The peak value equals the highest level of the index in a given country over the last two years. The higher the value, the higher the risk exposure.	https://www.wri.org/data

Selection of Indicators and Weights for Dar es Salaam, Tanzania

For the urban drought vulnerability assessment of Dar es Salaam, equal weights were selected for the three families of indicators, and for all the indicators selected (Figure B.1). Urban drought vulnerability of the city does not seem to be controlled by any of the families or indicators, but rather by their combination (Table B.2).

Figure B.1. Urban Drought SADC components and indicators

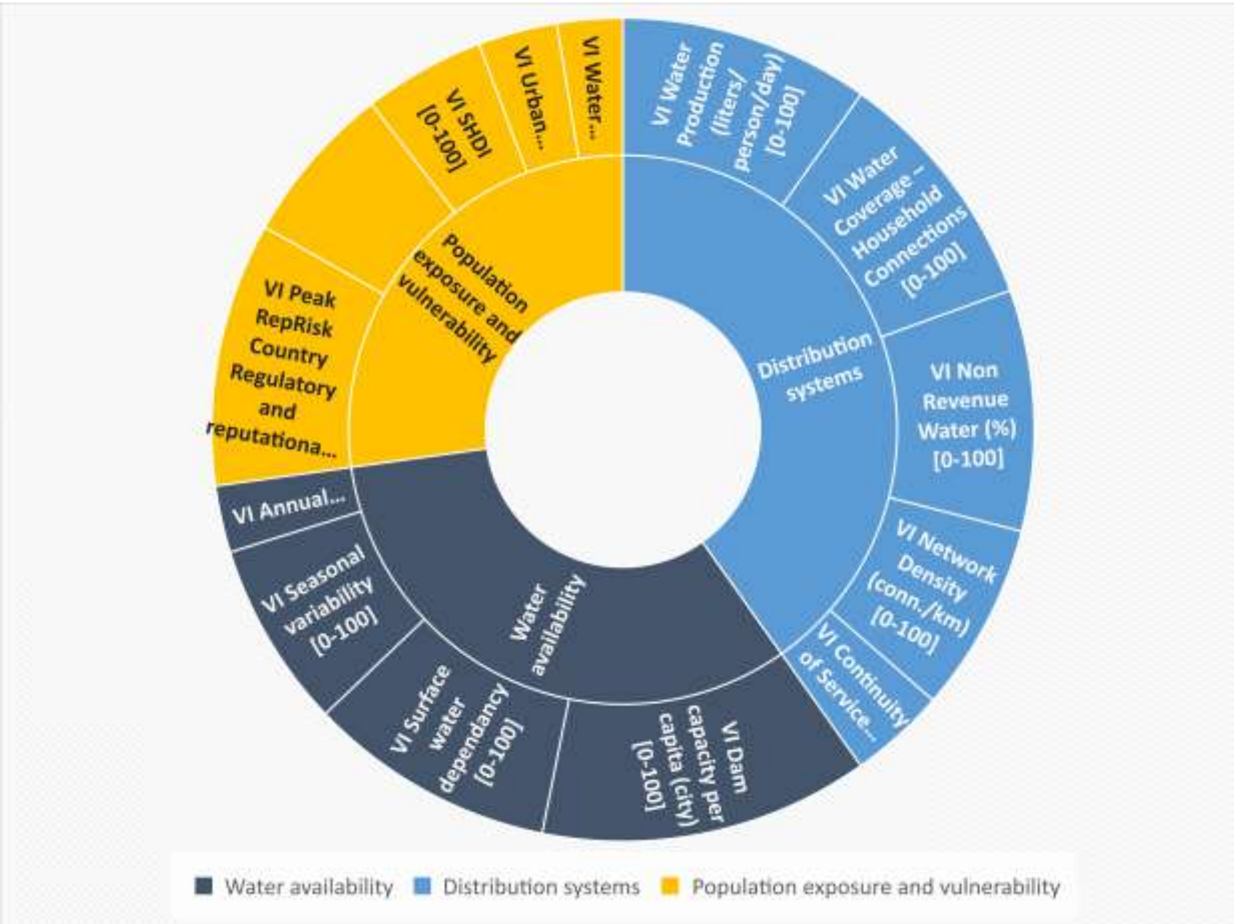


Table B.2 Dar es Salaam Urban Drought SADC Index

Component	Weight	Indicator	Weight	Value (0–100)	Individual components	Index
Water availability	0.33	VI Baseline water stress	0.20	0.00	50.43	51.43
		VI Dam capacity per capita	0.20	100		
		VI Surface water dependency	0.20	75.00		
		VI Seasonal variability	0.20	56.44		
		VI Average annual precipitation	0.20	20.25		
Distribution systems	0.33	VI Water coverage (number of household connections)	0.20	74.63	62.0	
		VI Network density (connections/km)	0.20	57.41		
		VI Water production (liters/person/day)	0.20	75.86		
		VI Non-revenue water (%)	0.20	72.94		
		VI Continuity of service (hours/day)	0.20	29.17		
Population exposure and vulnerability	0.33	VI Urban population density	0.20	24.03	41.94	
		VI IWI	0.20	48.89		
		VI SHDI	0.20	36.90		
		VI Water consumption	0.20	19.87		
		VI Country regulatory and reputational risk	0.20	80.00		

Note: VI: Vulnerability Index; IWI: International Wealth Index; SHDI: Subnational Human Development Index.

- Water availability: Although the region is not (yet) water stressed (Vulnerability Index [VI] Water stress) and average annual precipitation is relatively good (VI Average annual precipitation), Dar es Salaam is highly dependent on surface water (VI surface water dependency). Dam capacity is limited or nonexistent (VI Dam capacity) and surface water offtakes are susceptible to the variable rainfall patterns and droughts (VI Seasonal variability).
- Distribution systems: Distribution systems for Dar es Salaam appear to be among the most strained in the SADC region. Water production (VI Water production) and water coverage (VI Water coverage, number of household connections) are among the lowest in the region, and non-revenue water (VI Non-revenue water) is very high.
- Population exposure and vulnerability: Although Dar es Salaam is expected to soon become a megacity, urban population density is about half as high as Kinshasa, Democratic Republic of Congo, according to available data. International Wealth Index (IWI) and Subnational Human Development Index (SHDI) scores are moderate for Dar es Salaam in comparison to other cities (even in the same country). Dodoma, for example, has an IWI score of 100 (highest value possible). Tanzania's reputational and regulatory risk (VI Country regulatory and reputational risk) is very high. It has been shown, however, that people living in slums are particularly vulnerable to urban droughts, and a large part of Dar es Salaam comprises informal settlements (accommodating 70 percent of the population).
- For urban drought vulnerability assessment, consideration of an indicator related to the number or proportion of people living in slums is recommended. These data have not been included, as no reliable data—that meet the criteria—are accessible and systematically recorded at city level for most of the SADC. Particular attention should be given to this element since most of Dar es Salaam's population relies on uncontrolled and highly climate-dependent water sources. A more accurate assessment of urban drought vulnerability would consider the amount or share of the population living in slums, and with a higher weight assigned to this indicator.

Selection of Indicators and Weights for Blantyre, Malawi

For the urban drought vulnerability assessment of Blantyre, equal weights were selected for the three families of indicators, and for all the indicators selected. Urban drought vulnerability of the city does not seem to be controlled by any of the families or indicators, but rather by their combination (Table B.3).

Table B.3 Blantyre Urban Drought SADC Index

Component	Weight	Indicator	Weight	Value (0–100)	Individual components	Index
Water availability	0.33	VI Baseline water stress	0.20	0.00	55.6	57.46
		VI Average annual precipitation	0.20	37.57		
		VI Seasonal variability	0.20	40.86		
		VI Surface water dependency	0.20	99.90		
		VI Dam capacity per capita (city)	0.20	99.69		
Distribution systems	0.33	VI Network density (connections/km)	0.20	81.14	66.85	
		VI Water production (liters/person/day)	0.20	71.90		
		VI Water coverage (%)	0.20	34.84		
		VI Non-revenue water (%)	0.20	81.02		

		VI Water coverage (number of household connections)	0.20	65.35		
Population exposure and vulnerability	0.33	VI Urban population density	0.20	10.32	51.13	
		VI IWI	0.20	76.66		
		VI SHDI	0.20	44.40		
		VI Unimproved/no drinking water	0.20	68.26		
		VI Country regulatory and reputational risk	0.20	56.00		

Note: VI: Vulnerability Index; IWI: International Wealth Index; SHDI: Subnational Human Development Index.

Appendix C: Rapid Urban Drought Risk Vulnerability Assessments for Dar es Salaam, Tanzania, and Blantyre, Malawi

Urban Drought Risk Management Framework

Urban drought often has severe socioeconomic implications for a city, even when it is temporary. Typically manifesting as a sharp decrease in water supply or a sudden increase in water demand, water stress or scarcity in cities and towns is often aggravated by economic disparity, poor water management and governance, and institutional inefficiencies (Ray and Shaw 2019). Urban droughts often have cascading impacts and risks, such as health risks, unemployment and food insecurity, migration, social and political instability, and conflict.

Integrated drought management can help mitigate drought risk and strengthen drought resilience by simultaneously addressing multiple components of drought management, including disaster risk reduction, climate adaptation strategies, and national water policies (WMO and GWP n.d.). Integrated drought management is therefore based on not viewing droughts merely as natural hazards**,** and instead acknowledging and managing—preferably proactively and continuously, but reactively where necessary—the interactions and causalities between drought and society. By identifying who and what is at risk, and why, impact and vulnerability assessments should aim to inform targeted drought mitigation, preparedness, and response actions to reduce the root causes of current and likely future impacts and compounding risks. At the same time, they can enhance exchange and communication across sectors and across different levels of government, supporting resilient investments and building more resilient cities.

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

While drought crisis management focuses solely on response and interventions following disaster onset, integrated drought management emphasizes proactive risk management and resilience planning and preparedness, and early warning systems to permit timely and tailored interventions (Jedd et al. 2021). Reactive urban drought crisis management has generally been ineffective in reducing vulnerability to drought and dependence on external assistance (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 sound implementation of an urban 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 spheres of government for effective water management and communication throughout the 'drought life cycle'. Urban drought vulnerability and risk reduction requires coherent actions from city and water managers—that is, each performing their own role, but as part of a supportive intergovernmental system.

A comprehensive urban drought risk management policy must include systematic monitoring, early warning and information systems for decision support, impact and vulnerability assessments, and the identification and adoption of appropriate local-level mitigation and response measures aimed at risk reduction, which are linked to predefined early warning thresholds to mitigate drought impacts**.**

Dar es Salaam, Tanzania

Tanzania is experiencing one of the fastest rates of urbanization within the Southern African Development Community (SADC), with the urban population, as a proportion of the total population, expected to increase from 33.78 percent in 2021 to 55.43 percent by 2050 (UN DESA 2018). With a population of more than 7 million, Dar es Salaam is East Africa's largest and fastest-growing city (World Bank Group 2017a). The fast pace of urbanization and increased infrastructural inequalities can lead to higher vulnerability to urban droughts (Box C.1).

Seventy percent of the built environment of Dar es Salaam is unplanned, largely taking the form of informal settlements (World Bank Group 2017a). People living in slums are particularly vulnerable to urban droughts as these areas often lack adequate water management facilities and sustainable water supply, devoid of adaptive capacity and resilience to deal with disasters (Bates et al. 2008; Zhang et al. 2019). Informal settlements are overcrowded, with low-quality housing and inadequate access to clean water and sanitation.

Tanzania's resources are under increasing pressure as the economy and population grow, and per capita freshwater availability is declining at an alarming rate—from 4,969 cubic meters in 1977 to 1,537 cubic meters in 2017 (World Bank Data 2021)**.** This figure is projected to drop to 1,500 cubic meters by 2025, the level at which an area is considered to be 'water-stressed' (World Bank Group 2017b).

Dar es Salaam is forecast to have one of the greatest surface water deficits among African cities, exceeding 100 million cubic meters per year on average (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). In Tanzania, the probability of severe drought is expected to increase (+50 percent) under the future climate (of the period 2050–2100) (CIMA Research Foundation 2018).

Box C.1 *A Glance at Dar es Salaam's Drought Vulnerability*

Considering the interactions between the social**,** economic, and physical subsystems in the city, and by assessing the conditions that make city and its population susceptible to suffer adverse effects when affected by droughts, some vulnerability factors can be identified. (Appendix B presents a simplified assessment.)

- With a population estimated at over 7 million, Dar es Salaam is considered the fifth largest city in Africa today. It is experiencing fast rates of urbanization and population growth and is expected to become a megacity of more than 10 million by 2030 (Todd et al. 2019).
- The capacity of the city's water utility is under strain. Unsuccessful attempts have been made at private sector involvement, reorganization, and financing. The Dar es Salaam Water and Sewerage Authority lacks an integrated development plan for its service area (Andersson 2019). Tanzania's regulatory and reputational risk is among the highest in the SADC region (Hofste et al. 2019).
- The city is highly dependent on surface water, which comes from the Upper and Lower Ruvu treatment plants, sourced from the Ruvu River north of the region; and from the Mtoni treatment plant, within the service area, sourced from the Kizinga River. To supplement this, the city draws on boreholes—though to a lesser extent (Andersson 2019).

- Surface water offtakes are susceptible to the country's variable rainfall patterns and droughts. In 2014, it was assessed that that water demand could not be met for 18 days at the Lower Ruvu offtake, and for 7 days at the Upper Ruvu offtake. Assessments indicated that the dry season flows in the Ruvu were unable to meet future demand, despite the construction of Kidunda Dam, partly because farmers upstream were given significant water rights (Andersson 2019).
- Non-revenue water losses are estimated at a high 51 percent, equivalent to 57.6 cubic meters per kilometer per day (IBNET 2021). Water infrastructure is old: the three reservoirs of Upper Ruvu, Lower Ruvu, and Mtoni were built in 1959, 1975, and 1949 respectively; maintenance has not been prioritized; and there is limited documentation of the existing pipes and infrastructure (Andersson 2019).
- Water coverage is low (55 percent) and household connections are limited (25 percent). Informal settlements with no piped water rely on the city's shallow aquifer, which is polluted and salinized, and on water vendors for their water supply (Skinner and Walnycki 2016). About 70 percent of Dar es Salaam's residents live in informal settlements without clean water and decent sanitation (Sheuya, 2010)
- Water consumption is relatively low, compared with other countries in the region. Consumption in Dar es Salaam is estimated at 48.7 liters per person per day; for reference, Cape Town consumption is 216 liters per person per day (IBNET 2021).
- Dar es Salaam (region) scores 62.5 on the International Wealth Index (IWI). The index measures the economic situation of households on the basis of their ownership of assets, housing quality, and access to public services. IWI runs from 0 to 100, with 0 representing nil assets, the lowest quality of housing, and no access to services and 100 representing all assets, the highest quality of housing, and full access to services.

Urban drought risk in Dar es Salaam is expected to increase significantly as both the population and water demand grow and water stress increases (Flörke, Schneider, and McDonald 2018).

Recommendations for Addressing Urban Drought in Dar es Salaam

Based on the **Urban Drought Risk Management Framework (UDRMF)**, two groups of measures are recommended to address the vulnerability identified in Dar es Salaam (some measures are the same regardless of the drought phase):

1. Necessary preventive measures to minimize drought impacts in advance (including predefined measures for optimal response and recovery).
2. Contingency measures to reduce impact of existing urban drought risk (responsive).

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**	**Monitoring and early warning systems** • Monitor and alert the progress of urban drought (use 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

• 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	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

Determining an Ad Hoc Response to the Dar es Salaam Urban Drought

It is recommended that a specific water utility shortage contingency plan is prepared as soon as possible, and that the evolution of the urban drought and its impacts is monitored and recorded.

Data Requirements for Ad Hoc Response Planning

To develop a more detailed assessment of the urban drought in Dar es Salaam and the possible consequences, and to design ad hoc response measures, it is necessary to collect data on:

- Supply-side factors:
  - Reservoir, river, and groundwater levels (historic and present)
  - Present water supply capacity, differentiating between water sources
  - Inventory of boreholes and wells (location, water supply capacity, and water quality)
  - Infrastructure coverage (data and maps on piped water and water provided by other means)
  - Water distribution system (present and projected)
  - Revenue water

- Demand-side factors:
  - Volume of water per capita per day (data and map)
  - Location of slums
  - Location and water consumption of industrial and commercial facilities (data and map)
  - Water price rates or tariff scheme
  - Water utility's installed capacity to implement water shortage measures

- Governance factors:
  - Mapping of the national, city, and water utility actors (regulatory, operative, and finance)
  - Drought monitoring scheme and communication
  - Key vulnerability indicators (economic, environmental, social, and governance)

Impact Assessment for Improved Response and Recovery to Build Back Better

Assessing impacts during and after an urban drought will help identify who and what is affected, and why. This can then help define and tailor 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.

Impact Assessment: 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 costs 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

Malawi National Drought Context (Risk and Vulnerability)

One of the world's lowest-income countries, Malawi is also one of Africa's most densely populated nations and is ranked among the top 10 countries in the world projected to have the largest population increase in both rural and urban areas (Mawenda, Watanabe, and Avtar 2020). Its population of 18.6 million (2019) is expected to double by 2038, posing challenges for poverty reduction and environmental sustainability. Urbanization, however, has been relatively slow in Malawi, stagnating at around 15 percent since 1999 (World Bank Group 2018). The urban population as a proportion of the total population stood at 16 percent in 2018 and is projected to rise to 30 percent by 2030 and to 50 percent by 2050 (Mawenda, Watanabe, and Avtar 2020)**.**

Unplanned urbanization and poor building and infrastructure construction standards are underlying factors of vulnerability. Although only 16.4 percent of Malawi's population live in urban areas, and its rate of urbanization is modest compared with that of other African countries, Malawi's urban population is expected to almost triple, from 2.2 million in 2015 to 6.3 million by 2040. Urbanization is concentrated in four major cities—Blantyre, Lilongwe, Mzuzu, and Zomba—where growth is mostly informal and unregulated, largely because of a lack of adequate and affordable housing for the urban poor, a lack of enforcement capacity, and weaknesses in land use planning and building codes (World Bank 2020).

The country has one of the lowest per capita incomes in the world. Its economy depends mostly on natural resources exploitation, dominated by the agricultural sector, which drives livelihoods for two thirds of the population yet accounts for only one third of Malawi's gross domestic product (USAID 2019; World Bank Group 2018; World Bank Group 2019).

Weather-related shocks in Malawi are increasing in severity, frequency, and extent due to climate change, with climate projections demonstrating a higher likelihood of both flooding and drought events. The country has one of the most erratic rainfall patterns in Africa. Available records indicate that the country has experienced about 20 droughts over the last 100 years. In the last 36 years alone, it has experienced eight major droughts. Historically, the mean annual temperature in Malawi has increased by 0.9 percent from 1960 to 2006, with the average number of 'hot' days per year increasing by 30 from 1960 to 2003. Mean annual temperature is projected to rise by 2.1 degrees Celsius by 2050, with mean annual precipitation falling by 1.3 millimeters by 2050 (World Bank 2020).

Climate-induced shocks are exacerbating Malawi's macroeconomic instability and making it harder for Malawi to break the cycle of vulnerability (World Bank Group 2018). Malawians, especially the poorest 60 percent of the population, are highly vulnerable to shocks. Major floods and droughts in Malawi have a significant impact on national economic performance, with severe implications for the most vulnerable in society such as resource-poor, small-scale farmers and poorer urban households (World Bank Group 2018).

It is estimated that, on average, droughts and floods combined reduce Malawi's total gross domestic product by about 1.7 percent per year, with total gross domestic product declining by at least 9 percent during a severe once-in-20-years drought. Drought and flood events are becoming more frequent, and thus the average annual impact may increase in the future (GFDRR 2009), but few measures have been undertaken to mitigate this risk (World Bank Group 2018).

Malawi has made progress in building resilience to climatic shocks, improving early warning systems, and enhancing preparedness through improvement of policy and institutional frameworks for climate change adaptation and disaster risk management. Operationalizing holistic disaster risk management has, however, encountered a number of challenges: (1) limited allocation of the national budget for effective activities for livelihood restoration, climate resilience, and disaster risk management; and (2) lack of systematic disaster risk assessment and mapping for hydrometeorological and geological hazards to guide development and investment planning at the national and local level (World Bank 2020).

Addressing the deficits in access to and quality of water and sanitation services in both rural and urban areas should be a high priority, which will require private investments as well as deeper efforts to improve governance of water utilities (World Bank Group 2018). Hydrological drought risk is greatest in the Central and Southern regions of Malawi, in part due to the high concentration of population in vulnerable areas. In the Central Region, 700,000 people live in areas expected to experience some level of water scarcity each year, with a further 900,000 people living in such areas in the Southern Region (World Bank 2009).

Blantyre, Malawi

Blantyre is Malawi's second largest city by population (800,264 inhabitants in 2018) and size, covering an area of 240 square kilometers. It is the main commercial city and hosts most of the private sector headquarters in the country (Mawenda, Watanabe, and Avtar 2020). Blantyre is the commercial and industrial center of Malawi, in part due to its connectivity with neighboring countries Mozambique, South Africa, Tanzania, Zambia, and Zimbabwe (World Bank 2020). Blantyre currently hosts almost 5 per cent of the national population and has the highest population density of any urban area in the country, at 3,328 people per square kilometer (Mawenda, Watanabe, and Avtar 2020).

The geographic location of Blantyre, in the Shire-Zambezi River Basin, results in relatively abundant water resources in comparison to some parts of southern Africa (Price et al. 2021). Lake Malawi is one of the largest freshwater lakes in the world and it is the key water resource and reservoir for the country (Mtilatila et al. 2020). While the availability of water resources in Malawi is considered satisfactory, per capita water availability is declining due to population growth and because water resources are under threat from catchment degradation (World Bank 2019).

Malawi is highly exposed to natural disasters such as floods and droughts. The country has experienced eight major droughts in the last 36 years alone. The Shire-Zambezi River Basin and Blantyre have been severely affected by such events, with the 2015–16 drought particularly relevant in terms of damages and losses (World Bank et al. 2017).

Malawi has inadequate capacity for reliable and high-resolution drought forecasting. Knowledge, skills, and tools are urgently required for institutions and individuals involved in drought monitoring and early warning systems. In Malawi, two types of drought monitoring and early warning systems are used: scientific and traditional (Scientific systems are based on indicators derived from variables such as climate, soil moisture, and streamflow. Traditional systems use the behavior of plants or animals (Chabvungma, et al., 2015)). Blantyre city has no early warning system (World Bank et al. 2017).

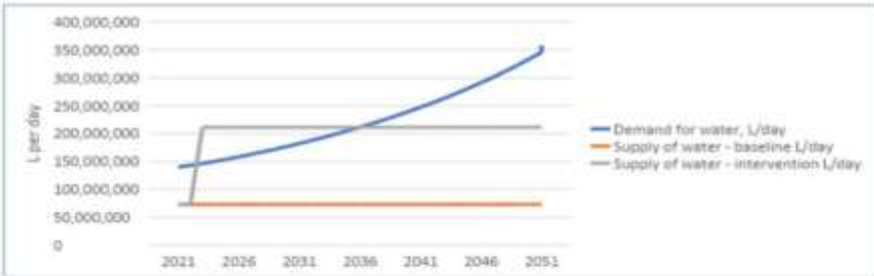
To deliver water to Blantyre city, Blantyre Water Board extracts most of its supply from the Shire River, with the rest produced from the Mudi Dam and boreholes (Banda et al. 2020; Blantyre Water Board 2022). Blantyre Water Board has a piped water network to supply water to the urbanized area.[18]

Unreliable water supply imposes costs on water users. Consumers store water in their homes or are forced to travel to other water sources to meet their needs. Across Malawi, around 16 percent of urban dwellers obtain their water from boreholes, which are typically outside of the main water board's supply system, a phenomenon confirmed by Blantyre Water Board. All these coping strategies incur extra costs, extra time, or both. The largest burden of insufficient water supply falls upon Blantyre residents living in informal settlements (National Planning Commission 2021).

The current demand shortfall is 50 percent (2021) and, in the absence of intervention, this is likely to rise to 80 percent by 2052 (Figure C.1**). The demand gap is much larger for those living in informal settlements (who rely on kiosks) than for those in permanent housing areas: informal settlements have about 1.5 times the number of people as domestic households, but receive less than 5 percent of supplied water** (National Planning Commission 2021). Sixty percent of urban residents live in informal settlements, with the remaining 40 percent living in permanent housing areas. Most supplied water (51 percent) is used by domestic customers who mainly live in permanent housing areas; 4 percent is supplied to kiosks for those living in informal settlements; 22 percent is for commercial and industrial use; and 23 percent is supplied to institutions (National Planning Commission 2021) (Figure C.1).

[18] https://www.bwb.mw; https://libguides.lib.uct.ac.za/GovtPubsWaterResources/WaterMalawi

Figure C.1. Demand and Supply of Water Per Day, With and Without Intervention



Source: National Planning Commission (2021).

Blantyre Water Board reports service continuity of 20 hours per day, but the availability of piped water from different sources varies. Whereas drinking water from public taps is available for only 12 hours per day, drinking water from a private tap is available for 21 hours per day on average (Box C.2). Most residents (85 percent) use a secondary source of water when their main source of water is unavailable (National Planning Commission 2021).

Box C.2 Blantyre Water Board Challenges

Formal urban water supply services in Malawi are provided by five parastatal water boards, namely Blantyre, Lilongwe and the Northern, Central, and Southern region water boards (Kalulu and Hoko 2010). Blantyre Water Board is a parastatal organization established and reconstituted under the Malawi Water Works Act No. 17 of 1995, to supply potable water for commercial, industrial, institutional, and domestic use in Blantyre city and surrounds. Blantyre Water Board supplies water to about 1.4 million people within its supply area, which includes the city and other areas such as Bvumbwe, Chileka, Chiradzulu, Limbe, Lunzu, and Mapanga (Blantyre Water Board 2022).

Blantyre Water Board extracts most of its water from the Shire River, with the rest produced from the Mudi Dam and boreholes (Banda et al. 2020; Blantyre Water Board 2022). Blantyre Water Board has a capacity to deliver 122 million liters of water per day, from sources at Walker's Ferry (96 million liters), Mudi Dam (6 million liters), and the Likhubula River (20 million liters). From Walker's Ferry, approximately 96,000 cubic meters per day are pumped uphill—over an elevation of 800 meters—through a 48-kilometer pipeline to the city, with additional booster stations needed to distribute water throughout the hilly city terrain, leading to the cost of electricity accounting for 40 percent of the water utility's total operating costs (National Planning Commission 2021).

A study on the performance of Blantyre Water Board conducted by Kalulu and Hoko (2010) concluded that the utility was generally performing poorly, as most performance indicators were outside the range of best practice targets for utilities in low- and lower-middle-income countries. The utility was found to be financially unsustainable as it had been making losses since 2002 and had a working ratio of more than 1.3, implying that the utility was unable to meet its operational and capital costs (Kalulu and Hoko 2010).

Major challenges for Blantyre Water Board include rising operating costs due to the ever-increasing costs of inputs; increasing water demand due to population growth; aging infrastructure, leading to high system losses; a culture of non-payment for services by customers, leading to inadequate collection of revenue; and high energy demand. Lack of resources, insufficient power-generating capacity by the electricity supply utility, and the resultant frequent blackouts have been negatively affecting the delivery of water services as water has to be pumped at a high elevation for a considerable distance (Kalulu and Hoko 2010). "Lack of public financing and an overreliance on debt from global–local financial markets have systemically compromised the efficacy of the state in mediating the politics of water production and distribution" (Tchuwa 2018, 1 pp).

Additional challenges (National Planning Commission 2021):

- **Revenue collection**: Funds to settle 70 percent of all invoiced bills were collected within 340 days, against an ideal target of 90 days. In response to this challenge, Blantyre Water Board migrated two thirds of the customers in its jurisdiction from a postpaid to prepaid billing system.
- **Inefficient administration**: The ratio of staff per 1,000 connections was found to be 18 versus an ideal value of 5.
- **Indebtedness**: Blantyre Water Board's profit after tax was negative in 2018, at -2.38 billion Malawian kwacha, with long-term debt of 20.4 billion Malawian kwacha.
- **Unaffordability of water**: With Blantyre Water Board so focused on cost recovery, its tariffs are beyond the reach of its targeted customers (the residents of informal settlements).

According to Price et al. (2021), most Blantyre residents (81 percent) are frustrated with some aspect of safe drinking water access in their community: intermittent supply, including seasonal changes in the quantity of water available, fixed or limited water point opening hours, or breakdown of water points (25 percent); affordability concerns related to the cost of water per bucket, or the billing system (20 percent); and lack of water points (20 percent).

The Blantyre case study highlights the urban drought–electricity nexus. Lake Malawi is the key water resource and reservoir for hydropower generation on the Shire River, which originates at the only southern outlet of the lake. The energy from hydropower plants in Malawi account for 98 percent of the country's total electricity power. It has been estimated that the below-normal rainfall seasons of 2014–15 and 2015–16 resulted in falling lake water levels and reduced river flows, which reduced power production by more than 50 percent. Water supply to Blantyre city is highly susceptible to power outages, given the need to pump the water uphill over such a long distance (Box C.3.).

Box C.3 A Glance at Blantyre's Drought Vulnerability

Considering the interactions between the social**,** economic, and physical subsystems in the city, and by assessing the conditions that make city and its population susceptible to suffer adverse effects when impacted by droughts, some vulnerability factors can be identified. (A simplified assessment is presented in appendix B.)

- Blantyre is producing insufficient water to meet current demand, and demand will likely increase in future as the city's population grows (National Planning Commission 2021).
- Water coverage is low (73.8 percent of the population) and even more so for household connections (45.86 percent of households). Network density in Blantyre is among the lowest of cities in the Southern African Development Community region, at 27.37 connections per kilometer. This is almost half that of Cape Town (South Africa): 60.62 connections per kilometer; or Antananarivo (Madagascar): 67.05 connections per kilometer (IBNET 2021).
- Non-revenue water losses are estimated to be as high as 46 percent of non-revenue water, equivalent to 23.3 cubic meters per kilometer per day (IBNET 2021).
- There are inequalities in access to water, with informal settlements receiving less than 5 percent of supplied water despite accounting for 1.5 times the number of people as domestic households (National Planning Commission 2021).
- Competing pressures on water use: Blantyre's economy (and that of Malawi) relies on the commercial and industrial sectors.
- The city is highly dependent on surface water and, in particular, on the Walker's Ferry offtake.
- The water utility is under strain in terms of its capacity, and it is financially unsustainable (Kalulu and Hoko 2010).
- The energy required to pump water from Walker's Ferry to Blantyre contributes to the cost of electricity accounting for 40 percent of the water utility's total operating costs. Frequent blackouts (Kalulu and Hoko 2010) continue to negatively affect the delivery of water.
- Water consumption is relatively low, compared with other cities in the region. Blantyre's consumption is estimated at 62.98 liters per person per day (compared with Cape Town's consumption of 216 liters per person per day) (IBNET 2021).

• Blantyre scores 41.2 on the International Wealth Index, which measures the economic situation of households based on their ownership of assets, housing quality, and access to public services. The International Wealth Index runs from 0 to 100, with 0 representing nil assets, the lowest quality of housing, and no access to services, and 100 representing all assets, the highest quality of housing, and full access to services. • An estimated 65 percent of households in Blantyre are poor—that is, they have an International Wealth Index score of less than 50. • The city scores 0.56 on the Subnational Human Development Index, which considers the dimensions of education, health, and standard of living.

Recommendations for Urban Drought Risk Management for Blantyre

Based on the **UDRMF** rapid analysis, **five key findings** are highlighted:

- Blantyre has no reliable urban drought monitoring and early warning systems are not in place.
- Water availability is not an issue even under drought conditions.
- Insufficient and aging water and sanitation infrastructure results in failure to meet water demand, high energy costs, and non-revenue water losses.
- Population growth, particularly in informal settlements, puts additional strain on the city's already inadequate water provision capabilities.
- No preventive or contingency drought plan or strategy is available and there is weak urban drought governance (as part of disaster risk reduction).

According to the UDRMF, two groups of measures are recommended based on the rapid vulnerability and risk analysis (key findings) developed for Blantyre (all measures that are part of the Framework apply and some measures are the same regardless of the drought phase):

1. Necessary preventive measures to minimize drought impacts in advance (including predefined measures for optimal response and recovery).
2. Contingency measures to reduce impact of existing urban drought risk (responsive).

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	**Monitoring and early warning systems** • Monitor and alert the progress of urban drought (use existing monitoring networks, forecasting, and early warning capabilities) and communicate 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 the effects of the response measures on vulnerability impacts • Develop impact assessments to identify vulnerable populations and stakeholder sectors and to assess the root causes of impacts

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	**Mitigation, preparedness, and response** • Coordinate the water shortage contingency plan and 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

Policy and Investment Portfolio Outcomes for Blantyre

Detailed implementation of the UDRMF allows for the identification of policy and a comprehensive investment portfolio of resilient measures.

Investments to reduce urban drought risk	• Investments in resilient infrastructure to improve water supply • Diversification of water sources (water supply and sanitation master plan) • Development of urban drought monitoring system (for example, urban drought monitoring network) • Hybrid monitoring: Meteorological and hydrological drought monitoring, initially at regional scale, with local capacity building • Water system flexibility and integration (water supply and sanitation master plan)
Policy recommendations for integrated urban drought risk management	• Development and implementation of policies and plans for urban drought risk management (link urban development with water development plan; update laws and regulations) • Institutional transformations and improved coordination between city manager and Blantyre Water Board to reduce urban drought risk, especially in slums (update legal mandates) • Development of a governance structure for urban drought risk management (update legal mandates) • Improvement of water suppliers' fiscal resilience and drought risk financing instruments and strategies

	• Coordination of water shortage contingency planning and implementation • Improvement of urban drought risk awareness, and reduction in water consumption
Analytical work to identify and address knowledge gaps	• Identification and documentation of relevant indicators for urban drought impact and vulnerability assessment • Development of urban drought impact and vulnerability assessments to better inform mitigation, preparedness, and response and link them to national/city budget allocation • Assessment of urban drought impacts across sectors and population groups/gender • Development of analytical work to assess the linkages between urban drought, urbanization, and poverty

Specific Policy and Investment Opportunities to Address Urban Drought in Blantyre

Five key policy and investment opportunities are identified:

- Establishment of an early warning system coupled with a disaster risk management plan for the city as part of the ongoing World Bank Malawi Resilience and Disaster Risk Management Project (previously known as the Malawi Drought Recovery and Resilience Project) (UDRMF pillar 1: monitoring and early warning).
- Immediate implementation of a long-standing program to minimize non-revenue water or not-accounted-for water through the replacement of aging infrastructure and the construction of a new pipeline network; and roll out of a contingency program to set up automated water kiosks (more water supplied to kiosks, reducing wastage, water operating costs, and waiting times) to increase water availability and accessibility for the population (UDRMF pillar 2: impact and vulnerability assessment—infrastructure dimension; and pillar 3: mitigation, preparedness, and response).
- Development of a new water source (project identified by Blantyre Water Board, to target the Shire River Basin); construction of emergency boreholes, including rehabilitation of existing boreholes; and development of secure and sufficient hydroelectric generation (UDRMF pillar 3: mitigation, preparedness, and response).
- Support for and enforcement of resilient urbanization programs for informal settlement areas (for example, a national slum upgrading project) (UDRMF pillar 2: impact and vulnerability assessment—social dimension; and pillar 3: mitigation, preparedness, and response).
- Drastic strengthening of preventive and emergency mitigation, preparedness, and response, while contingency plans need to be updated, reviewed, exercised, and better aligned to the budget cycle (especially the Shire River Basin and Blantyre City drought risk management plans from the World Bank project). This drought risk management planning must be mainstreamed in development strategies and programs and be supported by adequate (that is, more comprehensive, preventive, and enforced) institutional and legal frameworks (UDRMF pillar 3: mitigation, preparedness, and response—governance).

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