Water Resources Management, Floods, and Disaster Risk Management

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KEY MESSAGES

- **The most important manifestation of climate change in Africa is through water. Climate change is likely to greatly increase the number of people exposed to floods.** In Africa, over the period 2008–2018, floods accounted for 65 percent of disaster events and caused 24 percent of deaths.
- **Global research, including GCA work, has shown that those living in poverty are particularly vulnerable to climate shocks such as floods.** Floods also have long-term human capital impacts beyond their immediate disruptive effects. Globally, four out of the top ten subnational regions by the absolute number of poor with high flood exposure are located in Sub-Saharan Africa. This makes systematic disaster risk reduction (DRR) an indispensable step in the journey towards climate adaptation, and also of any wider program of equitable development in Africa.
- **Adaptation is a key component of disaster risk management.** Flood-informed land use planning and early prevention of construction in high-risk zones are a lower-cost alternative than reconstruction after flood damages, construction of expensive structural engineering solutions, or retrofits.
- **Integrated water resource management (IWRM) is another key aspect of DRR, as the flooding risks of cities or coastal areas depends in many cases on the characteristics and management practices of river basins and water catchments upstream.** Currently, 42 African nations have institutionalized most IWRM elements, providing a solid foundation to accelerate progress.
- **Transboundary cooperation is another important dimension of managing the water resources of Africa, as the 48 mainland countries of Africa share 134 transboundary basins and aquifers.** As over 90 percent of Africa's surface water is in transboundary basins, regional cooperation, ranging from simple data sharing to joint implementation of large transboundary infrastructure projects, greatly expands the range of possibilities for effective climate adaptation.

> **“It is imperative that we urgently reverse the current scenario, increasing the volume of funding for adaptation intervention, climate resilience, and recovery of the life and economy after the Covid-19 pandemic.”**
>
> **H.E. President Filippe Nyusi of Mozambique**
> Leader's Dialogue on the Africa Covid-Climate Emergency, April, 2021

INTRODUCTION

This chapter concludes Section 2 of this report by bringing together two areas that connect several previous chapters. These areas are, first, disaster risk management (and the closely associated issue of flood risks) and, second, integrated water resources management. The most important manifestation of climate change in Africa is through water. The Agriculture and Food Systems chapter examines the economic and poverty consequences of droughts. The Urban Development chapter reviews the impacts of climate change on urban services, including water and sanitation and flood protection. The Transport and Energy chapter examines how floods impact countries' transport networks and services throughout Africa, and how droughts make hydropower generation vulnerable.

This chapter discusses how three major international agreements reached in 2015 connect to climate adaptation and resilience: the Sendai Framework for Disaster Risk Reduction (DRR), the Sustainable Development Goals (in particular, Goal 6.5 on integrated water resources management), and the Paris Climate Change Agreement.

In this chapter, we review the Sendai Framework and the additional five targets that the African Union identified as part of its Programme of Action (PoA) for implementation. Disaster risk reduction is an indispensable step in the journey towards climate adaptation. Countries, economies, and communities cannot be prepared for future climate disasters if they are not ready for current disasters. We review the progress made by African countries and the level of mainstreaming of disaster risk reduction and climate change adaptation in planning documents and processes in the region.

The chapter then reviews the state of flood risks in Africa, the implication of floods on poverty, projections of climate change and their impact on poverty, and policy recommendations on flood risk management for the continent. Finally, it discusses the state of integrated water resources management (IWRM) in Africa. Even though IWRM has traditionally included flood and drought risk management through water storage infrastructure solutions, the IWRM and DRR programs and policies have not been well coordinated.

A rapidly changing climate requires a change of this situation. A review of the complementarities of IWRM and DRR and the comprehensive management of floods and droughts, from prevention and mitigation; to preparedness; to response and recovery, is presented, with specific policy recommendations based on successful case studies in the continent.

DISASTER RISK REDUCTION

Disaster risk reduction and the Sendai Framework

In 2015, the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) was endorsed by the UN General Assembly. The SFDRR advocates for "The substantial reduction of disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities, and countries."[1] The SFDRR focuses on the three dimensions of disaster risk (exposure to hazards, vulnerability and capacity, and hazard characteristics) to prevent the creation of new risk, reduce existing risk, and increase resilience.[2] As such, the SFDRR plays a critical role in the climate adaptation plans of African nations.

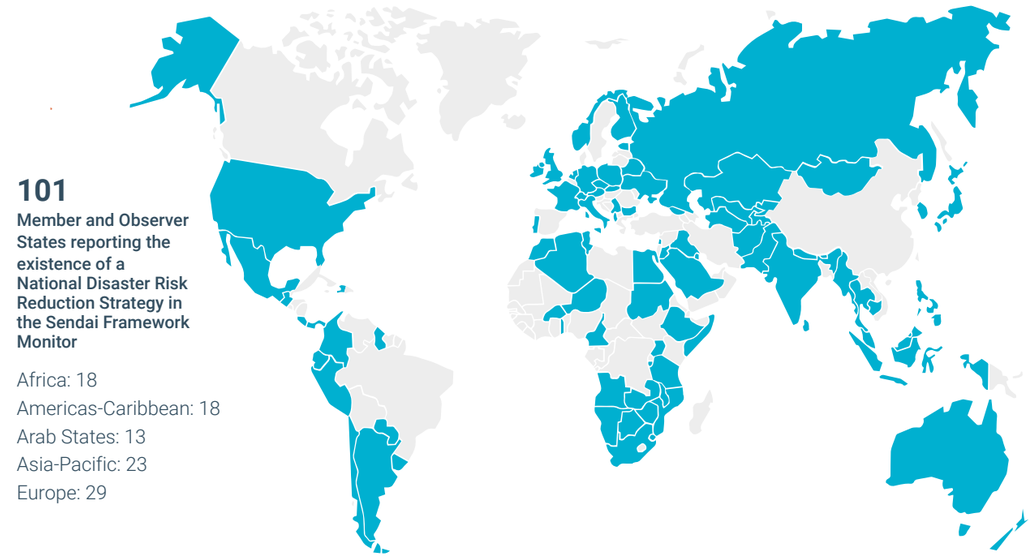
All African countries signed up for the Sendai Framework.[3] The African Union and its member countries identified five additional targets specific to the region. A Programme of Action (PoA) for implementing the SFDRR was adopted in 2016.[4] The seven targets of the SFDRR and the five targets of the PoA are presented in Table 1.

Table 1: The seven targets of the SFDRR and the five targets of the Programme of Action

The Seven Targets of the SDFRR	The Five Targets of the Programme of Action
a. Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015	1. Substantially increase the number of countries with DRR in their educational systems at all levels, as both stand-alone curriculum and integrated into different curricula
b. Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015	2. Increase integration of DRR in regional and national sustainable development and climate change adaptation frameworks, mechanisms, and processes
c. Reduce direct disaster economic loss in relation to the global gross domestic product (GDP) by 2030	3. Substantially expand the scope and increase the number of sources for domestic financing in DRR; Increase the number of countries with, and periodically testing, risk-informed preparedness plans, and response, and post-disaster recovery and reconstruction mechanisms
d. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030	4. Substantially increase the number of regional networks or partnerships for knowledge management and capacity development, including specialized regional centers and networks
e. Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020	
f. Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this Framework by 2030	
g. Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030	

> **"As you discuss climate change action and adaptation, please give water a central place in the discussion."**
>
> **Jakaya Mrisho Kikwete, Chair, GWP Southern Africa & 4th President of the Republic of Tanzania**
> High-Level Dialogue "An adaptation acceleration imperative for COP26", September, 2021

Figure 1: Progress towards Target (e) of the SFDRR



Source: UNDRR (2020) Annual Report

A key target of the SFDRR is the development of national and local disaster risk reduction strategies with a deadline of 2020. In Africa, 18 countries have validated strategies or policies aligned to the SFDRR, and seven more countries are developing or validating their strategies. Figure 1 shows the 101 countries worldwide that have reported the existence of national DRR strategies in the SFDRR framework monitor used to measure progress.[5] Africa is not too far behind the global average of developing regions.

Photo: Vadim Petrakov/Shutterstock

The African Union Commission (AUC), as the custodian of the PoA, prepares a biennial report on the implementation of the PoA. The latest report published in 2020 covers the period 2015–2018 and compiles data from 50 countries.[6] The report notes the significant progress in several areas of the SFDRR and the PoA, including establishing specialized DRR agencies in several countries. The AUC and the Regional Economic Communities have also established dedicated DRR units.

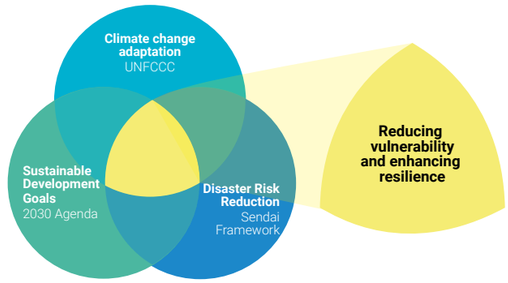
Our review of the various assessments of the state of DRR in Africa shows that financial resources are still insufficient to develop DRR and resilience programs. As discussed in the Present and Projected Climate Risks chapter, it is urgent to set up and expand multi-hazard early warning systems. Finally, the national planning and development processes have not yet fully mainstreamed DRR.

In-depth research of progress with the SFDRR and the PoA in Africa shows that African states are making progress. Still, better data and information systems are needed, and national programs need more robust local and community-based programs to build resilience.[7]

Disaster Risk Reduction and Climate Adaptation in Africa

In 2015, two other major international agreements were reached: the SDGs and the Paris Climate Change Agreement. Since then, there have been concerted efforts to coordinate these agreements at the country level. Climate adaptation and resilience reside at the center of these agreements (Figure 2).[8] However, the different institutional arrangements for DRR and climate change adaptation (CCA) lead to mismatches in governance, data and information, and funding streams.

Figure 2: Integrating adaptation with Sustainable Development Goals and the Sendai Framework



Source: UNSCCC (2017)

The UNDRR assessed 50 planning documents for DRR and CCA to evaluate their policy coherence and level of integration in 32 countries in Sub-Saharan Africa.[9] The review finds that coherence is more incidental than structural, and it happens on an ad-hoc basis. Specifically, the integration of CCA into DRR strategies varies widely. In contrast, the reciprocal integration of DRR into CCA strategies is partial primarily.

The operational elements of the documents indicate overlapping activities and a general lack of collaboration. The UNDRR makes a comprehensive set of recommendations for African nations, including:

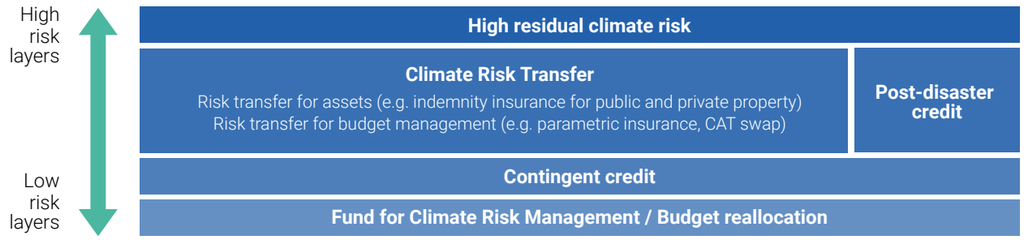
- Develop coordinated DRR and CCA risk assessments that can inform policymaking and educate all stakeholders in society.
- Strengthen governance for policy coherence between DRR and CCA, including more robust and formal vertical and horizontal collaboration between the two practices.
- Leverage existing planning processes (National Development Plans, NAP, and DRR strategies) and use the NDP as the overarching planning vehicle to support the policy and programming coherence of DRR and CCA.
- Promote legal frameworks that integrate DRR and CCA, clarify mandates, roles and responsibilities.
- Conduct risk-sensitive budget reviews and expenditure reviews and use them to identify investments and budget needs for DRR and CCA. Recently, 16 African countries have prepared Disaster Risk-Sensitive Budget Reviews.
- Develop joint risk financing strategies combining budget support, risk transfer, and insurance mechanisms.
- Ensure systematic integration of CCA to inform recovery planning.

DRR Financing

The level of domestic financial resources dedicated to DRR activities is insufficient in most African countries.[10] On average, 4 percent of national budgets, at the planning stage, is related to DRR. Some countries like Eswatini and Rwanda allocate more than 8 percent, while others like The Gambia and Sao Tome and Principe assign less than 0.5 percent. It is important to note that only 1 percent of the national budgets, on average, is directly dedicated to DRR interventions. Given the substantial economic losses resulting from disasters, there is an opportunity and urgency for increased resources—domestic government, private sector, and international—to support DRR interventions, particularly those linked to climate-related disasters.

The Finance chapter presents a variety of mechanisms to fund climate adaptation. Some of these are linked and should be coordinated with DRR financing. A wide range of instruments can be combined and leveraged in a multi-layer financial architecture for DRR and climate-related disasters (Figure 3). A key objective of this architecture is to mobilize as fast as possible the resources needed for post-disaster reconstruction and recovery.

Figure 3: Multi-layer financial architecture for DRR and climate disasters



Source: GCA (2020), *State and Trends in Adaptation*, adapted from The World Bank (2016), *Colombia: Policy strategy for public financial management of natural disaster risk.*

A case study in Malawi shows that instantaneous support by governments can minimize household costs related to disasters. However, a four-month delay can increase those costs to US$ 50 per household. A nine-month delay can go up to as much as US$ 1,300, due primarily to the impacts on the development of children and the distress sales of assets, in particular livestock.[11]


Photo: Vadim Petrakov/Shutterstock

FLOODS

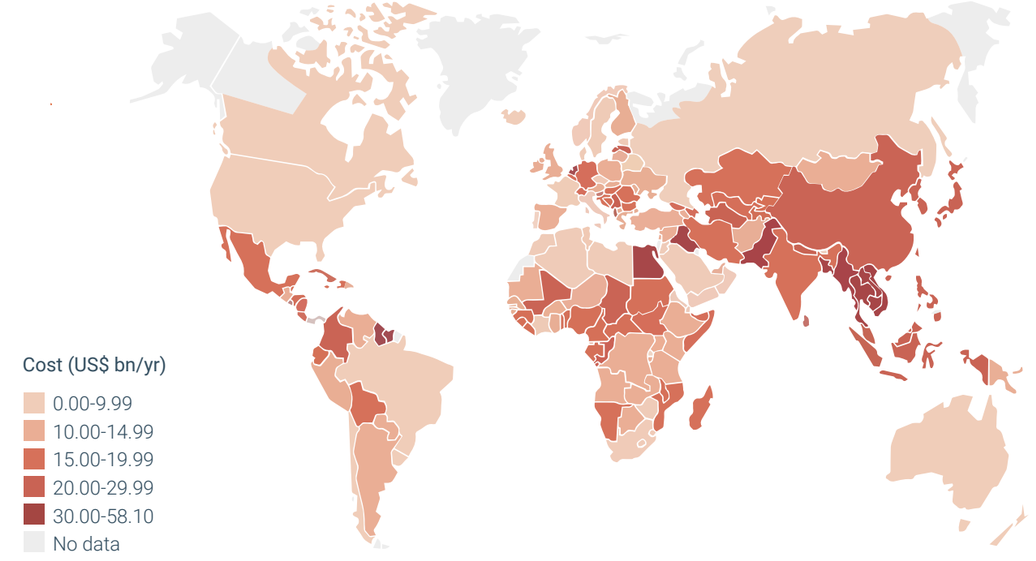
Flood risks in Africa

In Africa, over the period 2008–2018, floods accounted for 65 percent of disaster events and caused 24 percent of deaths. The 2018–2019 cyclone season caused the most considerable flood damage seen in the region. The leading cause was Cyclone Idai, which primarily affected Mozambique and Zimbabwe with at least 900 deaths and infrastructure damage estimated at more than US$ 1 billion.[12] The Transport and Energy chapter and the Agriculture and Food Systems chapter detail the level of current and projected damages by floods in these sectors.

The rainfall and river basin flows in the continent have a wide range of variability, which poses significant challenges for managing floods. These challenges range from managing floods in large transboundary river basins, understanding the extreme floods in ungauged catchments with minimal information, and reducing the vulnerability of low-income informal settlements in African cities.[13]

Recent advancements allow quantification over many possible flooding scenarios, probabilistic risk assessments, and estimations of potentially impacted populations. These quantitative results allow for cross-country comparison, hence providing valuable information for transboundary risk management. Figure 4 shows the very diverse flood exposure across Africa. It shows the percentage of the national population exposed to 15cm or more flood inundation risk in the event of a 1-in-100 year flood (before taking into account flood protection systems).[14] Countries with a high share of the population exposed to floods include Egypt, Sudan, the Central African Republic, Somalia, and Mali.

Figure 4: Relative population exposure to 15cm or more flood inundation risk at the country level (percentage)



Source: World Bank (2020), *People in Harm's Way: Flood Exposure and Poverty in 189 Countries*

Flood and poverty

Global research, including GCA work, has shown that those living in poverty are particularly vulnerable to climate shocks such as floods. This means that the poor lose more when such shocks hit them. This is due to a variety of factors linked to vulnerability which are particularly relevant for Africa, such as: (i) lower-quality housing that is more vulnerable to damage and loss; (ii) greater income dependence on climate-dependent agricultural and ecosystems; (iii) less-resilient infrastructure services; (iv) greater susceptibility to diseases linked to floods such as diarrhea and cholera; and (v) long-term human capital impacts through compromised health and education systems during floods.[15]

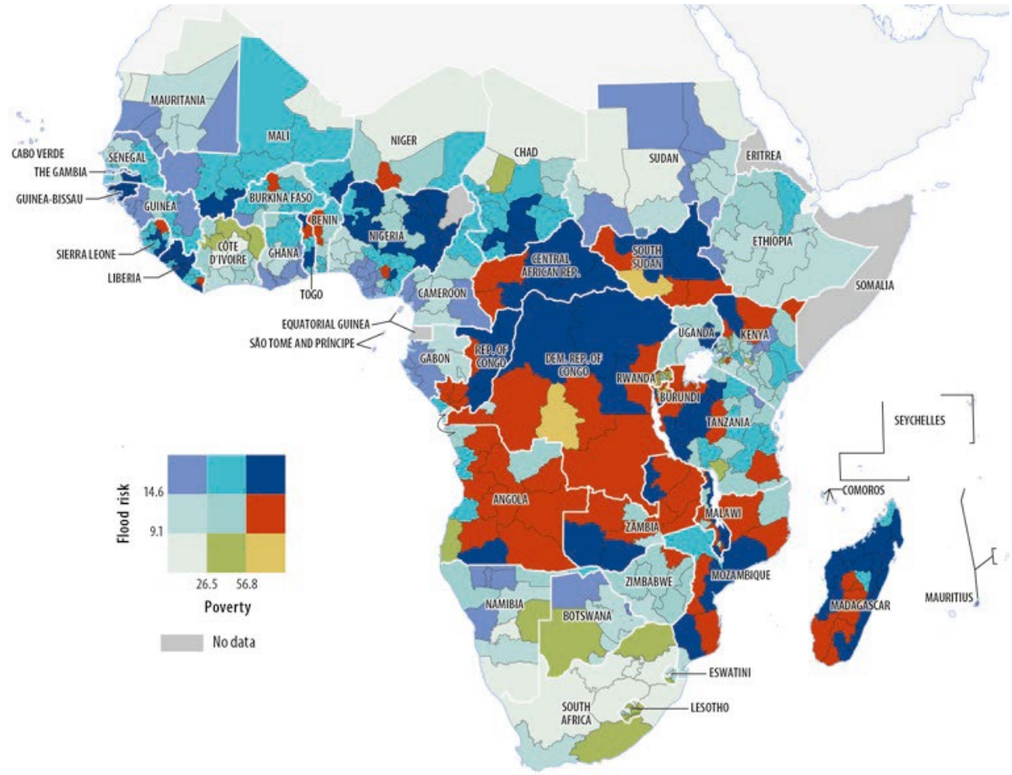
Globally, about 1.47 billion people are estimated to be living in areas with high flood risk. Of these, about 132 million people live under the poverty line (US$ 1.90 a day). Among world regions, Sub-Saharan Africa stands out. It accounts for slightly more than 10 percent of the total population with high flood risks, but for more than half of the global poor who face high flood risks. These numbers reflect the multidimensional character of poverty. Sub-Saharan Africa lags behind other regions on monetary poverty measures, and the poor also suffer from greater exposure (and vulnerability) to climate change risks such as flooding.[16]

At the local level, the relationship between poverty and flood exposure can be complex. For example, economically active coastal cities may be more exposed than other areas of a country. However, within cities, poor people in informal, unplanned settlements are more likely to be exposed. The World Bank analyzed data from 52 countries and found that poor people are often overexposed to urban floods. Some countries in Southern Africa, the Horn of Africa (except for Ethiopia, Rwanda, Zimbabwe, and Mozambique) and Egypt have a strong over-exposure of poor people to floods. In Western Africa, countries with larger rivers and delta areas (notably Benin, Nigeria, and Cameroon) tend to have poor people disproportionally exposed to floods. Overall, 73 percent of analyzed populations live in countries with a positive poor-exposure bias to fluvial floods, notably in Angola, Cameroon, the Democratic Republic of Congo, Nigeria, and Zambia.[17] In these countries, proactive land-use policies in cities to reduce exposure of the poor to floods can be a cost-effective measure, as discussed in the Urban Development chapter.

At the sub-national level, analyzing the distribution of floods and poverty can provide insights for spatially targeted policies to reduce flood vulnerability of the poor. Figure 5 shows the joint distribution of poverty and flood risk in Sub-Saharan Africa. There is a wide diversity of circumstances that call for targeted action. For example, the map shows areas in the Republic of Congo, Ethiopia, Gabon, and South Africa with a relatively high share of the poor exposed to flood risks but low poverty rates. In other areas of Central and West Africa, there are both high poverty and considerable exposure among poor people to flood risks. Globally, four out of the top ten subnational regions by the absolute number of poor with high flood exposure are located in Sub-Saharan Africa.[18]

Photo: Peter Titmuss/Shutterstock

Figure 5: Joint distribution of poverty and floods in Sub-Saharan Africa



Source: World Bank (2020), *Poverty and Shared Prosperity 2020: Reversals of Fortune*

Finally, flood management and poverty targeting based on demographics alone may not be sufficient. For example, the joint incidence of conflict and other climate risks is likely, as discussed in the Conflict and Migration chapter. The share of the poor in areas with a history of conflict and those with high exposure to flooding in countries with high degrees of exposure to both do not appear to be systematically linked. However, many countries in Sub-Saharan Africa, like Cameroon, Liberia, and South Sudan, have a relatively large share of the poor living in areas both affected by a history of conflict and facing high exposure to floods. Adaptation policies need to take into account conflict history.

> **"How do we best capture the outcomes so people around the world understand not just the challenge, but also the opportunity, the possibility: [adaptation] is not a message of despair, it is a message of hope and of action needed."**
>
> **Vijay Rangarajan, Director General, Americas and Overseas Territories at the Foreign, Commonwealth & Development Office (FCDO), Government of the United Kingdom**
> High-Level Dialogue "An adaptation acceleration imperative for COP26", September, 2021

Climate projections and floods

As discussed in the Present and Projected Climate Risks chapter, the Sixth Assessment Report of the IPCC indicates, with high confidence, that the frequency and intensity of heavy precipitation events are projected to increase almost everywhere in Africa with additional global warming. The data in the IPCC report shows that there has been an observed increase in flooding in West, East Southern, and West Southern Africa. Projected increases in pluvial flooding are expected for all sub-regions in Africa, except for North Africa (Mediterranean areas).[19]

Partly driven by population increase, the number of people exposed to river flooding in Africa is predicted to rise to 23.4 million by 2050, with a 57 percent increase in fatalities if global average temperatures increase by 1.5°C. Without additional flood protection and following the projected substantial increase in economic value in flood-prone areas, the projected economic damage in the region could reach US$ 266 billion per year by 2050. With a 3°C rise, the number of people exposed to floods will rise to US$ 33.7 million, and the death toll by 135 percent. Sub-Saharan Africa is predicted to have an increase in the share of the population exposed to flooding, driven by substantial population growth, migration to urban areas, and slum expansion.[20]

Climate change is likely to increase the number of people exposed to floods. Under a high-emissions scenario (RCP 8.5), the number of people exposed to river floods could increase by 4 to 15 percent in 2030 and 12 to 29 percent in 2080. In some regions, the population exposed to floods rises rapidly with global warming, such as in the Horn of Africa and parts of West Africa and Egypt. Some countries will see a combined increase in exposed people larger than 10 percent and a high percentage of poor people disproportionately exposed. Under RCP 8.5, in 2050, some of these countries in Africa include Egypt, Guinea, Kenya, Nigeria, Sierra Leone, and Uganda.[21]

Flood risk management

Current and projected flood risks in Africa are significant and growing. The practice of flood risk management in Africa is nascent. It has grown in importance in urban areas and some of the largest river basins (Congo/Zaire, Niger, Nile, Zambezi, Senegal, and Lake Chad), where population growth in the floodplains has been fast. Our GCA analysis suggests that the following policy recommendations bring together regional and international good practices applicable to Africa:

Understanding flood risk is fundamental: Flood risk management requires not only understanding the types, causes, and likelihood of flood events but also the population and assets in potentially affected areas and their vulnerability and understanding of floods. The low data coverage of most river basins in Africa is an essential barrier to flood management.

Traditional structural flood reduction infrastructure is expensive and needs careful targeting: The traditional structural measures to reduce floods such as dams and reservoirs, dikes and levees, embankments and diversions, or river and channel improvements are a necessary part of flood risk management.[22] However, they have high costs, and their location and design need to be carefully planned for areas with a high risk of life losses and high-value asset damages, such as densely populated urban areas. For areas where structural flood risk reduction infrastructure is not economically viable, other lower-cost measures are required.

The most essential and cost-effective non-structural flood risk management measures are planning and preparedness: Non-structural measures as part of disaster risk management programs can significantly reduce the loss of life and the protection of mobile assets, as discussed earlier in this chapter. Non-structural measures include emergency planning and management, including early warning systems and evacuation plans, preparedness via awareness campaigns, drills, and continuous information to communities and households. Non-structural measures are needed even when structural measures are in place. Structural measures will never prevent every possible disaster, including those that may have more substantial impacts due to climate change. The need for continued awareness and preparedness over years or decades without a destructive flood event is an important challenge for these non-structural measures.

The next level of non-structural measures is related to land use planning and management: This is particularly relevant for rapidly growing urban areas, as discussed in the Urban Development chapter. Flood-prone areas are often economically productive and attractive for agriculture and housing. This dichotomy creates a tension between economic and social uses, on the one hand, and flood risk management, on the other. Flood-informed land use planning and early prevention of construction in high-risk zones are a lower-cost alternative than reconstruction after flood damages, construction of expensive structural engineering solutions, or retrofits.

Rapid changes in Africa make flood prediction in the short- and medium-term challenging: In addition to insufficient data, the ability to project future flood risk is affected by rapid changes in African societies and economies, from urbanization to land-use change, development of floodplain areas, and climate change. Defending against future floods in Africa will require more robust, flexible, and incremental approaches that can adapt to a broader range of future development paths and a changing climate.

Other structural measures to reduce flood risks with lower costs and greater flexibility are nature-based solutions: These include, among many others, the preservation of wetlands, the preservation or restoration of natural floodplain storage, and the management of forest and vegetation cover. Structural and non-structural measures are not exclusive. Instead, flood management strategies need both types. The balance will depend on the level of economic development and population density of areas affected, the existing risk and projected changes in risk levels, and an open science-based discussion among stakeholders on preferred levels of risks and their management.

Flood risk management needs, at times, to look at large spatial scales: The flooding risks of cities or coastal areas depends in many cases on the characteristics and management practices of river basins and water catchments upstream. Often the most practical option to prevent flooding downstream is to take action upstream.[23] The following section of this chapter reviews the importance of water resources management in the reduction of flood risks and the adaptation to various water-related risks in a changing climate.

Photo: Lucian Coman/Shutterstock

INTEGRATED WATER RESOURCES MANAGEMENT

The state of IWRM in Africa

One of the most direct transmission channels of the consequences of climate change is through water: too much, too little, at unexpected times. The Agriculture and Food Systems chapter discusses the enormous implications of droughts on African economies and the malnutrition of its population. The Urban Development chapter reviews the challenges to provide safe water and sanitation in the face of a rapidly changing climate and the impacts of floods on the concentrated economic assets and lives in urban areas. This chapter has discussed the impacts of floods on poverty. The rapidly growing population of Africa, more water-intensive growth paths worldwide and in the region, and increasing pollution, are all factors that, combined with the projected increase in rainfall variability, will make climate adaptation more complicated and more urgent. The solutions and policy recommendations described in those chapters point to the need for integrated water adaptation solutions that connect economic sectors and different levels of government. The river basin is the spatial scale required for such integration.

Integrated water resources management (IWRM) is a holistic framework used to address the diverse demands and pressures on water resources across sectors and at different scales – from the local to the transnational – in an equitable, sustainable manner. The African Ministers' Council on Water (AMCOW) was established in 2002 to promote cooperation and socioeconomic development by effectively managing the continent's water resources and providing water supply services.[24]

In the most recent status report on the implementation of IWRM in Africa,[25] AMCOW highlights that, based on data submitted by 51 African countries, the region's overall performance of IWRM (linked to SDG indicator 6.5.1) is a bit lower than the global average (41 compared with 49 in a scale 0–100). AMCOW estimates that, based on current trends, almost 36 out of 51 countries will not meet SDG target 6.5 by 2030, namely to implement IWRM at all levels, including through transboundary cooperation. At the same time, 42 nations have institutionalized most IWRM elements, providing a solid foundation to accelerate progress. Implementing IWRM is a critical element of the AMCOW Strategy 2018–2030.

Transboundary cooperation is an important dimension of managing the water resources of Africa, as the 48 mainland countries of Africa share 134 transboundary basins and aquifers.[26] Over 90 percent of Africa's surface water is in transboundary basins, and transboundary aquifers underlie over 40 percent of the continent.[27] For this reason, River Basin Organizations are important for the region. Africa has the largest number of transboundary river basins globally, with the Nile, Niger, Senegal, Zambezi, Congo, Volta Rivers, and Lake Chad as the region's primary regional growth arteries.

Photo: Dennis Wegewijs/Shutterstock

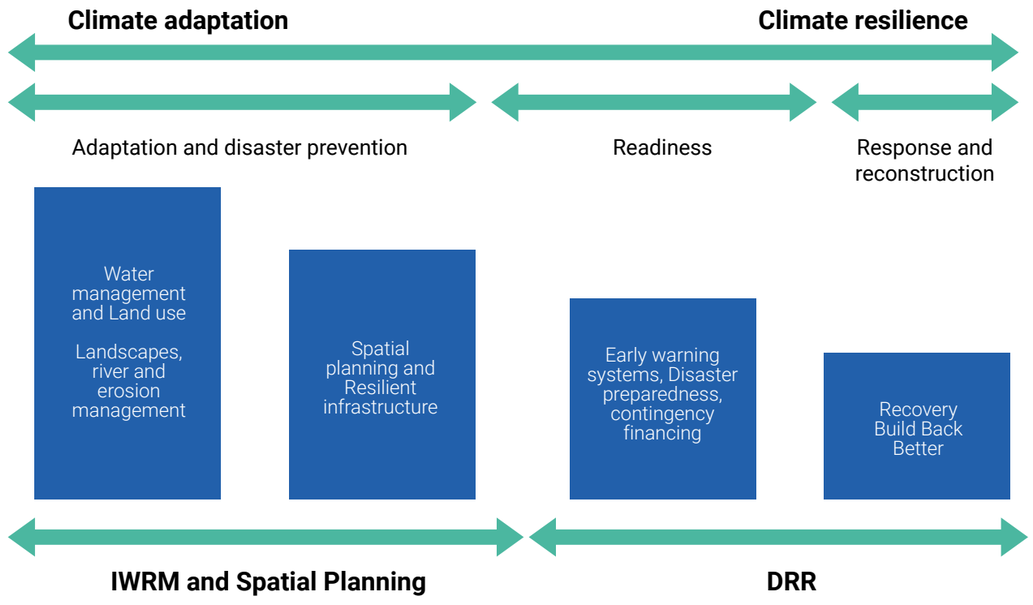
IWRM, DRR, and climate adaptation

In its last IWRM status report, AMCOW highlights the need to enhance investments in disaster risk management, especially in water management plans and systems, to enhance the continent's adaptation and resilience to water-related disasters in a changing climate.[28] These plans and strategies need strengthening in information, institutions, and infrastructure (both natural and built) with a lens of climate adaptation.

IWRM has traditionally included flood and drought risk management through a combination of water storage solutions and water availability information for decision-making under stress conditions. Generally, IWRM and DRR have not coordinated actions and programs under different institutions with different approaches and areas of focus. Our GCA analysis shows that the growing urgency of climate adaptation actions makes this coordination even more critical.

Figure 6 illustrates the complementarities of IWRM and DRR by viewing all phases of a comprehensive management strategy of floods and droughts, from prevention and mitigation; to preparedness; to response and recovery. Prevention and mitigation include upstream land use measures that help manage downstream water flows; and spatial planning, landscape, and infrastructural developments for water storage. Although drought and flood risks can be reduced, it will not always be possible to fully mitigate their threats. Upfront investments in preparedness, response, and recovery, including social protection and cash transfer programs—practices traditionally part of the DRR domain—will be necessary to deal with residual flood risks. Upfront investments will also be needed in more effective early warning systems, better ex-ante planning, rapid response in the aftermath of a disaster, and overall resilience building of vulnerable populations.[29]

Figure 6: Integrated flood risk management – The links of IWRM, DRM, and climate adaptation



Source: Authors, adapted from Johannessen, A. and C. Wamsler (2021). "Extraordinary Governance to Avoid Extraordinary Events." Chapter in J. Baird, R. Plummer (eds.), *Water Resilience*, Springer Nature.

As over 90 percent of Africa's surface water is in transboundary basins, climate adaptation options will be a lot more limited if they only consider national boundaries. Regional cooperation expands the range of possibilities for climate adaptation. The collaboration can range from simple data sharing to joint implementation of large transboundary infrastructure projects. The World Bank's Cooperation in International Waters in Africa (CIWA) partnership has identified lessons from case studies on resilience and adaptation in transboundary waters in Africa. These are presented in Box 1.[30]

Good examples of basin-wide collaborations include the Niger Basin Agreement, where nine countries have come together to develop a sustainable development action plan (SDAP) and climate resilience investment plan (CRIP). The SDAP aims to protect resources and ecosystems; build infrastructure, including transboundary infrastructure; and build capacity for managing the basin. CRIP, meanwhile, aims to increase knowledge related to impacts and vulnerabilities and integrate adaptation into the activities of basin institutions.[31] Other examples include the "Eco-DRR" project by the UN Environment Programme and the European Commission. The project established the Lukaya River Basin Users Association in the Democratic Republic of the Congo to reduce flood and gully erosion risks and support community livelihoods by integrating IWRM and DRR.[32] The World Bank-supported "Enable Plan Invest Control" (EPIC) Response Framework is also promising. It combines existing flood and drought approaches into a unified framework that allows hydro-climatic risks to be managed synergistically, and promotes collaboration between agencies in the DRM and IWRM domains.[33]

Photo: Migel/Shutterstock

Box 1: Lessons on Resilience and Adaptation in Transboundary Waters in Africa

Photo: Nebojsa Markovic/Shutterstock

A series of case studies prepared for the World Bank report "Climate Resilience in Africa the Role of Cooperation around Transboundary Waters" show that appropriately planned transboundary cooperation can improve the resilience of economies, livelihoods, and ecosystems in Africa. Specifically, the case studies show that

1. Shared, trusted information enables:
   - Preparedness through cross-border sharing of information that can greatly improve prediction and help avert large losses of lives and property; and
   - Shared planning tools that can help riparian communities jointly decide ways to optimize water use, manage trade-offs, and share benefits;
2. Flexible, adaptive institutions enable:
   - Alignment of regional and national policies that help countries build climate resilience through integration and interconnectivity of regional systems; and
   - Frameworks for cooperative action that help countries learn together and collectively manage their responses to a changing climate in a flexible and adaptive manner;
3. Shared approaches to infrastructure enable:
   - More cost-effective, efficient, sustainable, and climate-robust investments in both natural (for example, watershed management, and reforestation) and built (for example, multipurpose dams) infrastructure. Since infrastructure represents both a major cost, and sometimes a major ecosystem risk, the potential benefits of a joint approach can be considerable; and
   - Resource and capacity stretched countries to pool together technical capacity, mobilize financial resources, and adopt increased transparency to facilitate improved design, operation, and restoration of built and natural infrastructure.

Source: World Bank (2017). Climate Resilience in Africa: The Role of Cooperation around Transboundary Waters. World Bank, Washington, DC

Photo: IUCN - Poorly maintained traditional water source in Ariwi West village, Mutu parish, Paimol Sub County, Agago District in Northern Uganda.

Community Environment Conservation Fund for Water Resources Management

Geography: Upper Aswa sub-catchment (Lira and Otuke districts) in northern Uganda.

Adaptation measures: The project provided support to village natural resource micro-catchment plans and bylaws to implement fencing and greening of water supply areas, no-cultivation zones in wetland and riparian areas and micro-business development.

Key outcomes: A total of 4,346 households are served by 196 improved water sources managed by community committees and protected by green and grey infrastructure enhancements; and 168 km of riverine areas were restored and protected to provide improved water quality and flow regulation, particularly during dry periods. The project also nearly doubled the yearly income of participating households (from US$ 550 to US$ 1,000) through small enterprises, and it improved communities' and local governments' adaptive capacity to manage natural resources and monitor progress towards locally-set goals.

Partners and funding: IUCN, Austrian Development Cooperation, Ministry of Water and Environment, district local governments, community leaders, NGOs and CSOs. 2011-2016. € 680,000.

PROJECT SUMMARY

Uganda is experiencing an increased frequency of extreme weather events, with an average of 200,000 Ugandans affected each year. In 2010 and 2011, the country saw losses of more than $60 million/year from floods and US$ 1.2 billion (7.5 percent of the GDP in 2010) from droughts.[34] Climate change is projected to increase mean annual temperature by 1.2 to 2.5°C between 2040 and 2059 and will also impact water availability. The central and southern regions will experience a greater risk of flooding due to increased intensity of rainfall, while the northern, northeastern, western and southwestern regions can expect continued aridity and increased drought frequency.[35] Some climate models predict a 14 percent increase in heavy rain events by 2060.[36]

The Aswa catchment basin in northern Uganda is no exception, with an expected increase in temperature of more than 3°C and an annual coefficient of variability of precipitation between 14 and 56 percent,[37] causing precipitation patterns to become increasingly erratic by end of this century.[38] Increased climate variability will impact the agriculture, water, wetlands and forestry sectors, as well as livelihoods that depend on ecosystem services and biodiversity. Up to 97 percent of the land in Uganda also suffers from human-induced land degradation,[39] increasing the susceptibility of smallholder farmers to production shocks.[40] Impacts on food crops like cassava, corn, millet and groundnuts could bring economic losses of up to US$ 1.5 billion by 2050, in a sector employing 70 percent of the working population and contributing 25 percent of the GDP.[41] Reducing these risks requires an integrated approach to strengthen climate change adaptation, combat land degradation and enhance food security.

IUCN, through its Community Environment Conservation Fund (CECF), applied the principles of integrated water resources management (IWRM) in this project. Management of local water sources was brought under community committees, with women, as primary water users, constituting the majority of the committee members. All water source points were fenced (to prevent degradation and overuse) using locally available materials and schedules were drawn for periodic cleaning. The catchments of these water sources were protected with planted grass and trees, in accordance with government water source protection guidelines. The committees also mobilized their communities to stop farming in wetlands and along stream and river banks. As a result, they reported natural vegetation regeneration, improvement of water quality and turbidity and increased water flows, especially during the dry season.

Each of the 100 participating villages accessed a grant of US$ 1,500 to provide its community members with microcredits. The funds are managed by locally elected committees that reports progress and households' participation on a monthly basis in coordination with local government officials. Access to the CECF microcredits enabled small-scale enterprises to access landscape restoration markets, including through establishing tree nurseries and preserving shea trees to sell the nuts instead of producing charcoal. As a result, household income in participating communities nearly doubled. The project showed positive initial results with regards to repayment (often recovered at no additional charge) and has laid the foundation to explore institutional arrangements to scale the approach and ensure its

Photo: IUCN - Part of the water source still has signs of protection in Akileng village, Akileng parish, Alito Sub County, Kapelebyong District in Northern Uganda.

sustainability. Areas for improvement were identified with relation to capacity building, funding thresholds and the need to implement processes to avoid elite capture of funds.

The funding has also catalyzed the development of natural resource management bylaws, which were approved and implemented at the community level, increasing communities' capacity for an adaptive management of the impacts of climate change.

The National Water Policy Committee recommended in 2014 that the CECF approach should be adopted and scaled up as a tool for natural resources management, economic empowerment and social cohesion. The CECF fund is still being managed by the communities after the end of the Building Drought Resilience (BDR) project life cycle in 2018. Further scaling of the approach requires fund capitalization efforts to avoid dependency on donor contributions.[42]

Photo: IUCN - A well-protected community water source (borehole) in Tetugo village, Mutu parish, Paimol Sub County, Agago District in Northern Uganda. This water source has a committee that manages its daily operation.

Photo: IUCN - Monitoring of CECF in Mutu and Arwotngo parishes, in Agago and Otuke districts, northern Uganda respectively.

Photo: Ieshiy985/Shutterstock

Earth observations to monitor disasters and build resilience in the nile basin and the north coast of Egypt

Geography: Egypt

Adaptation measures: The project focuses on integrating remote sensing and Earth observation data to monitor extreme events and downscale assessment of impacts and damages to sub-national and basin level, and on building the capacity of personnel at national statistical offices.

Key outcomes: The project aims to promote the integration of remote sensing and geospatial information with official statistics to improve disaster monitoring and to better understand the impact of extreme events on people, land and infrastructure; inform disaster management approaches; and support data-driven advocacy and decision making.

Partners and funding: UNESCWA, Google Earth Engine (GEE), Group on Earth Observation (GEO) and the Central Agency for Public Mobilization and Statistics (CAPMAS), the official statistical agency of Egypt. US$ 3 million. 2020–2022.[43]

Figure 1: CHIRPS Daily Precipitation Data on March 12, 2020-Egypt

PROJECT SUMMARY

Observational data since the 20th century have provided evidence of consistent and significant warming trends across the Arab region, with increased frequencies of warm days and warm nights, more extreme temperatures, fewer cold days and nights and shorter cold spells since the early 1970s.[44] In Egypt, warming has increased at a rate of 0.1^{0}C per decade on average between 1901 and 2013; however, a substantial increase to 0.53^{0}C per decade has been observed over the past 30 years (compared with the per decade global average increase of 0.08^{0}C since 1880s and 0.18^{0}C since 1981).[45,46] Since the 1960s, there has been an increase in daily minimum temperatures throughout the country, with warming having been more pronounced in the winter (0.31^{0}C) than in the summer (0.07^{0}C).[47] Climate models[48] predict an increase in mean annual temperature of 1.5^{0}C-3^{0}C by 2040-2059, with more rapid increases in the interior parts of the country.[49] Increased temperatures are also expected to impact precipitation patterns, with models suggesting a prevalence of drier conditions in most months by 2050 and dry spells expected to increase by 75 days per year by the 2080s.[50]

These climate change impacts pose a critical threat to Egypt's Nile Delta, which has been recognized as one of the world's three extreme vulnerability hotspots. Future projections point towards a greater risk arising from sea level rise, water scarcity, and greater frequency of extreme events such as heatwaves, flash floods and sand and dust storms. In addition to being the most populated area in the country, the Nile Delta also contains 50 percent of Egypt's agricultural land, while the Nile River supplies 95 percent of the country's water.[51,52] Climate change is expected to impact water flows in the Nile, affecting water supply not only in Egypt but in other countries in the Nile Basin (e.g. Ethiopia, Sudan, South Sudan and Uganda). Studies estimate that by the late 21st century the frequency of hot and dry years will increase by a factor of 1.5-3, even if warming is limited to 2^{0}C. Combined with increasing population, this will exacerbate chronic water scarcity in the Upper Nile Basin, leaving an additional 5-15 percent of the population at risk of having insufficient water.[53]

Climate change is also projected to cause inundation of the coastal areas due to sea level rise. About 6.1 million coastal inhabitants could be displaced and 4,500 km^2 of cropland lost, which would result in GDP losses of up to 6 percent for a 1 m sea level rise scenario and 16 percent in case of 5 m sea level rise.[54] Rising sea level threatens facilities at Port Said with economic damage of more than US$ 2 billion at 0.5 m and US$ 4.4 billion at 1.25 m, respectively. In Alexandria, the estimated cost of constructing sea walls for shoreline protection is around US$ 300 million per year.[55]

In the face of these growing climate risks, programs and projects that strengthen and improve disaster monitoring are essential for adaptation. UNESCWA's Google Earth Engine Project on the Use of Remote Sensing for Disaster Monitoring in the Nile Basin and North Coast in Egypt is one such project. The project falls under UNESCWA's mandate to

Figure 2: Affected Areas from Floods in 2020

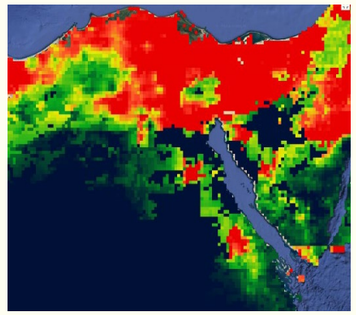


Figure 3: Affected Areas from Floods in 2020

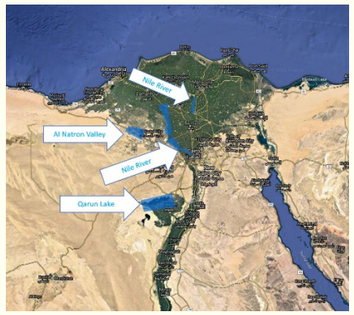


Figure 4: Affected area in Qarun Lake

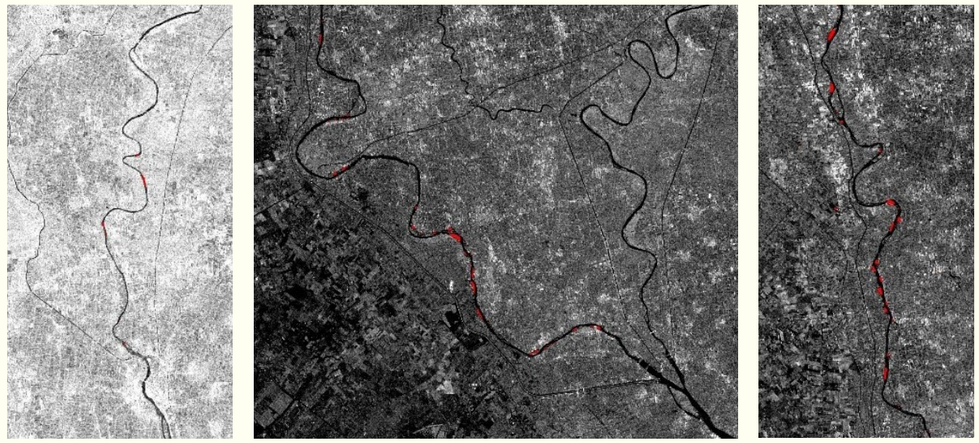
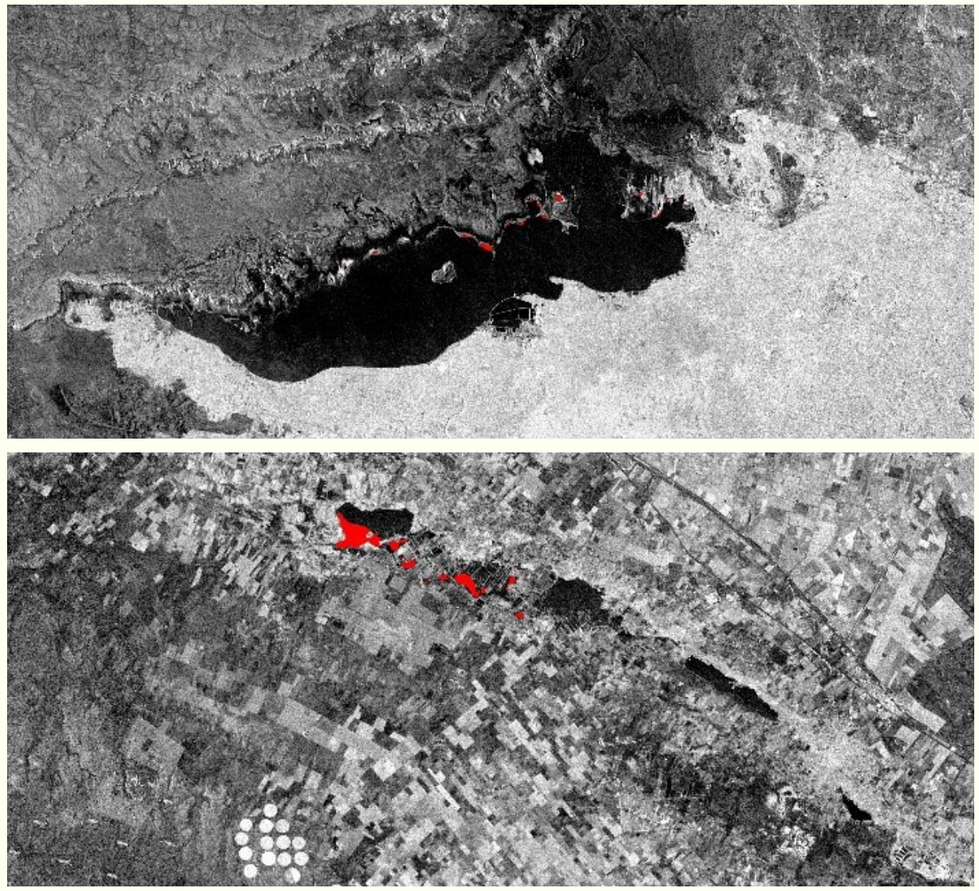


Figure 5: Affected area in Al Natron Valley



support the modernization of national statistical offices across Arab countries, while promoting the integration of geospatial information and big data. Its overall objective is to assess the utility of open medium-resolution satellite data for extreme event monitoring and impact evaluation, and to support the national statistical offices and their counterparts with supplementary data to enable damage assessment, reduce disaster risk and strengthen resilience, allowing for more effective monitoring and reporting on the Sendai Framework for Disaster Risk Reduction[56] and the Sustainable Development Goals (SDGs). The approach combines several datasets, including: remote sensing data from Sentinel-1&2, part of the Copernicus program of the European Space Agency; world population data from the Gridded Population of the World from NASA's Socioeconomic Data and Applications Center; land use data from Copernicus Global Land Covers; climate hazards from CHIRPS'[57] daily rainfall dataset and Emergency Events Database; and national databases including census, disaster and infrastructure data. Analyzing these, the project evaluates the magnitude of potentially inundated agricultural and urban areas and affected population.

Despite these advancements, there are several technical limitations that may limit the feasibility and usability of this approach; for instance, cloud cover can limit the utility of multispectral satellite imagery, and the existing resolution of images received from satellites limits the ability to accurately detect urban floods.

In addition to providing analytical support, the project provides training and builds the in-house capacity of national statistical offices to make use of Earth observation data to analyze and improve disaster assessment. This includes increasing understanding of flood-prone areas like Wadi Al Natron and Ras Ghareb, the damages to crops in flooded areas, and associated loss of biodiversity and ecosystems services. The project can also help in assessing the impact of planned interventions, such as understanding future changes in the flow and level of the Nile River due to Al Nahda Dam.

The project takes a complementary approach to the broader Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR), which has helped to deepen the understanding of the impact of climate change on water resources, water-dependent sectors and associated implications for socio-economic vulnerability in the Arab region through regional climate modeling. UNESCWA Google Earth Engine project enhances capacity and advocacy for better use and integration of remotely sensed geospatial data to improve data-driven decision making in Egypt and other Arab countries in relation to disaster risk management through replicating the GEE codes from the case study of Egypt for applications in other areas in the Arab region. Thus, it informs progress towards the SDG targets related to climate change and disasters.

AfDB's new water policy

In line with Africa Water Vision 2025, the goal of the African Development Bank (AfDB) is for a water secure Africa with equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and stable and peaceful societies.

The African Development Bank's new water policy is based on the principles of integrated water resources management.

In the medium-to long-term, AfDB seeks to ensure that sound economic, social, and environmental considerations influence water sector investment decisions in African countries, across regional bodies and in watersheds. As of 2021, the Bank's active water sector portfolio stood at US$ 4.3 billion, with nearly a hundred national projects implemented in 40 countries, and six multinational projects.

AfDB's new water policy, approved in May 2021, includes four key implementation pillars: enabling environment; institutions and participation; management instruments; and financing. Recognizing the clear need to address water security in areas where it directly contributes to fragility, or where enhanced water security will resolve conflicts and bring peace to communities, AfDB interventions are informed by assessments using the Country Resilience and Fragility Assessment tool and the integrated Climate Safeguards Screening tool.

The new water policy is guided by seven operational elements:

- **Economic valuation of water, pricing of water services, and cost recovery.** This contributes to evaluating the trade-offs involved in the allocation of water resources between competing needs, while reflecting the resources used for investment, and expenditures for operations and maintenance.

- **Sustainable, smarter, and resilient infrastructure.** This contributes to achieving water security at national and regional levels, and to addressing the issues of sustainable access to water resources and maintaining a high quality of water services.
- **Governance and enabling environment.** Institutional and human resources capacity for sustainable water sector services delivery remains a challenge in Africa. Capable results-oriented institutions and good governance are crucial for attaining water security, sustainable implementation of water policies, and effective operations and maintenance at household, community, local, national, and regional levels.
- **Financing and investments.** Sustainable and innovative financing, including from the private sector and micro-finance schemes, is important to develop, implement, and maintain the hard and soft infrastructure and institutional components of water systems.
- **The multi-purpose use of water and ecosystem services-based approach.** This provides multiple benefits from a single investment, promoting efficiency, while fostering equality and sustainability.
- **Knowledge management, innovation, technology, and research**. This supports the water sector in Africa to make evidence-based decisions, using innovative and technologically-sound solutions.
- **Participation and inclusion.** It is only through the support of stakeholders, their willingness to pay, and their compliance with user guidelines that countries can move towards achieving water security. Consulting stakeholders in a timely, transparent, and inclusive manner is therefore critical.

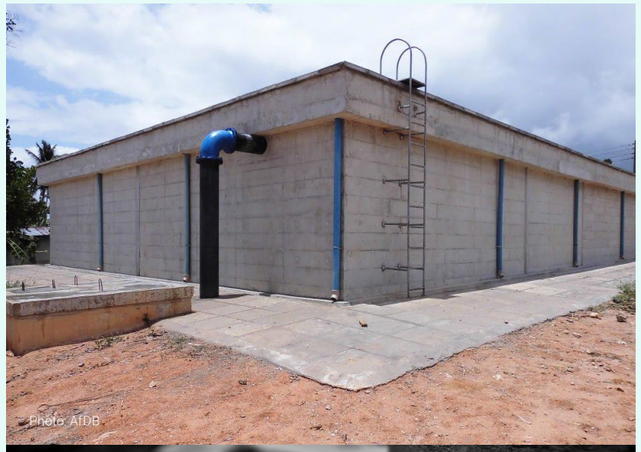


Photo: AfDB


Photo: AfDB


Photo: AfDB


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Photo: AfDB

Africa needs adequate infrastructure to access, store, and conserve its water resources; and to strengthen resilience against disasters and climate change effects. Only 68% of Africa's population has access to improved water supply. Considerable investments in infrastructure are therefore required to improve access, manage water-related risks, and increase water security. The integration of green infrastructure and nature-based solutions (NbS) plays an increasingly important role in providing safe, clean, and regular water flows – including, for instance, by preserving wetlands that buffer coasts from storms, aquifers that store water, and forests that reduce erosion and help keep water free of sediment. Integrating NbS approaches into conventional water system infrastructure planning can be cost-effective; regulate water supply and quality; and reduce climate vulnerability.

AfDB is currently implementing innovative projects such as the Strengthening Climate Resilience in the Kafue Sub-basin Pilot Program for Climate Resilience (SCRiKA) project in Zambia, launched in 2014 with US$ 38 million in funding from the Climate Investment Funds. SCRiKA helps farmers develop greater resilience to floods and droughts through community-driven activities such as micro-projects for flood control and diversion structures, small-scale irrigation schemes, and water reservoirs. Activities are selected through a demand-driven process facilitated by qualified non-governmental organizations and local governments. About 1,200 micro-projects had been rolled out by the end of 2020, helping 800,000 Zambian farmers develop greater resilience to floods and droughts.

The Urban and Municipal Development Fund (UMDF) is another innovative initiative, a multi-donor trust fund that aims to quickly roll-out support to African cities for climate diagnostics, the identification of local vulnerabilities, and the implementation of transformative solutions. AfDB will assist African countries and regional bodies in developing climate change adaptation and resilience strategies, and tackling climate change impacts on the water-related sectors. Activities related to diagnostics are already planned in five cities, following which a vision for each city will be developed, along with a prioritized list of projects to achieve future sustainability.

Mukuru lights the way for resilience-building in slums

Akiba Mashinani Trust

A staggering 60 percent of the residents in African cities live in slums, on average.[58] These "informal citizens" are among Africa's most vulnerable, living in fragile and dangerous conditions with high levels of poverty, and without risk-reducing infrastructure and support to cope with shocks. They are at the very frontline of the urban risks that, according to the Intergovernmental Panel on Climate Change (IPCC), are rising rapidly due to climate change – including heat stress, extreme precipitation, flooding, and water scarcity.

Providing even basic services like roads and water and sewage systems to crowded informal settlements can be a challenge, given the lack of space for infrastructure, and limited flexibility in planning regulations and city masterplans. Existing efforts to provide these services, including by non-government organizations, are generally piecemeal, sector-by-sector, and small scale.

Against this complex background, the story of Mukuru, a large slum in east Nairobi, Kenya, lights the way forward for efforts to build the resilience of informal settlements. It demonstrates how locally-led efforts that engage the residents in finding solutions, combined with the support and flexibility of local governments, a multisectoral approach, and the concerted support of multiple partners can provide basic services, and at the same time reduce climate vulnerability.

Mukuru is spread over 689 hectares of land, most of which was gifted to select private citizens in the 1990s as political patronage, despite the presence of pre-existing tenements. The constant threat of eviction by these owners became a rallying point for the residents of Mukuru, and they came together under the Muungano alliance to seek legal recourse.

The alliance was created by three organizations: Muungano wa Wanavijiji' ("united slum dwellers" in Kiswahili); Slum Dwellers International Kenya; and Akiba Mashinani Trust (AMT, a fund for the urban poor and SDI affiliate). Over time, the efforts of the alliance expanded to efforts to improve the quality of life of Mukuru's residents.

These efforts were buoyed by Kenya's new Constitution in 2012, which devolved power, resources, and representation down to the local level. With the full support of the local government, Mukuru was declared a "Special Planning Area" (SPA) in 2017, to allow flexibility in city planning regulations on account of Mukuru's special circumstances. This set in motion a locally-led process for developing a Mukuru Integrated Development Plan covering three settlements in Mukuru, with around 300,000 residents, for integration into Nairobi's 20-year City Integrated Development Plan.

The Mukuru approach to planning is considered "ground-breaking" because it sought to engage the residents of Mukuru in a community-wide, iterative planning process for the provision of basic services, while minimizing displacement and disruption to their lives.[59] The process was driven from within the community, with a strong element of ownership. The planning process first identified seven sectors as priorities (mirroring sectoral departments in the Nairobi City County): housing, infrastructure and commerce; education, youth affairs and culture; health services; land and institutional frameworks; finance; water, sanitation and energy; and environment and natural resources. To ensure that the planning process for each sector has adequate technical support, technical experts from 46 organizations (local government, academia, and international and local NGOs) were grouped into seven "consortia," each led by Nairobi City County staff.

The planning process was not without conflict with residents (who feared it was an innovative way of evicting them), and with private service providers (who saw it as a threat to their businesses and livelihoods). These had to be allayed through awareness creation efforts, including through local radio.

While it is early to judge the resilience impacts of the planning process, over 50 kilometers of roads are under construction in Mukuru, stormwater drains are being laid, and each plot is being connected to electricity, clean (free) water, and to the sewerage network. Reducing basic service deficits and building resilient infrastructure systems in urban areas can significantly reduce hazard exposure and vulnerability to climate change, according to the IPCC.[60] Effective upgrading can also provide a foundation into which climate-change resilience and disaster risk reduction can be integrated.[61]

The Mukuru planning approach has been endorsed by the President of Kenya, and is being replicated in Kibera and Mathare, two other informal settlements in Nairobi. The scale of the achievement is already inspiring work in other informal settlements across Africa, and in Asia. Replicating and scaling up this planning approach, with a stronger climate resilience component, can provide a locally-led solution to the complex but urgent problem of reducing the climate vulnerability of 200 million people living in slums across the continent.

Water and sanitation

Source: Author

Electricity and fires

Source: Author

Flooding

Source: Author

Aerial view of Mukuru

Source: Author