GLOBAL CENTER ON ADAPTATION

State and Trends in Adaptation Report 2022

Adaptation at the core of a prosperous Africa in an uncertain and warming world

Conference edition

Report Direction and Preparation

The State and Trends in Adaptation 2022 report was co-directed by Ede Jorge Ijjasz-Vasquez (Senior Advisor) and Jamal Saghir (Senior Advisor). The reports were prepared with the support of numerous knowledge partners, institutions, researchers, and practitioners who brought their best expertise from diverse technical and policy perspectives. We wish to acknowledge their contributions.

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Cover photo: Trials of CIAT-improved “magic beans” in Malawi, which have performed well despite the worst drought in three decades (Photo: CIAT/NeilPalmer)

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Foreword

A year on from State and Trends in Adaptation 2021 (STA21) which set out our blueprint for adaptation action, the evidence of the impact of deepening, growing climate change daily invades our screens.

2022 has seen record-breaking extreme weather globally, with mighty floods, vast wildfires, enduring heatwaves, and drought on every continent. More frequent and intense extreme weather and climate-related events are creating new and increasing risks everywhere.

But Africa is especially vulnerable. In the last 21 months more than 52 million people—some 4 percent of the continent's population—have been directly affected by drought and floods. Temperatures are increasing across all regions of Africa and the continent is warming faster than the global average over both land and sea.

Climate change poses risks to health, ecosystems, agriculture, infrastructure, cities, and economically and socially vulnerable communities. Nevertheless, with wars and pandemics being fought, the nature-born catastrophes that flash across our screens still struggle to make the political and public impact they merit amid all the noise of the 24-hour news cycle.

Tackling the causes of climate change is a Sisyphean challenge when its consequences are already wreaking havoc and destruction. If we have any remaining hope of achieving the goal of limiting global warming to 1.5°C by 2030 it must be aided and matched by massive scaling up of adaptation to the climate change that is happening here and now.

This report, State and Trends in Adaptation 2022 (STA22), builds upon the innovative adaptation and resilience ideas, solutions, and policy recommendations that STA21 presented. In this latest edition, we remain focused on Africa. We are right to do that, because Africa is the continent with the most to lose from climate change and the most to gain from adaptation to it.

Adaptation to climate change is urgently needed to reduce its impact on people and build resilience. Disaster risk management, climate services, and risk spreading and sharing can all contribute to this.

In the following pages we dive deeper into individual countries, as well as analyzing sectoral and thematic areas. We take a forensic look at the climate finance instruments available, the means by which resources can be mobilized for mainstreaming climate into public budgets, and how to attract and apply private adaptation finance.

In spite of the scale of the challenge posed by climate change, I remain optimistic about the future of Africa and the world, because I am confident that our Africa Adaptation Acceleration Programme (AAAP) is a roadmap that can lead the continent to a more stable, secure, and resilient future.


Photo: mbrand85/Shutterstock

The AAAP will mobilize US$25 billion for adaptation in food security, resilient infrastructure, climate finance, and crucially, youth employment. Adaptation in Africa is a jobs agenda that equips young people with the skills and resources to become the entrepreneurs that will power the continent's economic ascent while reducing the impact of extreme climate events.

As the evidence mounts that our world is changing around us, as extreme weather events become stronger and deadlier, the existential threat of climate change is clear. But how humanity will answer it is not yet clear.

My hope and belief is that this report—and its predecessor STA21 and subsequent editions in the years to come as we count down to 2030—will become a global primer for adaptation.

Resisting change is a default human reaction, but it is no longer an option. As Tancredi says in The Leopard, the iconic novel by Tomasi di Lampedusa, "Things will have to change if they are to stay the same." Adapting to climate change is our best hope of preserving our way of life. This report's purpose is to help us achieve that goal.

Dr. Patrick Verkooijen

Chief Executive Officer
Global Center on Adaptation

Executive Summary

Accelerating Progress Toward a More Resilient Africa

THE BACKGROUND

Last year, the Global Center on Adaptation (GCA) published its State and Trends in Adaptation 2021 report (STA21). The report described the urgent need to adapt to climate change, as rising temperatures cause more extreme storms and floods, rising sea levels, more intense heatwaves, and longer and more severe droughts.

As the report documented, Africa is particularly vulnerable to these extreme impacts of climate change. It faces exponential collateral damage, posing systemic risks to its economies, infrastructure investments, water, and food systems, public health, agriculture, and livelihoods, threatening to undo its hard-won development and reverse decades of economic progress.

This year, the impacts of the conflict in Ukraine on agricultural exports and fertilizers, the resulting food price hikes, inflationary pressures, unsustainable debt levels for many countries, and the possible global economic recession are severely impacting African economies and communities.

Though the risks are great, so too are the opportunities that successful adaptation can bring. The 2021 report presented a comprehensive blueprint for how individuals and institutions in the African and international policy space can finance, design, and implement adaptation plans to best protect the lives and livelihoods of millions of African people from such disruptive change.

Moreover, the report showed, these adaptation measures are enormously cost-effective, working hand in hand with development to put Africa on a more resilient path to growth and to create a virtuous cycle. Even as adaptation measures protect people and communities from the impacts of climate change, they can also help lift people out of poverty, reduce hunger and undernourishment, raise incomes and living standards, fight diseases like cholera and dysentery, create jobs, reduce inequities, reduce the tensions that lead to conflicts, and empower women. Those gains, in turn, further increase resilience, enabling communities to better cope with future extreme weather events or other climate change impacts. Most of the adaptation measures reviewed in this report have important climate mitigation, biodiversity, and sustainability benefits.

THE CURRENT CHALLENGE: INCREASING THE PACE OF PROGRESS

The 2021 report laid a strong foundation for creating a more resilient, more prosperous Africa. This new 2022 State and Trends in Adaptation report is designed to build on that foundation, with a goal of accelerating the pace of progress while considering the challenging global and regional

economic conditions. The 2022 report builds upon and complements the 2021 report. The first report includes topics ranging from food systems to gender and water that are not repeated here. We recommend that readers view the two reports as an integrated review of climate adaptation for the region.

This report first updates the growing impacts of climate change on African nations. In 2021 and 2022, for example, major wildfires swept across Algeria; devastating floods stuck Niger, Sudan, South Sudan, and Mali; the Horn of Africa region was struck by drought; and three strong tropical cyclones hit Mozambique and other Southern African countries, destroying buildings, displacing thousands of people, flooding farmlands, and crippling economies. Such impacts pose increasing threats to food systems, ecosystems, water resources, human health, and economic growth. The magnitude of many of these climate shocks can overwhelm communities, entire regions, or even small nations. The global humanitarian support system is stretched in its mission to help affected populations and economies.

The report then uses in-depth analyses and numerous case studies to identify innovative adaptation and resilience ideas, new solutions, the most effective regulatory and legal instruments, and new recommendations for action. Given the tight fiscal situation of most African nations and the economic challenges of their communities, the report pays special attention to adaptation actions with lower costs and significant benefits, including nature-based solutions (NBS) and locally led adaptation programs. In particular, the report covers three major topics in its three sections.

The first point of focus is boosting the amount of finance that is available for adaptation and using that money in the most effective ways. Some of the key opportunities lie in the private sector, where companies can not only reduce their own risks from the impacts of climate change but also take advantage of new markets and new businesses in the adaptation space.

The second topic is how to accelerate progress on adaptation in individual sectors, such as agriculture or cities. This section also provides a comprehensive evaluation of the innovative Africa Adaptation Acceleration Program (AAAP), developed as an Africa-owned and Africa-led response to the climate crisis. The AAAP supports programs across multiple sectors.

The third section covers the themes and opportunities that cut across multiple sectors. They include improving education, empowering youth and stimulating entrepreneurship, improving security, and identifying further research to help unlock the many benefits of successful adaptation measures.

INCREASING FINANCE FOR ADAPTATION

The Finance Gap

The Paris Agreement includes a global goal for adapting to the effects of climate change. At COP26, new financial pledges were made to support developing countries in achieving this goal. Moreover, at COP26 new rules for the international carbon trading mechanisms ("Article 6") were agreed upon to support adaptation funding.

While significant work is being done toward those goals, it remains clear that mitigation is still receiving considerably more attention and funding support than adaptation. Indeed, adaptation finance has remained at between 20 and 25 percent of committed concessional finance across all sources. COP26 urged developed countries to at least double their aggregated provision of adaptation finance from 2019 levels by 2025, in order to achieve a fair balance between adaptation and mitigation. The pressure to increase and deliver substantial adaptation financing is likely to continue in COP27 and beyond.

Analysis shows that current annual spending on adaptation across all of Africa is US$11.4 billion, which represents about 39 percent of total climate finance committed to Africa annually. This amount falls far short of what is needed. Simply meeting the goals set out in the Nationally Determined Contributions (NDCs) of African countries would require additional funding of US$41.3 billion each year. In addition, much of this adaptation finance (53 percent) comes from just one source—multilateral development finance institutions (DFIs)—with national governments a distant second at 23 percent.

There is thus a serious and urgent need to both dramatically increase the flow of adaptation finance in Africa and to develop new sources of financing. Those could include commercial banks, private equity and venture capital, institutional investors, insurers, large corporations, national development banks, multilateral and national climate funds, foundations, and non-profits.

Closing the funding gap will not be easy. This report identifies and acknowledges numerous barriers to increasing the flow of adaptation dollars. To name just a few: Adaptation measures are complex. There are challenges in understanding and recovering the costs of projects. Reliable and accessible information about climate risk is often lacking. Regulatory incentives for crucial adaptation measures like climate-smart agriculture have yet to be developed and implemented. And given that every sector has many stakeholders, coming to an agreement on projects can be difficult.

In addition, these existing problems have been made more challenging by global strains and conflicts. The COVID-19 crisis and the war in Ukraine have raised energy and food prices, for example, while also massively disrupting international trade and supply chains.

Lessons from Individual Countries and Regions

To pinpoint specific barriers and initiatives that have been successful in increasing adaptation finance, in-depth studies of such finance in Ghana, Rwanda, Kenya, and Egypt were conducted. The analysis found, for instance, that while Ghana has created a promising Ghana Infrastructure Investment Fund and is now seeking Green Climate Fund (GCF) accreditation for it, the country may be missing out on US$1.2 billion annually in general tax revenues that could be used for climate finance because of misaligned tax incentives. Meanwhile, Kenya's adaptation efforts could be improved by modernizing its public financial management system to enable better climate finance expenditure tracking.

In the four countries studied, one promising model that others might adopt is Egypt's Green Sovereign Fund. Investor interest in the green bonds was so strong that the Egyptian Ministry of Finance increased the sale from the initial US$500 million to US$750 million. Of that, roughly US$400 million has been spent on 14 water and wastewater projects, and the rest on a clean monorail system that connects Cairo to the new capital. Three crucial ingredients have made the Fund successful: early involvement from key ministries; using the nation's largest private bank to issue the green bond sale; and partnering with the World Bank and the International Finance Corporation (IFC).

The report also presents a detailed analysis of one important region of the continent—North Africa. The region faces an even larger financing gap than Africa as a whole, with total public climate finance between 2010 and 2020 at a level that is only 7 percent of that needed to meet NDC goals over the next 10 years. Moreover, only 20 percent of that finance went to pure adaptation projects. Making the task in the region even more challenging are the historically high and still rising debt service burdens.

One potentially effective strategy for this region (and other African countries as well) is using innovative debt-for-climate swaps, like one being piloted in Jordan. A task force, with members from the ministries of planning, finance, energy, environment, and water, has identified projects in areas like forest management, water supply, and energy efficiency that could be supported by the debt swap.

Recommendations for Increasing the Flow of Finance

To mobilize the levels of investment needed to close the huge gap between current spending and the urgent need, and to increase the resilience impact of these investments, African nations can succeed by adopting three main strategies:

- **Mainstream adaptation and resilience into all investment decision-making:** That requires increasing access to climate information, such as groundwater data and precipitation predictions; building the capacities of financial institutions and governments to evaluate and act on climate risk; and requiring the disclosure of climate risk in line with the recommendations of the Task Force for Climate-related Financial Disclosures (TCFD) (see also next section on risk regulation). The International Monetary Fund's (IMF) perspective on adaptation policies includes three pillars for mainstreaming adaptation—prevention, alleviation, and strategies for fiscal resilience.
- **Build an enabling environment for adaptation investment:** Only six countries in Africa have submitted National Adaptation Plans. Such plans

Photo: GCA

are particularly important in mainstreaming climate adaptation into procurement plans to ensure that the construction of new infrastructure will build in resilience. Countries should also build capacity to make policies and projects science-based, and work to relieve existing debt burdens. Mainstreaming climate considerations into public budgets and incorporating adaptation finance into all stages of the budgeting process can provide a direct channel of funding for dedicated climate adaptation projects. Also, multilateral development banks (MDBs) need to be more focused on adaptation finance and action. They have a critical role to play in the adaptation finance architecture.

- **Deploy innovative financial instruments:** One example is the AAAP, jointly developed by the GCA and the African Development Bank (AfDB), which provides upfront capital and makes projects more attractive to private investors by improving their risk-return profiles (see later section for more details). Another way to achieve this is for debt-swap mechanisms to be scaled up, and by moving away from ad hoc bilateral deals for debt-for-adaptation swaps to a more institutional approach. Blended finance resources could incentivize institutional investors to invest in adaptation and could also unlock the potential of institutional investors such as pension funds, sovereign wealth funds, and insurance companies in scaling up climate adaptation finance.

Identifying and Regulating Climate Risks

One of the general recommendations in the previous finance flow section—regulating climate risks—is so important that this report devotes a whole chapter to the impact of climate risks on African financial systems. It includes in-depth case studies on the Democratic Republic of the Congo (DRC), Egypt, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Rwanda, South Africa, Tunisia, and Zimbabwe, supported by interviews and discussions with regulators and stakeholders in these countries.

African nations are among the most vulnerable in the world to climate risks. In 2019, five African nations ranked among the 10 countries around the globe most affected by extreme weather. Topping the list was Mozambique, which was struck by two devastating cyclones and a severe long-lasting drought.

Such severe impacts not only take a huge toll in terms of human suffering, they also have major consequences for financial institutions and financial markets. Across all of Africa, climate change is already reducing economic growth and reversing hard-won gains, the Intergovernmental Panel on Climate Change (IPCC) reports. Unless banks

Photo: Tommy Trenchard/Panos Pictures

and other institutions take action to identify and manage these risks, they will experience a damaging deterioration of credit quality and profitability.

There are two main types of climate risk: 1) property damage, business disruption, and other physical risks from such impacts as more severe floods and droughts; and 2) the transition risks from falling behind in the global effort to reduce greenhouse gas emissions. Those transition risks can include stranded fossil fuel assets and the need for increased capital spending on cleaner technologies.

Some Africans have recognized the need to identify and regulate such risks. The Bank of Ghana has issued voluntary "sustainable banking principles" as part of its environmental and social risk management, for example, while Kenya's 2016 Climate Change Act provides both a regulatory framework that responds to climate change and a mechanism for climate finance. Moreover, interviews with finance officials show that climate risk is a top and urgent priority for almost all financial officials.

Yet the efforts to integrate climate risk in financial systems face significant challenges, including the lack of data on climate risks and the lack of internal capacity to develop regulations and guidelines. Key recommendations thus include:

- Develop the capabilities of public authorities and financial regulators, such as by highlighting best practices and offering training programs.
- Mandate minimum disclosure standards, covering governance, strategy, risk management, metrics, and targets.
- Identify both physical and transition risks and make the data more accessible.

Refocusing and Increasing Investment by the Private Sector

Successful adaptation and resilience efforts will depend heavily on the involvement of the private sector. In Africa, the private sector currently is responsible for two-thirds of the continent's investment. It generates 75 percent of the total economic output and provides 90 percent of the total employment.

Companies are also increasingly threatened by climate change. Floods, droughts, heatwaves, and more extreme storms are damaging factories, warehouses, and other assets; disrupting supply chains; reducing productivity; threatening workers' wellbeing and safety; and raising insurance premiums, among many other consequences.

That is why it is important for companies to reduce their exposure by relocating their facilities or supplies away from high-risk areas, and to invest in projects that strengthen their resilience. For example, the OCP Group, a global fertilizer producer based in Morocco, has invested in desalination stations and wastewater recycling plants to reduce water pollution and to increase water supplies, bringing benefits both to its own production systems and to North African communities.

Such adaptation measures can also open new markets and businesses. In one example, the Swiss multinational Holcim and UK development finance institution British International Investment have created a joint venture called 14Trees that uses innovative construction technology, such as 3D printing, to rapidly build energy-efficient affordable housing in Africa, especially in response to damaging natural catastrophes. In addition, a survey of small and medium-sized businesses showed that 81 percent of them anticipated markets for new or more sustainable products, such as drought-resistant seeds, farm machinery powered by renewable electricity, enzymes for the food and beverage industries that reduce water consumption, more detailed weather predictions, and new insurance products.

Taking advantage of these new opportunities and reducing the harm from the impacts of climate change will require collaboration across the private sector, the public sector (with public–private partnerships), and the financial and insurance sectors.

Resilient Recovery in Senegal and Côte d'Ivoire

To illustrate how investments in adaptation and green sectors can deliver a sustainable and environmentally friendly recovery from the COVID-19 pandemic and from the stresses caused by the war between Russia and Ukraine, the report looks in detail at Senegal and Côte d'Ivoire, both of which have suffered large economic hits. In Senegal, 85 percent of households reported significant income losses in the first few months of the pandemic, and many businesses closed. In Côte d'Ivoire, sectors like education, tourism, restaurants and hotels, and financial services were hit especially hard. More than one-third of firms closed, some permanently.

Those countries now face a choice. They could try to recover from these stresses by investing in traditional approaches, such as stimulating the mining of gold, phosphate, and other metals and minerals. Or they could use a green stimulus approach that boosts adaptation through investments in ecotourism services, coastal protection, climate-smart agriculture, ecosystem restoration, renewable energy, energy efficiency, electric vehicles and rapid transit, green buildings, flood mitigation, and wastewater treatment.

Modeling shows that the green stimulus approach is substantially better. Not only would it improve resilience to the impacts of climate change, it would also bring much higher economic returns—creating 700 percent higher returns over 20 years in Senegal and 265 percent higher in Côte d'Ivoire.

Lessons from the AAAP Technical Assistance Program (TAP)

As this report describes, filling the huge gap between the current level of adaptation funding and what is needed requires innovative financing approaches. In one effort to close the gap, the United Nations Framework Convention on Climate Change created the GCF to help developing countries reduce their greenhouse gas emissions and adapt to climate change.

To access funds from the GCF, countries first must have an ambitious national climate strategy, a government institution capable of overseeing the use of the funds, and a pipeline of projects that meet the GCF's requirements. To help African countries meet these conditions, the AAAP created a TAP to build capacities for adaptation planning and to promote large-scale transformational adaptation projects.

The TAP was launched just over a year ago in Burkina Faso, the DRC, Niger, Nigeria, Seychelles, Côte d'Ivoire, Senegal, and Ghana. In Ghana, for example, the program held two workshops with the staff of the Ghana Infrastructure Investment Fund; one to explain the accreditation process for the GCF and the second to discuss the details of the technical assistance offered. In another example, the program worked with Ethiopia, Guinea, Senegal, and Togo on an ambitious US$427 million proposal to create "staple crop processing zones" that promise to boost agricultural productivity, employment, and incomes, while reducing both greenhouse gas emissions and vulnerabilities to climate change.

To assess the performance of the TAP after a year, key officials, partners, and other stakeholders were interviewed. The feedback shows that the program is effective, but it also highlighted areas for improvement, such as maintaining a regular presence in partner countries, offering a roster of experts, and strengthening partnerships with other providers.

SECTORS

The Africa Adaptation Acceleration Program (AAAP)

Launched in April 2021, the AAAP is the flagship program of an Africa-owned and Africa-led response to the threats from climate change and to the opportunities for more sustainable growth and development. It will mobilize US$25 billion by 2025 to accelerate adaptation action across multiple sectors, focusing in particular on investments that will bring large dividends. Those include improving productivity and reducing vulnerabilities in agriculture and the food supply chain, thus improving food security; making forestry more sustainable; reducing risks and vulnerabilities in both urban and rural areas through measures like more resilient infrastructure; restoring ecosystems and increasing biodiversity; empowering youth and creating jobs; and increasing climate finance.

The first set of projects under the AAAP are spread across multiple sectors in 18 countries: Senegal, Kenya, Uganda, The Gambia, Benin, Ghana, Tanzania, Liberia, Gabon, Guinea, Madagascar, Chad, Burundi, Burkina Faso, Mali, Mauritania, Niger, and Ethiopia. The targeted areas include renewable energy, transmission, and distribution; highways, railways, and ports; and water infrastructure, such as dams and treatment plants. In The Gambia, for example, the program is assessing the risks from sea level rise and flooding to the Port of Banjul—the vital gateway to the country's economy—to ensure that planned increases in cargo handling and storage capabilities will make the operations less vulnerable to climate change impacts. Another study is aimed at improving resilience in Chad's flood-prone capital city, N'Djamena. And a US$380 million "desert to power" initiative will finance renewable energy investments in Burkina Faso, Chad, Mali, Mauritania, and Niger (for details, see the Insert: Adaptation in the Desert to Power Program in the full report).

The success of the AAAP to date is leading the GCA to expand the number of its partners to scale up and accelerate the mainstreaming of climate adaptation in Africa and in other regions in the world, such as South Asia.

The needs and opportunities for adaptation in specific sectors were also analyzed, and are described in detail in subsequent individual chapters in this report.

Improving Productivity and Resilience with Livestock

Raising livestock provides a living for millions of Africans. In Kenya, the dairy sector provides three million jobs—15 percent of the country's labor force. Overall, the livestock sector accounts for 55 percent of the household income in pastoral systems across Africa. The sector will become even more important as the demand for meat and dairy in Africa is predicted to triple by 2050.

These livestock systems and livelihoods are being increasingly threatened by rising temperatures, more extreme precipitation and droughts, and other climate change impacts. Just one impact—heat stress suffered by cattle—could reduce the production of milk and meat by hundreds of millions of dollars per year by 2085, modeling studies suggest. Climate change is also enabling pests like ticks to expand their ranges in Africa, and is reducing the productivity of the grasslands and agricultural crops that cattle, camels, and other animals need for feed.

There is thus is an urgent need for adaptation measures. Potentially effective interventions fall into several broad categories: breeding cattle and other livestock to be more heat- and drought-tolerant and disease-resistant; improving management of rangelands and croplands to make the feed supply more sustainable; developing better treatments for diseases; establishing feed inventories and feed stores; and providing both early-warning alerts and adaptive safety nets for herders and livestock farmers. One promising approach is adding trees to rangelands in "silvopastoral" systems, where the trees provide shade to reduce heat stresses. It may also be possible to boost local incomes through carbon credit trading and benefit sharing when rangelands are restored.

However, there currently is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa, pointing to the need for more research and support.

Improving Productivity and Resilience in Agriculture

Agriculture is the foundation of lives and livelihoods in Africa. More than 60 percent of Sub-Saharan Africans are smallholder farmers, and nearly a quarter of Africa's GDP comes from agriculture. As the State and Trends in Adaptation 2021 report described, however, farmers in Africa are already being harmed by extreme weather events, and a planetary warming of 3°C in the next 30 years would be catastrophic. At the same time, increases in yields are essential to meet the growing demand for food by a rapidly increasing African population.

Photo: GCA

As a result, many recent reports, such as the Food and Agriculture Organization of the United Nations (FAO) Strategic Framework 2022–2031, see adaptation in food and agriculture as essential for reaching Sustainable Development Goals. Not only can successful adaptation improve yields and livelihoods, studies show, adaptation measures also are far less expensive than paying for repeated disaster relief and recovery efforts in the wake of extreme weather events. Moreover, effective adaptation measures will enable agriculture to be an important part of the effort to mitigate climate change, because it has the potential to offset or sequester as much as 20 percent of annual emissions through improvements in soil management.

Realizing these benefits requires a transition to a new way of thinking about agriculture—so-called climate-smart agriculture. Its key elements include:

- **Taking advantage of advances in breeding technologies and tool development:** New techniques and tools, such as sequence-based trait mining and CRISPR-Cas9-based gene editing, have made it possible to pinpoint genes that boost crop yields, allow crops to tolerate harsher conditions like more severe droughts, or better fight off pests. Then the tools can precisely insert those genes into the major crop plants. One effort already under way is the Genomics Open-source Breeding Informatics Interface (GOBii), funded by the Bill & Melinda Gates Foundation, which is systematically mapping genes in rice, wheat, maize, sorghum, and chickpea with the goal of breeding improved versions. Elsewhere, the National Root Crops Research Institute in Nigeria has bred a new stain of cassava called Gamechanger cassava that is resistant to both diseases and pests.
- **Improving soil health:** Soils in many parts of Africa have been badly degraded, and in the Sub-Saharan region as much as 40 percent of the soils are low on nutrients. Degraded soils not only reduce yields, they are also more susceptible to erosion and desertification. In contrast, healthy soils increase water retention, resilience to flooding, and carbon sequestration. One successful strategy for creating healthier soils and improving crop productivity has been allowing trees to naturally regenerate on fields in countries such as Niger and Burkina Faso. Another is planting new forage grasses. In Tanzania, a leafy deep-rooted perennial called Bracharia is being used to increase soil carbon and reduce nitrous oxide emissions, while also providing a useful animal feedstock. Still another approach is replacing fertilizers with natural nitrogen-fixing in the soil through the association of legumes with nitrogen-fixing bacteria like *Rhizobia* species. The N2Africa project, funded by the Bill & Melinda Gates Foundation, is working in 11 African countries to optimize crop types and *Rhizobia* strains in many important legumes, including the common bean, chickpea, cowpea, fava bean, groundnut, and soybean.
- **Harnessing smart technologies, such as artificial intelligence, robotics, and smart sensors linked to the internet and big data:** These technologies have been called a “fourth agricultural revolution.” They enable farmers to access markets, to anticipate and manage the impacts of weather events, to guide inputs of water, fertilizer, or pesticides; to spot diseases; and to increase agricultural productivity and sustainability. Numerous apps and services already exist in this realm. The Farmerline app in Ghana and DigiFarm in Kenya provide access to business intelligence, quality inputs, and access to financial services, for instance, while PlantVillage Nuru enables farmers to diagnose crop diseases in the field.


Photo: Golden_Brown/iStock

Implementing these climate-smart approaches will require investing more in rural agricultural infrastructure, expanding broadband internet availability, bundling digital services, and creating regional networks of plant breeders and other scientists to share knowledge, tools, and equipment. Careful consideration of barriers caused by the knowledge and preferences of farmers and herders will also be critical for success. Moreover, these efforts must specifically target women, since women account for about half of the world's smallholder farmers and grow 70 percent of Africa's food.

Making Cities More Resilient

The populations of major cities in Africa, especially the capital cities, are growing rapidly, both because of migration from rural areas and small towns and because of natural population growth. Of the 100 fastest-growing cities in the world, 79 are in Africa.

But the provision of basic urban infrastructure has not kept pace with population growth. Water supplies, sanitation, energy, transport, durable housing, and other vital services are inadequate. Jobs are in short supply. As a result, many cities now are seen as being at "extreme risk" of climate hazards, especially because of large informal settlements that are particularly vulnerable to flooding, heatwaves, droughts, and (in coastal cities) sea level rise.

A case study of Accra, Ghana, shows that more than 60 percent of the city's households live in informal settlements with substandard housing, where regular flooding is a major problem. The city faces numerous barriers in improving resilience, such as lack of planning, authority, and trust in government, but it has begun to make some infrastructure investments, such as improving drains and paving alleyways to reduce flash flooding.

Many African cities are still in early stages of urbanization, so there is a unique opportunity to get things right. To help realize that opportunity, the GCA has developed an approach called Rapid Climate Risk Assessment (RCRA) and has implemented it in five cities: Antananarivo, Madagascar; Bizerte, Tunisia; Conakry, Guinea; Dodoma, Tanzania; and Libreville, Gabon. The RCRA gathers key information on climate hazards and risks, infrastructure bottlenecks, past and current initiatives, and relevant policies and institutions. It also identifies specific neighborhoods and districts that have recently experienced floods and other high-impact climate-related disasters.

The assessment then identifies the most cost-effective measures (including those in the "no-regrets" category) for reducing the toll in human suffering and economic damages from extreme weather events and other climate impacts. For the cities studied, effective measures include strengthening disaster evacuation planning, investing in water and sanitation infrastructure, and creating parks and other green spaces (or restoring wetlands and ecosystems) to reduce both flood risks and the urban heat island effect.

One of the key lessons learned is the importance of having strong local champions within municipalities to help identify problems and climate risks, generate data, and develop solutions. In the next round of RCRAs, the GCA will focus specifically on a large informal section in a major African city to gain more experience in involving local community members.


Photo: Nyani Quarmyne/Panos Pictures

Implementing NBS such as Agroforestry

As many other sections of this report describe, the power of nature can be harnessed to successfully adapt to the impacts of climate change and to increase resilience. Restoring forests or wetlands upstream of cities can help solve problems like urban flooding and water scarcity, for example. Protecting and regrowing mangrove forests fights coastal erosion and enhances local fisheries. Creating parks and green spaces in cities reduces the urban heat island effect and the risks of flash floods. In fact, more than a third of the priority adaptation actions in the NDCs of African countries involve so-called NBS.

One especially effective NBS in many parts of Africa is agroforestry—a land management practice where trees are grown around or among crops, pastureland, or homes to provide shade, shelter, fertilizer, fuel, food, fodder, and other products. Not only can agroforestry increase crop yields, land productivity, and local incomes, it also fits well with current African farming systems, skills, and livelihoods.

Agroforestry can involve a variety of practices and forms. In the Sahel region, many farmers have allowed the regeneration of root stocks or seeds long buried in the soil, thus regrowing a few dozen trees per hectare on their fields. This practice, called Farmer Managed Natural Revegetation (FMNR), is credited with helping to "regreen" hundreds of thousands of hectares of farmland in countries such as Niger and Burkina Faso, bringing substantial increases in yields and incomes, while also helping to restore soils and water resources.

In another example, experiments on 25 agroforestry plots in Togo show that most beneficial agroforestry mix includes shade trees, fruit trees, palms, and bananas. In addition, in other parts of Africa, a tree called *Faidherbia albida* offers substantial benefits. A nitrogen-fixing tree that is widespread and native to Africa, *Faidherbia* has an unusual annual growth cycle. Because it sheds its foliage early in the rainy season and regrows it early in the dry season, it does not compete with crop species, which grow during the rainy season. Its leaves also provide useful fodder for livestock.

It is now essential to continue building the case for NBS in general, and for agroforestry in particular, as critical adaptation measures. Unfortunately, there are still too many examples of poorly designed agroforestry efforts that end up undermining development, mitigation, and adaptation. As a result, it is necessary to provide more support for research that pinpoints which actions are most cost-effective and most beneficial for both farmers and ecosystems, and to take better advantage of the considerable traditional and local knowledge of workable solutions. A genuine co-creation of solutions that will be adopted by farmers will help maximize the potential of agroforestry.

Improving the Sustainability of Africa's "Blue Economy"

Africa's 34 coastal countries depend heavily on a "Blue Economy" based on fisheries, aquaculture, tourism, transport, ports, coastal mining, and energy. Continent-wide, these coast-based activities are worth more than US$300 billion per year and support 49 million jobs.

The Blue Economy will become even more important if countries seize the opportunity to increase the amount of carbon captured and stored by coastal ecosystems such as mangroves, kelp forests, seagrass beds, and salt marshes. This "blue carbon" could be used to help countries meet their greenhouse gas emissions reduction targets and to bring in new revenue through carbon capture credits.

As with other sectors, however, the Blue Economy faces huge challenges. Fisheries are being overexploited. Coral reefs, kelp beds, and mangrove forests are disappearing. With sea levels rising and natural protections being lost, coastal erosion is increasing (see next section). Marine heatwaves and water acidification are predicted to reduce primary production by phytoplankton, further bleach coral reefs, and change fish distribution and abundance—with profound potential consequences for fisheries and tourism.

Yet only 26 of the 34 coastal countries have formal strategies or policies to protect their Blue Economies. There is thus an urgent need to create such plans.

The important elements of effective national strategies include coastal and marine spatial planning that takes climate change into account, fisheries regulations that adjust allowable catches based on real-time fish stock data, efforts to protect marine and coastal ecosystems, and rehabilitation and restoration measures such as planting of nursery-grown corals back onto natural reefs or creating artificial reefs; planting mangrove and seagrass seeds in damaged habitats; and transplanting kelp.

One of the success stories in making the Blue Economy more sustainable is the Seychelles Marine Spatial Plan (SMSP) Initiative. The plan set a goal of expanding marine protected areas from only 0.04 percent of the country's marine waters to 30 percent—a goal that was reached in March 2020, 10 years ahead of schedule. The Seychelles government succeeded because the effort was backed by strong political will; because it tapped into numerous resources, experts, and scientific data to understand the problem and solutions; and because it developed an effective funding strategy (in this case, a debt conversion). Those lessons should be applied in other African countries.

Protecting Coasts from Erosion

Africa's ports are tremendously important as drivers of Africa's economic growth, especially in West and North African countries with no land access to distant consumer markets, but they are suffering from serious erosion. A 2021 World Bank study showed that the costs of erosion in the Maghreb countries of North Africa already range from US$273 million per year in Libya to more than US$1.1 billion per year in Tunisia. Sea level rise, more extreme storms, ecosystem degradation, and the trapping of sediment by upstream dams are making the problem worse, helping to create coastal erosion rates up to 10 times higher than the global average.

Traditionally, countries around the world have used "hard" infrastructure, such as groynes, breakwaters, jetties, revetments, and dikes to protect ports. Hard infrastructure is expensive, however, and does not provide long-term protections without costly long-term maintenance.

The better solution for West African countries is using NBS, also known as "soft" or "green" infrastructure, such as restoring mangroves, dunes, seagrasses, wetlands, and other ecosystems. One promising project is the "Management of Mangrove Forests from Senegal to Benin" initiative funded by the European Union for a period of five years (2019–2024).

To scale up the use of such NBS, it is necessary to:

- Improve access to data so that erosion hotspots can be clearly identified and studied.
- Monitor and model coastal morphology, sediment flows, and fluid mechanics, as well as the impacts of coastal developments in many locations.
- Share information, work together across national boundaries, plan and implement coastal ecosystems restorations, and consider altering upstream dams to allow more sediment to flow to the coast to support coastal protection.

CROSS-SECTORAL THEMES

Realizing the Promise of "Locally Led Adaptation"

Whether they live in rural farming communities, urban informal settlements, or other areas, local people often have unique perspectives and knowledge about the risks from the impacts of climate change, and the barriers and opportunities for adaptation. The evidence shows that taking advantage of that knowledge and giving local people more control over defining, designing, monitoring, and evaluating adaptation actions can lead to more effective adaptation actions and raise the benefits relative to the costs.

This new paradigm of "locally led adaptation" builds on existing ideas of community-based adaptation and community-driven development, which are designed to reflect the views of communities and ensure that interventions are aligned with local norms and values. However, locally led adaptation goes a step further by putting local leaders in charge.

Implementing locally led adaptation can be challenging. International finance institutions are typically mandated to deliver finance through multilateral actors or national government agencies, not local leaders. In addition, local actors often do not have a complete understanding of the climate risks they face or have the capacity for effectively accessing, managing, and using climate finance.

Case studies show, however, that when these challenges can be met, locally led adaptation can deliver benefits that far outweigh the costs. In Kenya, Tanzania, Mali, and Senegal, for example, climate change committees were established at the local level using subnational climate funds. Those locally led committees identified and implemented a total of 284 highly cost-effective adaptation projects in water, soil, agroforestry, livestock, natural resource management, and food security. Similarly, a locally led effort in Mukuru, one of Nairobi's largest slums, identified key investment priorities for improving water supplies and sanitation.

The promise of this approach has led more than 80 international organizations, national governments, multilateral organizations, bilateral institutions, non-governmental organizations, climate funds, private sector companies, and social enterprises to formally endorse the Principles for Locally Led Adaptation. Taking advantage of that promise, however, will require scaling up financing from international funders for adaptation at the local level, moving some of the planning for climate action to local governments, and exploring how the private sector can better support local adaptation.

Improving Education

Africa is experiencing a silent crisis in education. If current trends continue, it will take 100 years to reach universal primary education, and another 235 and 280 years to reach universal lower secondary and universal upper secondary education, according to UNICEF and the African Union Commission.

These low levels of education threaten the prosperity of individuals, communities, and nations, and can lead to a vicious cycle in which poverty forces people to withdraw their children, especially girls, from school, and makes communities even more vulnerable to the impacts of climate change.

In addition, climate change increases the size of the education challenge. Many schools cannot cope with impacts like heatwaves, water scarcity, or extreme weather. In Mozambique alone, for example, Cyclone Idai destroyed 3,400 classrooms and left 305,000 children without a place of learning in 2019.

But even as education is threatened by both climate change and economic conditions, it is also a crucially important solution to both problems. Education enhances the adaptive capacity of people, especially children, by building critical green skills for adaptation action, in addition to providing a more skilled workforce to improve the economies of African countries.

This report recommends four ways to accelerate education for adaptation:

- Better monitor, diagnose, and address both the local climate vulnerabilities of the education sector and the local climate impacts across the continent.
- Invest in schools to enable them to better withstand or adapt to climate-related shocks, such as higher temperatures or more extreme floods: In 2010, for example, the UNEP/UNDP, CC DARE, and the Danish International Development Agency began a project to harvest and store rainwater during the rainy season in schools around the

Seychelles. The project solved a pressing problem of schools running out of affordable water in the dry season while also educating schoolchildren and the community about climate change and its effects on water resources.

- Invest more in the education workforce: More money is needed to end a serious teacher shortage, to raise salaries, and to provide the training and resources needed to support climate adaptation, local adaptation needs, local resilience practices, and adaptation solutions.
- Invest in climate literacy: Teaching about the anthropogenic causes of climate change and how individuals, communities, and societies can both mitigate against further environmental damage and adapt to present and future impacts of climate change has been shown to reduce the toll from climate disasters and build community resilience. In one example, the Campaign for Female Education (CAMFED) is teaching thousands of female "Agriculture Guides" about climate-smart agriculture. The project is helping to improve the productivity, sustainability, and profitability of local smallholder farms, while also reducing the school interruptions that girls often experience.


Photo: Laurent Weyl/Panos Pictures

Creating Stronger Institutional Arrangements to Support Adaptation Actions

To successfully plan, legislate, and manage their activities to meet climate targets and to design and implement adaptation solutions, governments need strong institutional arrangements. Last year's GCA STA21 analysis found that while significant strides have been made in African countries in integrating climate adaptation and resilience into long-term planning, there still is room for improvement.

Two important tools can help countries identify the strengths and weaknesses of their institutional frameworks. The World Bank's Climate Change Institutional Assessment (CCIA) evaluates five crucial components of effective governance: organization, planning, public finance, subnational governments and state-owned enterprises, and accountability. Meanwhile, the Capacity for Disaster Reduction Initiative (CADRI) has developed a digital disaster risk reduction tool for assessing countries' capacities for reducing disaster and climate-related risks.

Effective institutional arrangements can take different forms. In the DRC, the National Committee on Climate Change coordinates climate efforts with relevant ministries and governmental bodies. In Angola, the main authority lies with the Ministry of Culture, Tourism, and Environment (MCTA), while mitigation and adaptation policies will be implemented by ministries in charge of core adaptation strategies.

To improve institutional arrangements, this report recommends:

- Additional mainstreaming of finance and disaster risk reduction considerations throughout the institutions.
- More effective systems for monitoring, reporting, and verifying the effectiveness of adaptation measures.
- Ensuring that disaster risk reduction and disaster risk management are important components of climate mitigation and adaptation institutional frameworks, policies, and processes, while also working harder to move from response strategies to disaster preparedness and risk reduction.


Photo: Media Lens King/Shutterstock

Youth and Entrepreneurship

Africa has a large and growing young population, with about 60 percent of the total population under the age of 25. While the sheer size of this young population poses challenges in terms of providing education and employment, it also brings major opportunities. As the most educated generation ever in Africa, African youth today bring unprecedented innovativeness, energy, and entrepreneurship that can accelerate economic growth, build resilience, and drive transformational adaptation.

To better unlock this potential, GCA and AfDB created and organized the Youth Adaptation Solutions Challenge, an annual competition and awards program for youth-led enterprises under the AAAP framework. The goal of the Challenge is to spark a revolution in young business entrepreneurship on adaptation.

In its first year, the Challenge received more than 2,000 applications from small- and medium-sized businesses led by young people. From those, 10 winners were chosen and honored at an award ceremony at COP26 in 2021. Most of the winning companies are focused on making agriculture more productive and sustainable. In Ghana, for example, grain producer Global Farmers is teaching smallholder farmers to intercrop their grain with trees and adopt good conservation practices like zero tillage. In rural Nigeria, agro-processor Simkay Green Global Ventures has trained 400 farmers in a technique of growing crops in bags at different heights—called vertical sack farming—that boosts yields and productivity and protects crops from flooding.

Other companies are providing early-warning systems to farmers, promoting hydroponic farming methods, cleaning drainage channels and waterways to improve irrigation and limit flooding, and converting plastic waste collected from drainage channels into products like shoes.

To better understand the challenges young entrepreneurs face in developing innovative adaptation solutions, the Challenge team conducted interviews with the winners and reviewed their business plans. The interviews revealed six main barriers:

1. Limited access to financing.
2. Lack of business development and operational skills.
3. Knowledge gaps.
4. Uncertainties about the impacts of climate change on everything from greenhouses to roads.
5. Resistance to changing behavior among farmers and customers.
6. Difficulties caused by lack of infrastructure, such as poor roads or unreliable electricity, or by licensing and regulatory requirements.

Key recommendations for overcoming these barriers include:

- Making access to financial capital easier for young entrepreneurs, such as with simplified loan systems, lower interest rates, or more visible grant and funding opportunities.
- Offering tax incentives, such as early-stage tax cuts or adaptation tax rebates.

- Increasing training and mentorship programs.
- Giving youth a seat at the table during policy formation.

Reducing Conflicts and Making Countries More Secure

Climate change is a "threat multiplier" that exacerbates fragile situations and worsens social tensions and upheaval. It is no coincidence that six of the eight African countries most affected by the impacts of climate change are also currently experiencing armed conflicts.

A 2022 study by The Hague Centre for Strategic Studies (HCSS) identifies seven ways that climate change can lead to conflict. For instance, climate change can lead to shortages of water, food, or land resources, forcing pastoralist groups to alter their routes and compete for resources, or causing people to migrate, sparking social unrest. (For a detailed discussion, see the Insert on Migration in the full report). Climate change can also create fertile ground for armed conflicts and radical Islamist groups, as experienced in countries like Mauritania, Mali, Niger, and Chad. Social unrest and conflicts then make adaptation even more challenging. Without effective governance and social and political stability, adaptation projects can fall by the wayside, or may even risk making populations more vulnerable.

As a result, there can be no adaptation without security, just as there is no security without adaptation.

This report describes a detailed five-step framework and policy recommendations for achieving both successful adaptation and improved security:

- Identify and analyze the pathways from climate impacts to potential conflicts, as the Hague Centre study has done.
- Implement forecasting and early-warning systems that predict where climate change will pose the greatest security risks. Systems that already exist for Africa or globally include the African Union's Continental Early Warning System, which spots areas where resources are limited, and USAID's Famine Early Warning Systems Network, which looks for weather-related or economic shocks that could lead to famines.
- Develop conflict-proof adaptation planning. Measures that restore degraded farm and pasturelands will also reduce the potential for conflicts between farmers and pastoralists, for example.
- Translate climate-security risk assessments into localized action.
- Improve links between security with climate policies and action. The military, especially local security forces, are often the first and best equipped to take rapid action when disasters hit.

The Unfinished Research Agenda

The report and many others draw on a huge and growing body of research on adaptation in Africa. However, there are areas where research efforts in climate science, economics, psychology, and other social sciences are still needed to fill in present and future knowledge gaps on adaptation.

In particular, additional research is needed to provide:

- More climate risk data and models for actors seeking to invest in adaptation, particularly at more detailed levels.
- A better understanding of adaptation to the possible impacts from more extreme climate change, if the planet warms by 3–4°C.
- More knowledge about the social acceptability of adaptation measures, the institutional barriers that can make adaptation more challenging, and the exact roles adaptation can play in the larger challenges of economic development and social evolution.
- A deeper understanding of behavioral change at the local level in response to adaptation measures, and of how to ensure that such measures address underlying vulnerabilities as well as climate change impacts.

More broadly, to successfully bring effective adaptation measures to millions of people in Africa, research is needed to better understand how to produce and productively use comprehensive and localized information on climate risks, to identify the best adaptation solutions for every type of community or situation, and to develop and use the tools that can scale up adaptation efforts to reach all those who might benefit.

Synthesis

INTRODUCTION

Last year, the Global Center on Adaptation (GCA) published its 2021 State and Trends in Adaptation report (STA21). The report described the urgent need to adapt to climate change in Africa, as the continent is one of the regions in the world most affected by the extreme impacts of climate change to its economies, infrastructure, agriculture, livelihoods, and every aspect of society and communities.

The 2022 issue of the State and Trends in Adaptation flagship series again focuses on Africa, with an update on some of the most important trends in climate adaptation finance and economics, along with deep dives on new topics from low-income urban communities to livestock, security, and education, among many others. This synthesis presents a brief summary of the report, with a special focus on the challenges and practical recommendations for action.

The 2022 report builds upon and complements the 2021 State and Trends in Adaptation report. The 2021 report covers a wide range of economic and social sectors that are not repeated in this 2022 report. We advise readers to view the two reports as an integrated review of climate adaptation for the region, covering a range of critical sectors for adaptation, including food systems, gender, health, and water, among many others.

In 2022, Africa faces additional headwinds caused by the invasion of Ukraine and its impacts on agricultural exports and fertilizers. Equally important, inflationary pressures, risks of global and regional economic recession, and unsustainable debt levels for many countries are amplifying the impacts of climate shocks on African economies and communities. The limited resources available to Africa for adaptation need to be used in the most efficient and productive manner to dampen the combined impacts of climate shocks and economic downturns. Nature-based solutions (NBS) and locally led adaptation (LLA) programs are critical in this respect. This report pays special attention to this category of actions.

CLIMATE RISKS IN AFRICA

This chapter provides an update on new climate data published since STA21. It presents an overview of climate-related disasters experienced in Africa in the last year; a closer look at high-impact events across the continent; and outlines the expected impacts of physical changes to the climate system, highlighting the critical interconnection between climate change, society, and nature for climate-resilient development.

Challenges

Africa is substantially impacted by natural hazards, which are set to increase in severity and frequency with climate change. Between January 2021 and September 5, 2022, more than 54 million people were affected by disasters linked to storms, droughts, wildfires, floods, and landslides in Africa. Drought-related disasters affected the most people in Africa over this period, followed by floods. Eastern Africa has been hit the hardest by climate-related disasters,

with a total of more than 33 million people who were injured, affected, or killed. In North Africa, the greatest impacts were from floods and wildfires. In the past decade, most disasters triggered by natural hazards globally were caused by extreme weather and climate-related events such as heatwaves, floods, and storms. This number has been increasing since the 1960s and has risen almost 35 percent since the 1990s. Between 2011 and 2020, the disasters that have affected Africa have mostly involved droughts and floods. On average, approximately 13 million people per year were impacted by droughts over that period, and 3.5 million were impacted by floods.

For Africa, climate risks are expected to pose significant challenges to food security. African food systems are particularly vulnerable to climate extremes and shifts in weather patterns, as food production is largely dependent on rainfed agriculture and pastoralism. Considerable negative impacts of a changing climate are also expected for marine and inland fisheries.

Water-dependent sectors across Africa are also largely and negatively impacted by extreme variability. Extreme hydrological variability will progressively amplify under all climate change scenarios (relative to the current baseline), depending on the region. The number of people projected to experience water stress by the 2050s varies widely, with decreases or increases by hundreds of millions. This requires planning under high uncertainty.

Adaptation to climate change is more than ever a crucial strategy to minimize the impacts on livelihoods and build resilience in the long run. While it cannot prevent all losses and damages, there are a range of options that can be broadly applied across sectors, including disaster-risk management, climate services, and risk spreading and sharing. Multi-Hazard Early Warning Systems (MHEWS) are critical for adaptation and disaster risk reduction. Barriers to climate change adaptation in Africa include a lack of access to climate information, inadequate research opportunities, and a funding gap for adaptation. It is important to strengthen adaptation finance flows to Africa, develop legislative frameworks that facilitate effective design and implementation of adaptation responses, and emphasize good governance for climate-resilient development.

SECTION 1—ECONOMICS AND FINANCE

Adaptation Finance Flows in Africa

The impacts of climate change in Africa are being exacerbated by rapid urbanization, geopolitical tensions, and the impact of global shocks such as the COVID-19 pandemic and the ongoing war in Ukraine. Rising prices of energy, food, and other commodities have worsened the climate-related food security and energy access risks to the population of Africa. Despite these challenges, there is a significant opportunity for climate investments in Africa to mainstream resilience and low-carbon development in the long term. Current adaptation finance flows in Africa are insufficient to meet the growing adaptation needs on the continent.

Funding for Climate Adaptation

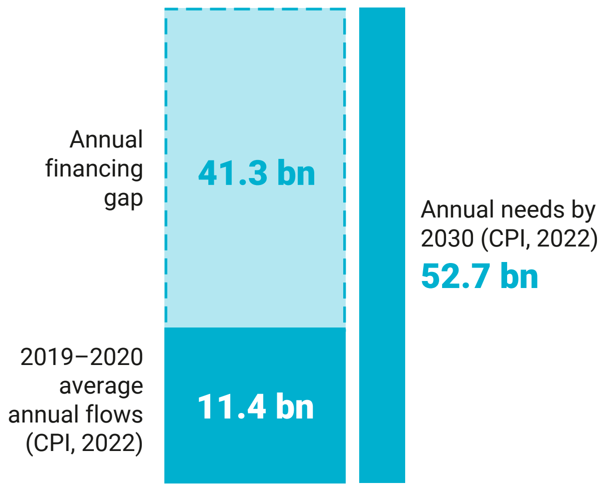
The Paris Agreement includes a global goal for adapting to the effects of climate change. At COP26, new financial pledges were made to support developing countries in achieving this goal. Moreover, at COP26 new rules for the international carbon trading mechanisms ("Article 6") were agreed upon to support adaptation funding.

While significant work is being done toward those goals, it remains clear that mitigation is still receiving considerably more attention and funding support than adaptation. Indeed, adaptation finance has remained at between 20 and 25 percent of committed concessional finance across all sources. COP26 urged developed countries to at least double their aggregated provision of adaptation finance from 2019 levels by 2025, in order to achieve a fair balance between adaptation and mitigation. The pressure to increase and deliver substantial adaptation financing is likely to continue in COP27 and beyond.

Our report shows that multilateralism and collaboration between governments, international organizations, international financial institutions, civil society, and the private sector are critical to ensure more support for adaptation.

Africa faces a serious and urgent shortfall in funding for climate adaptation, even as the costs of delayed action rise. Cumulative analysis of the Nationally Determined Contributions (NDCs) of 51 African countries show a need for an estimated US$579 billion in funding for adaptation through 2030. The analysis indicates that an annual average of US$29.5 billion in climate finance was committed to Africa in the years 2019 and 2020. Approximately 39 percent of those commitments, amounting to US$11.4 billion, targeted adaptation activities. (Figure 1). Most of the funding for adaptation presently comes from the public sector. To tap a wide range of potential actors, it is necessary to build the enabling environment for adaptation investment and aggressively deploy innovative finance instruments at scale toward adaptation activities.

Figure 1. Adaptation Finance Commitments (US$ billion) vs. Needs in Africa



Across Africa, multilateral development finance institutions (DFIs) were the most significant source of adaptation finance flows (53 percent, US$6 billion), followed by governments (23 percent, 2.6 billion) and bilateral DFIs (16 percent, US$1.8 billion). In line with the global trend of increasing prioritization of adaptation in development finance institutions' climate portfolios, the 2019–2020 period was the first period where more finance commitments tracked from multilateral DFIs were directed to adaptation than to mitigation in Africa.

More than half (53 percent) of the adaptation finance commitments to Africa in 2019–2020 were loans. A high share of financing from multilateral DFIs was committed in the form of commercial-rate loans (41 percent) and concessional loans (32 percent), whereas bilateral DFIs primarily committed concessional loans (82 percent). By contrast, more than 90 percent of adaptation finance committed from governments was in the form of grants, with less than 6 percent in the form of loans. The share of grants and loans varies across regions and the income profile of countries. Low-income countries primarily attracted grant commitments for adaptation financing, whereas lower-middle-income countries largely saw commitments of loans at market rate (58 percent). As shown in Figure 2, there is limited to no correlation at the country level between tracked adaptation finance and climate vulnerability.

Figure 2. **Tracked Adaptation Finance (US$ million) vs. ND-GAIN Vulnerability by Country**

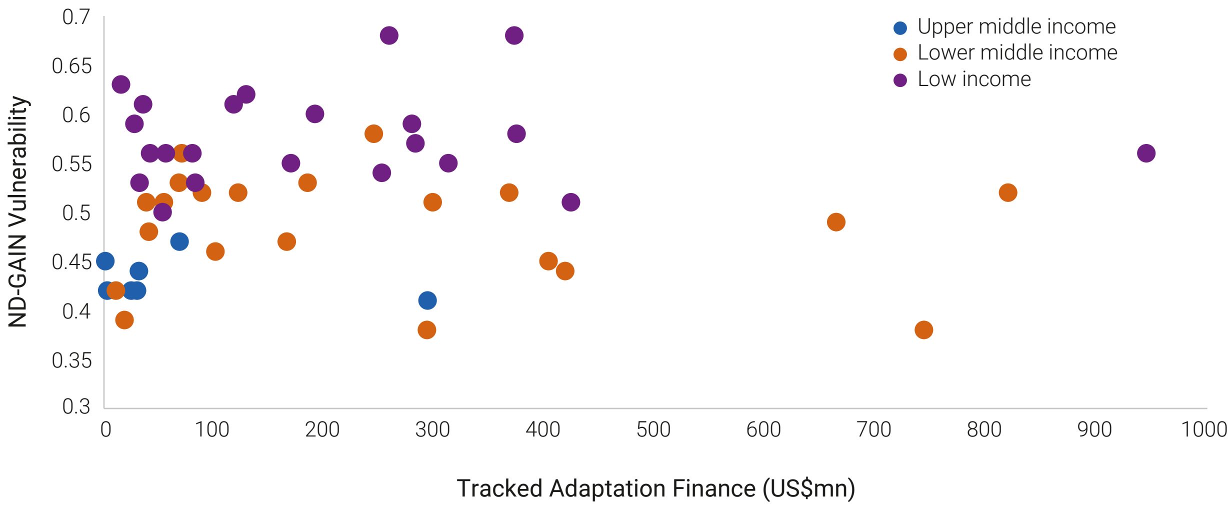


Photo: Simon Townsley/Panos Pictures

Adaptation finance commitments to Africa remain substantially below the estimated needs detailed in NDCs.

To mobilize further adaptation investment and to increase the impact of investments in terms of building resilience, a wide variety of sources of finance need to be tapped along a spectrum of terms, ranging from highly concessional terms (lower return expectations and/or longer tenors) to commercial terms (market returns and tenors expected). Concessional capital is intended to fill a gap where the private sector (commercial capital) would not otherwise invest.

Lessons Learned from Case Studies

A number of case studies in the chapter focused on adaptation and funding strategies in Rwanda, Ghana, Kenya and Egypt offer insights into best practices that, given the right context, can be modeled in other African countries.

- Private-sector adaptation finance mobilization remains a challenge in Rwanda and Ghana. To date, most entities engaging in climate finance have focused their efforts on mitigation. Lack of government incentives for private-sector involvement and limited awareness of public initiatives in this space are often cited as key barriers to private-sector finance for adaptation. Moreover, small and medium enterprises in these countries often lack access to credit and funding, which limits their ability to invest in resilience measures.
- In Rwanda, supported by several grants, the Rwanda Green Fund (FONERWA) has developed capacity-building training specific to private-sector actors and routinely holds private-sector stakeholder engagement workshops. The Fund, which also received grant funding to build capacity to identify climate interventions within the private sector, actively seeks out private-sector project co-finance and reserves 20 percent of funds for private-sector projects. More generally, in both Rwanda and Ghana, public–private partnerships (PPPs), the use of compliance, and voluntary carbon market mechanisms have been put forward as potential options to attract private-sector funds.
- There is a need for African nations to modernize their public financial management systems to enable more granular levels of climate finance expenditure tracking. In the case of Kenya, adaptation frameworks need to be institutionalized into ministries and departments that oversee tagging and tracking of climate finance expenditures.
- There is a need for these existing taxonomies and frameworks to be substantively used and to filter down to the line ministries that are tasked with tagging climate finance. This will help align climate projects implemented by entities at different levels of government as that data is fed into a public financial management system, thus streamlining data reconciliation and improving the quality of the qualitative information that is reviewed and tagged for adaptation.
- Though Egypt's green bond is not solely climate adaptation-focused, it has significant potential to deliver climate-resilience benefits. Other countries can benefit from the lessons learned from Egypt's implementation to move forward with similar initiatives. African DFIs and ministries of finance can, for example, look to leverage and potentially replicate Egypt's Regional Center for Sustainable Finance (RCSF) to build institutional capacity. Following the launch of the green bond program, Egypt established the RCSF with the aim of removing market barriers in the Middle East and North Africa region to integrate sustainable finance practices, instruments, and management models. African nations should take advantage of RCSF's training and educational institutes for capacity building on sustainable finance literacy, debt management operations, cross-ministry coordination, and technical support for setting up their own green finance programs.
- Egypt's green bond issuance benefited from the establishment of a robust legal and green financing framework in collaboration with international finance institutions including the World Bank and the International Finance Corporation (IFC). Egypt brought together three crucial ingredients that enabled the right economic and political conditions for its green bond program, setting a template for other African nations to model. First, early involvement from key ministries that established a guiding green bond framework. Second, utilizing the Commercial International Bank (CIB), the nation's largest private bank, to issue the green bond sale. Lastly, partnering with the World Bank and IFC to act as

technical advisors on the project created global credibility on the execution of the sale and use of proceeds and served to guide assessments of impact indicators.

Recommendations

1. **Mainstream adaptation and resilience into investment decision-making.** To enable financial institutions to mainstream resilience into the investments they are making, the following steps are critical:
   - Increase access to robust climate information.
   - Build capacity of African financial institutions and government entities to evaluate and act on climate risks.
   - Require disclosure of climate risks, via national legislation and/or via DFI on-lending.
2. **Build the enabling environment for adaptation investment.** To build the enabling environment of countries, key actions needed include:
   - Articulate investment-ready National Adaptation Plans (NAPs) and mainstream climate resilience in government procurement.
   - Build capacity to develop science-based policy and projects.
   - Improve macroeconomic environments and adopt a multifaceted approach to address debt burdens faced by African countries.
3. **Deploy innovative finance instruments.** There is a wide array of available investment instruments, risk finance mechanisms, and broader finance-relevant solutions that financial actors are already mobilizing in support of climate resilience across Africa. Financial instruments can be used to finance activities that build physical resilience to climate change impacts (reducing physical risk) and are also useful in responding to risks where physical climate impacts cannot or have not been eliminated (through risk transfer and risk reduction instruments). It is critical to carefully select a financial instrument or structure that meets the conditions and activities targeted. Key factors that must be considered when designing an instrument include currency stability, strength of the project pipeline, strength of debt capital markets, presence of a strong policy environment, existence of a sovereign credit rating, existence of a corporate bond market, robustness of climate information, and engagement/existence of a domestic private sector.

Multilateral development banks (MDBs) committed US$66,045 million in climate finance in 2020–US$49,945 million or 76 percent of this total for climate change mitigation finance and US$16,100 million or 24 percent for climate change adaptation finance. This is far from the objective of reaching 50 percent for adaptation. It is recommended that MDBs be more focused on adaptation finance and action. They have a critical role in the architecture of adaptation finance.

Fiscal Policies For Adaptation—The IMF Perspective

Climate change is emerging as a critical threat to long-term economic growth and stability. The fiscal impacts of climate shocks are very important for many economies with weak resilience. The International Monetary Fund (IMF) policy guidance on adaptation focuses on financial and institutional resilience-building against natural disasters and infrastructure investments to cope with rising sea levels and other warming-related phenomena.

Climate change impacts and adaptation to it will affect economies across the world. However, these impacts will be heavier for lower-income and small vulnerable nations with a higher proportion of economic activity in climate-sensitive sectors. The complexity, cost, and limits of adaptation increase with the speed and severity of climate change.

Despite its many benefits, adaptation to climate change cannot replace mitigation. Both are necessary to reduce damages from climate change. Adaptation can only partly compensate for delayed mitigation efforts, and without stark greenhouse gas (GHG) reductions, the stabilization of global temperature will not be possible, making adaptation impossible or too expensive for some countries.

Climate adaptation can lead to productive and stable economies in Africa in the long term. Deliberate investment in risk reduction results in significant development co-benefits. For example, adaptation actions have resulted in the decline in deaths from climate disasters over the last hundred years (especially from droughts), and the modest or no upward trend in economic losses due to climate disasters at the global level. However, climate change can exacerbate inequalities between and within countries and will disproportionately affect the poorer sections in countries of all income levels.

Some countries are on the verge of entering a poverty trap through a vicious cycle of low economic growth and increasing climate vulnerability. Sub-Saharan Africa, with limited adaptation capacity, is at particular risk from extreme weather. Capacity development, large investments, and external aid are indispensable to prevent such vicious cycles.

According to recent IMF calculations for Sub-Saharan Africa, each large-scale drought reduces medium-term growth by one percentage point, with low-income households severely affected. IMF research reflects that key adaptation policies integrated into the near- and medium-term budgets can impactfully reduce vulnerability to climate shocks and support sustainable and inclusive growth. For instance, in Ghana, the use of improved seed varieties and irrigation has bolstered cocoa's drought resistance and increased productivity. Similarly, the development of rust-resistant wheat varieties has increased yields by up to 40 percent in some cases in Ethiopia.

Recommendations

The IMF recommends:

- Decision-makers should use principles of welfare economics to make informed choices on adaptation policies and programs to climate change. The priority adaptation policies are those that can be achieved by removing market imperfections and implementing policies that hinder adaptation actions by the private sector. Given that adaptation benefits tend to be local and private, individuals and firms are strongly incentivized to adapt.
- Considering adaptation and other development priorities together, including synergies and tradeoffs among different development goals. Consistent investment in projects with the highest returns will maximize the impacts of governments' spending. Estimating net benefits for adaptation

Photo: Mikkel Ostergaard/Panos Pictures

programs and monetizing the benefits far in the future is fraught with deep uncertainty, but using cost-benefit analysis African policymakers can estimate the benefits over the entire lifetime of the project, including the growing risks linked to climate change.
- Giving preference to a combination of efficient adaptation policies with dedicated redistributive programs if they have larger aggregate net benefits for the entire population and the most vulnerable. It is important to ensure a consistent approach to analyze diverse programs through a standardized assessment of tradeoffs across different ministries and agencies, investment programs, and targeted groups in society.

Macro-Fiscal Implications of Adaptation to Climate Change

Natural disasters worsen fiscal balance ex post, creating explicit and implicit liabilities that trigger additional borrowing. Assessing disaster risks would help countries calculate the size of required fiscal buffers. Examining both explicit and implicit liabilities can inform financial planning and post-disaster response.

Climate change costs are calculated as the sum of the cost of adaptation and the costs of residual risks. Experience shows that these costs can be greatly reduced by timely adaptation. Estimating and incorporating projected climate damages into macro-fiscal policies can aid government planning for climate change.

Global estimates of public funding needs for adaptation are 0.25 percent of world GDP per year on average. However, this is not representative of the challenges faced by many countries. For some lower-income vulnerable countries, bottom-up self-assessment of their needs tends to be larger, ranging from 100 to 250 times higher than global averages.

According to IMF calculations, strengthening exposed existing and projected public assets could cost between 0.2 and 0.4 percent of GDP annually from 2021 to 2025 with large disparities across countries. The largest costs would be faced by emerging markets, followed by low-income countries. The costs of improving private-sector asset resilience could be twice as high, though more evenly distributed across income groups.

Recommendations

- Market distortions arising from policy failures can be addressed by governments as part of a comprehensive plan to improve the efficiency of the economy while considering the distributional implications of these measures.
- Subsidies can help deliver a socially optimal amount of climate change adaptation with positive externalities: for instance, subsidies for investments in research and development in agriculture, energy technology, etc.
- Costs and benefits of adaptation investments must be weighed by international donors if the investments are not additional to existing development assistance or if they do not have significant development benefits. This will ensure that adaptation projects effectively contribute to development goals of the society.
- For longer horizons, macro-frameworks should reflect all climate change effects, additional to disaster episodes.

Financial Instruments in North Africa

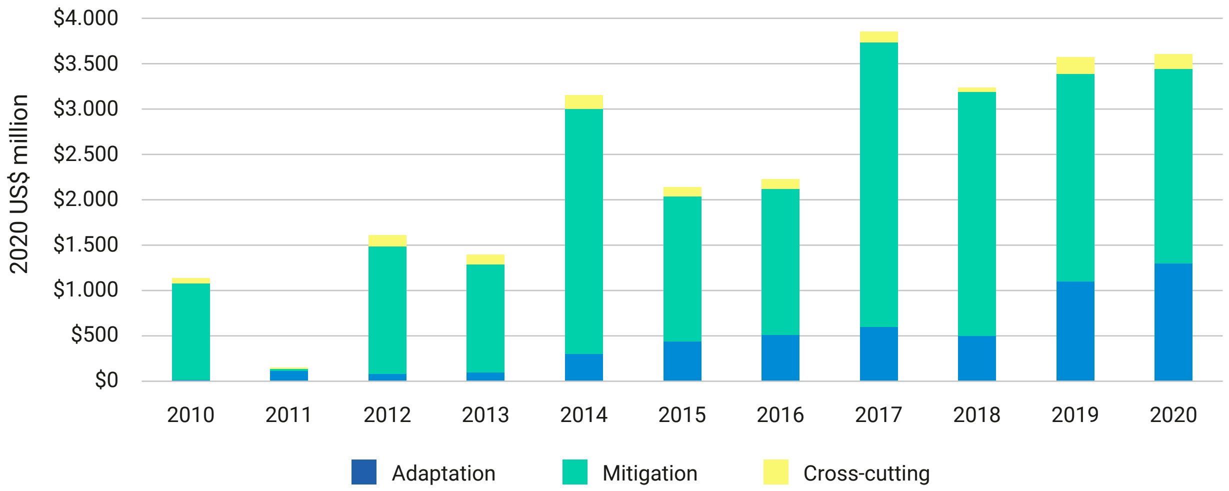
Despite the pressing adaptation needs expressed by several countries in the North Africa region in their NDCs, current adaptation finance represents less than 30 percent of total climate finance received. At the policy and prioritization level, many countries in North Africa have identified their climate financing needs. A review of the updated NDCs for five North African countries (Egypt, Mauritania, Morocco, Sudan, and Tunisia) indicates that climate financing needs total US$393 billion for the implementation of the NDCs over the next decade. Of this amount, almost three-quarters (US$288 billion) are requested for climate mitigation actions, and US$105 billion for adaptation.

Mobilizing the climate finance that responds to the country needs and avoids potential sustainable development tradeoffs remains challenging for many states in North Africa. Nevertheless, promising signals exist. A slight increase in climate financial flows to the region has been witnessed since 2018 (Figure 3). Climate finance also continued to be disbursed to the region even after the onset of the COVID-19 pandemic in 2020. However, total public climate finance between 2010 and 2020 totaled only US$26.1 billion, which represents less than 7 percent of the amount of financing required for NDC implementation over the coming decade.

Access to Adaptation

Access to adaptation financing is particularly difficult. Of the US$26.1 billion the region received in total public climate finance over the past decade, on average only 20 percent was directed at pure adaptation projects; and 4 percent supported cross-cutting climate mitigation and adaptation projects. Mitigation projects received the largest share of public climate finance. The share of adaptation finance in total public climate finance flows has been growing slightly since 2017, but remained at just 31 percent in 2019 and 36 percent in 2020. Comparing across African sub-regions, the imbalance between adaptation and mitigation finance seems particularly high in North Africa, while the allocations are closer to parity between

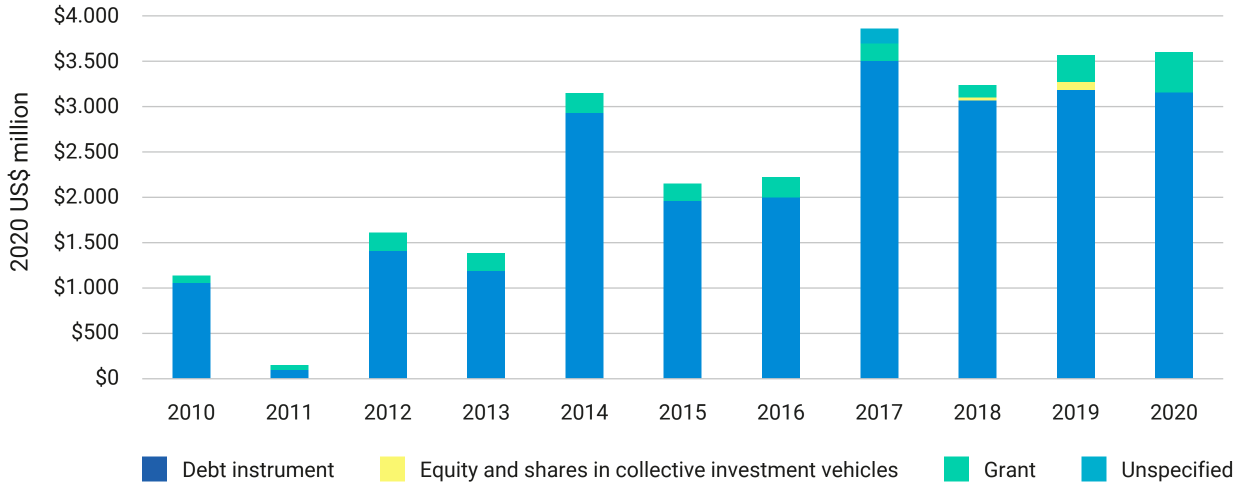
Figure 3. Climate Finance Flows to North Africa by Purpose (2010–2020)



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cross-cutting	$55.12	$0.19	$125.60	$111.30	$157.30	$104.60	$104.30	$110.40	$44.79	$184.80	$167.50
Mitigation	$1,071	$29.19	$1,389	$1,188	$2,693	$1,588	$1,600	$3,127	$2,675	$2,290	$2,131
Adaptation	$17.60	$125.70	$96.85	$108.10	$308.50	$447.80	$523.80	$612.90	$515.90	$1,103	$1,310

Source: ESCWA calculations based on OECD DAC data (recipient perspective)

Figure 4. **Climate Finance Flows to North Africa by Type of Financial Instrument (2010–2020)**



Source: ESCWA calculations based on OECD DAC data (recipient perspective)

mitigation and adaptation finance for West Africa (54 percent for mitigation), Central Africa (52 percent for mitigation) and East Africa (52 percent for mitigation) for the period 2014–2018.

In addition, climate finance flows to North Africa were almost exclusively in the form of debt-based instruments (88 percent), despite the large debt burden many countries in the region are currently facing (Figure 4). There are also large regional disparities in received climate finance. Egypt and Morocco have been most successful in attracting public international climate finance, while the least developed countries Mauritania and Sudan received only 3 percent of total flows to the sub-region.

Challenges

Countries can mobilize climate finance from a broad range of sources and in many different forms. There are public and private as well as national and international financing instruments. Furthermore, in addition to mobilizing external funds, existing national resources can be freed for financing climate action by mainstreaming climate into public budget and expenditure processes as well as fiscal mechanisms. Unlike mitigation projects, adaptation projects tend to accrue benefits over a longer time horizon and face more difficulty in ensuring cost recovery and profitability. This renders them less attractive for private-sector investment.

At the same time, countries in the region face a contraction in their fiscal space. Public debt has been rising in an unprecedented way over the past decade. Debt burdens have been aggravated further by the COVID-19 pandemic and the Russian invasion of Ukraine, particularly through price increases for energy and wheat, of which many North African countries are net importers. For middle-income countries in the Arab region, the total public debt more than doubled between 2008 and 2020, reaching US$658 billion in 2020, which implies a debt-to-GDP ratio of 91 percent. This severely limits the resources available for investing in climate action. In addition, debt vulnerability considerations might limit a country's external borrowing ability. More innovative financial instruments are needed to ensure that the cost burden for adaptation is not placed exclusively on the public purse.

A country's legal and regulatory framework can create an enabling environment for mobilizing adaptation finance and climate-proofing public and private-sector investments. Dedicated climate laws, national strategies, and directives from financial authorities help set the scene for adaptation finance and define the overall level of ambition by showcasing high-level endorsement. For example, Egypt recently published its National Climate Change Strategy 2050.

Institutional structures can also help to create an enabling environment for mobilizing adaptation finance. Several North African countries have passed decrees to establish national management units to coordinate, streamline, and monitor national climate-related activities.

Further, an enabling environment for mobilizing adaptation finance should engage all levels of government and involve local stakeholders. Drawing upon local knowledge helps to develop tailored solutions responsive to stakeholder needs. As such, a bottom-up approach can help strengthen local authorities and actively engage communities in the planning and implementation of projects as well as in knowledge and capacity-building processes.

A better understanding of climate risks and vulnerabilities for individuals, firms, and the public sector is paramount in defining adaptation needs and thus for mobilizing and accessing adaptation finance. Climate-related financial risk disclosures regarding adaptation and disaster risk can do just this.

Establishing a reliable system for tagging and tracking climate-related public expenditures is important to earmark funds and assess whether public budgets have been used to their designated end in a results-based framework. Thus far, climate-related budget tagging and budget tracking are still rare in the North Africa sub-region, which can in part be attributed to the lack of data and monitoring capacity, including a clear taxonomy and performance indicators, manifest in several countries in the region.

Another public budget instrument is the provision of dedicated national funds to allow both for ad hoc financing in the aftermath of a disaster as well as for investing in strategic adaptation measures.

Financial Instruments for Adaptation

Green Bonds

Recent years have witnessed an increasing interest in green bonds. Egypt and Morocco are both active on the green bond market. However, bond proceeds have primarily financed climate mitigation projects. Morocco issued its first green bond in 2016 for a total of US$447 million. Additional bonds were issued in 2018 and 2020, financing renewable energy, energy efficiency, and sustainable housing projects. Egypt issued its first sovereign green bond in September 2020 with a five-year term worth US$750 million. As of November 2021, 75 percent of the net proceeds of the issuance (US$564.46 million) have been used to finance eligible projects. Of these, 46 percent are being used for the Cairo Monorail as a clean transportation project. The remaining 54 percent are supporting 14 sustainable water, water desalination, and wastewater management projects.

Debt Swaps

Debt-for-climate or debt-for-nature swaps present an innovative financial tool that can help secure funding for adaptation projects and thus accelerate climate action while not increasing the country's debt service burden further. A debt swap converts national debt servicing payments on external debt into domestic investments, which can in turn be directed toward projects or programs that support national sustainable development or climate goals. Egypt is currently implementing a debt swap program with Germany over three phases with a total value of €240 million. The United Nations Economic and Social Commission for Western Asia (ESCWA) launched the Climate/SDGs Debt Swap-Donor Nexus Initiative in 2020 to provide an alternative to debt restructuring by facilitating a debt swap between bilateral creditors and middle-income countries that are facing increasing fiscal pressure, but which are not at risk of defaulting on their payments. ESCWA's debt-swap initiative is currently being piloted in Jordan.

Our analysis shows that for the debt swap mechanism to be scaled up, there is a need to move from ad hoc bilateral deals for debt-for-adaptation swaps to a more institutional approach.

Multilateral Development Banks and Climate Funds

MDBs and climate funds provide climate finance through different channels, some of which specifically focus on adaptation. These funding instruments support readiness projects to help prepare countries for securing climate finance. They also finance climate adaptation and mitigation projects through grants. Concessional international finance can be used catalytically for crowding in new finance, including from the private sector, which tends to charge commercial rates.

MDBs have become the dominant source of climate finance, providing almost two-thirds of total public climate finance flows to the Arab region between 2013 and 2019. However, most of these flows have been non-concessional debt instruments with a very small share of grants offered. MDBs have also diversified their offerings into green financial instruments, in support of commitments made to align their operations with the Paris Agreement and the 2030 Agenda.

Climate funds can also play an important role in providing alternative forms of financing, but their overall contributions remained at 1 to 2 percent of total public climate finance.

This report highlights the need to address the imbalance in adaptation finance generated by the public and private sectors. We indicate that of the US$11.4 billion in adaptation commitments tracked from 2019 to 2020, more than 97 percent came from public actors, while less than 3 percent was tracked from the private sector. In total, private-sector adaptation finance commitments tracked in 2019 to 2020 in our analysis come to just under US$250 million annually. Of that total of approximately US$250 million, nearly 90 percent was committed by institutional investors (which includes foundations, insurance companies, asset management firms, pension funds, and endowments), 9 percent was committed by commercial financial institutions, and the remaining 1 percent was committed by corporations and other private sources.

The African Development Bank (AfDB) estimates that about 75 percent of the financing required for successful implementation of African NDCs needs to be provided through private investments. It is therefore important to promote innovative financing solutions, including more blended finance resources, and incentivize institutional investors to invest in adaptation to unlock the potential of institutional investors such as pension funds, sovereign wealth funds, and insurance companies in scaling up climate finance on the continent and helping bridge the continent's adaptation finance gap.

Mainstreaming Climate Considerations Into Public Budgets

Mainstreaming climate considerations into public budgets and incorporating adaptation finance into all stages of the budgeting process can provide a direct channel of funding for dedicated climate adaptation projects. It can also facilitate the climate-proofing of planned or ongoing public investments, such as in infrastructure or housing. Transparency and strengthened fiscal discipline can improve the efficiency of climate expenditure management as well as the intersectoral allocation of climate funds to maximize the value of existing budgetary resources.

Recommendations

- Innovative financial approaches and instruments can help access additional funds and maximize the value of existing ones. As such, financial instruments for adaptation range from greening public budgets and climate-proofing public expenditures to the mobilization of private-sector financing through an enabling institutional environment, and from regulatory provisions as well as credit guarantee schemes to traditional revenue-oriented financing instruments such as green bonds, innovative debt swap programs, or MDB and climate fund financing.
- In order to enhance access to adaptation finance and maximize the value of existing resources, current barriers and challenges need to be overcome. In particular, standardized methodologies are vital for assessing country-specific climate vulnerabilities and risks and in turn identifying adaptation needs. In addition, a clear taxonomy and well-defined evaluation methodology are important to create a collective understanding of what qualifies as adaptation action. Fostering cooperation and communication between ministries and decision-makers at all levels of policymaking can create an enabling institutional framework and support the prioritization of adaptation at the planning and funding stage. This can help generate synergies and avoid distortions.
- A clear policy, legal, and regulatory framework that takes international standards and good practices into account while at the same time responding to local needs and circumstances is needed to establish an enabling investment environment for project identification and active private-sector engagement.
- Similarly, a comprehensive monitoring and evaluation system and ambitious budget tagging and tracking will allow countries to supervise whether funds have been used for their purpose, help to respond to reporting requirements by funders, enhance transparency, and build trust.

Climate Risk Financial Regulation in Africa

This chapter focuses on the impact of climate risks on African financial systems. Financial regulations and self-regulation practices of financial institutions are critical enablers of a resilient financial system and encourage more climate investment in the region. The increased quantification, pricing, and management of physical climate risks by financial institutions can help foster social resilience, not only by assuring the financial system's resilience to climate change, but also by providing price signals that influence economic behavior.

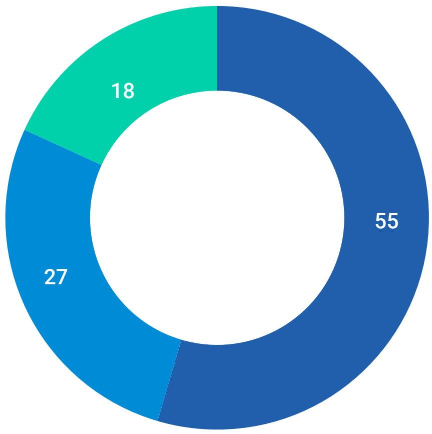
As long-term measures to address climate-related financial risk, all 54 African countries have signed the Paris Agreement and submitted ambitious Intended Nationally Determined Contributions (INDCs), while the majority have ratified NDCs. However, many of their commitments require financial, technical, and capacity-building support. In the financial-sector, the African Financial Alliance on Climate Change (AFAC) brings together leaders in the African financial industry: central banks, insurance companies, sovereign wealth and pension funds, stock exchanges, and commercial and development banks. AFAC aims to increase financial-sector participation in climate action to raise the share of investments supporting low-carbon and climate-resilient development in Africa.

The effects of climate change on financial stability depend on the distribution of financial exposure and the evolution of prospective financial-system losses. African banks are vulnerable to climate change shocks increasing in frequency and severity, as they are projected to do. An analysis by Moody's Analytics found that 49 banks across 14 African countries had extended US$218 billion of credit to environmentally sensitive sectors—about 29 percent of their total loans.

The chapter focuses on the exposure of Africa's financial sector to climate-related risks, pointing out that some African nations are among the most vulnerable in the world to climate risks. It shows that there is a growing momentum globally among financial authorities, including in Africa, to develop a broad-based regulatory framework to address such risks, and details the transmission channels through which climate risks threaten the stability of the financial system. It also presents the research and findings of the 2021 McKinsey report on climate risk integration in Africa's financial regulatory network, carried out in collaboration with AfDB, GCA, and UNEP FI.

This study, based on a series of semi-structured interviews and a questionnaire for each country, included 19 African countries with different levels of financial-system sensitivity to climate-related hazards. Overall, 25 organizations were surveyed, including 11 financial regulators and 14 private entities. The study shows African financial authorities and the private sector have a growing awareness of climate-related risks, which can be divided into physical risks and transition risks. Climate risks pose a significant threat to financial stability by reducing the collateral value of economic agents and jeopardizing the soundness of financial institutions.

Figure 5. Priority Perception of Climate Risk Among Financial Authorities



- Very high priority
- High priority
- Medium priority

82% of the authorities interviewed considered climate risk a high or very high priority

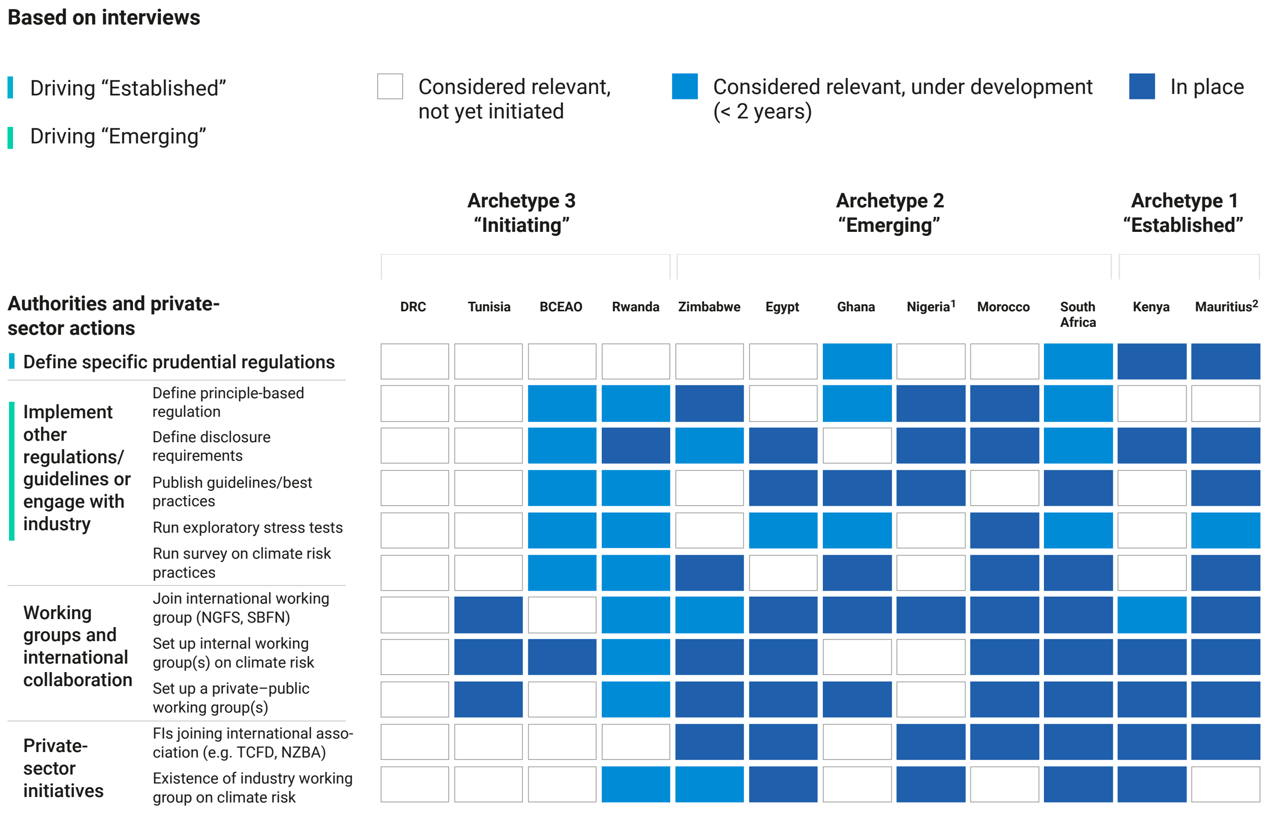
"With monetary policy, climate risk has become our top concern"

Central Bank – Head of Sustainability Department

Source: Reproduced from Figure 5 in AfDB et al. (2021), Climate Risk Regulation in Africa's Financial Sector and Related Private Sector Initiatives

Climate-related risks have been added to the research agendas of various central banks and supervisory organizations as governments acknowledge the threat that climate change could

Figure 6. Overview of Climate Risk-Related Regulations and Initiatives Across African Regions



Notes: Archetypes were defined in terms of regulatory advancement. (1) Implementation Guidance to the Nigerian Sustainable Banking Principles are not binding per se, but can generally be considered detailed. (2) Mauritius has drafted its prudential regulations and should be finished by the end of the year 2021.

Source: Reproduced from Figure 6 in AfDB et al. (2021)

pose to their economies and financial systems, including financial losses caused by climate-related disasters and implications on financial valuations of a necessary transition away from high-emitting sectors of the economy.

However, very few authorities and supervisors in the financial sector have established regulations or supervisory expectations. According to the report’s conclusions, most regulators and supervisors in the financial industry have not addressed climate-related risks or more significant sustainability-related concerns through binding rules and supervisory guidelines. Although authorities can evaluate these risks as part of their existing duties, there are ongoing attempts to build effective and comprehensive frameworks to detect, analyze, manage, and communicate climate-related risks that are connected to developments in the private sector.

There are three significant challenges that African governments are currently facing in their efforts to integrate climate risk into their financial systems: a lack of data; a lack of internal capability to define regulations and guidelines; and a lack of international standards or common methodologies, such as stress tests.

Recommendations

- **Address the lack of capacity and capabilities of authorities.** Public authorities and financial regulators should be encouraged to develop their own capabilities while also contributing to the capacity development of private-sector players, for example by highlighting best practices, offering training programs, forming working groups, and so on. Several interviewees mentioned the importance of collaborating with external organizations and initiatives to implement this approach.

- **Set standard disclosure instructions/Set mandatory reporting and disclosures.** Consider mandating minimum disclosure standards for the financial and non-financial sectors in accordance with the Task Force on Climate-Related Financial Disclosures (TCFD) recommendations, covering governance, strategy, risk management, metrics, and targets. Consider specific regulations and supervisory guidelines and metrics to ensure that financial institutions adequately consider climate risk and facilitate interactions with counterparties, investors, and clients.
- **Promote access to data and information/develop stress test models and scenarios analysis.** Make physical and transition risk-related data and information more accessible, for example by incorporating reliable sources into a central repository. Develop stress test models and scenario analyses for supervisory purposes as well as institutional reference points.
- **Promote non-bidding measures.** Non-regulatory actions are often the most effective ways to raise awareness about climate change. For instance, conducting awareness-raising events and surveys is often the most effective way to gather information about the financial sector's exposure to climate risk. Sharing best practices, for example via guides and roundtables, publishing assessments of the financial sector's aggregate climate-risk exposure, and defining a taxonomy for economic activities are other tools and resources that can help financial stakeholders make informed decisions when assessing their exposure to climate risk.


Photo: JordiRamisa/iStock

Resilient Recovery: The Cases of Senegal and Côte d'Ivoire

In STA21, the report covers the role that adaptation and resilience programs can have in the post-COVID recovery trajectory of a selected group of African countries. This year, two additional countries were analyzed. Senegal and Côte d'Ivoire face steep challenges, including from climate change, in making a transition to the next stage of economic prosperity. As these countries plan for the future, investment in green sectors could deliver a sustainable and environmentally friendly post-pandemic recovery.

Both economies exhibit a recovery path from COVID-19, with real GDP growth in 2021 of 6.1 percent and 7 percent respectively. However, the economic fallouts of the outbreak, the appearance of new variants, and the low rates of vaccines still threaten their recovery. Further, the tensions between Russia and Ukraine have led to a steep increase in food and energy prices, a deterioration of terms of trade, and a shortage of fertilizers, threatening the macroeconomic outlook and food security.

Crucial for an effective green recovery plan is mainstreaming climate change adaptation into it. Adaptation measures must be implemented in every sector—agriculture, transportation, energy, trade, water resources, and urban development. It is important to invest in NBS, such as restoring mangroves to protect coastal communities or creating urban parks that absorb stormwater and moderate heatwaves in cities. Given the vast human and natural resources of Senegal and Côte d'Ivoire, there is immense potential to move forward rapidly in labor-intensive modern industries such as ecotourism services, climate-smart agriculture, renewable energy, green building, and infrastructure.

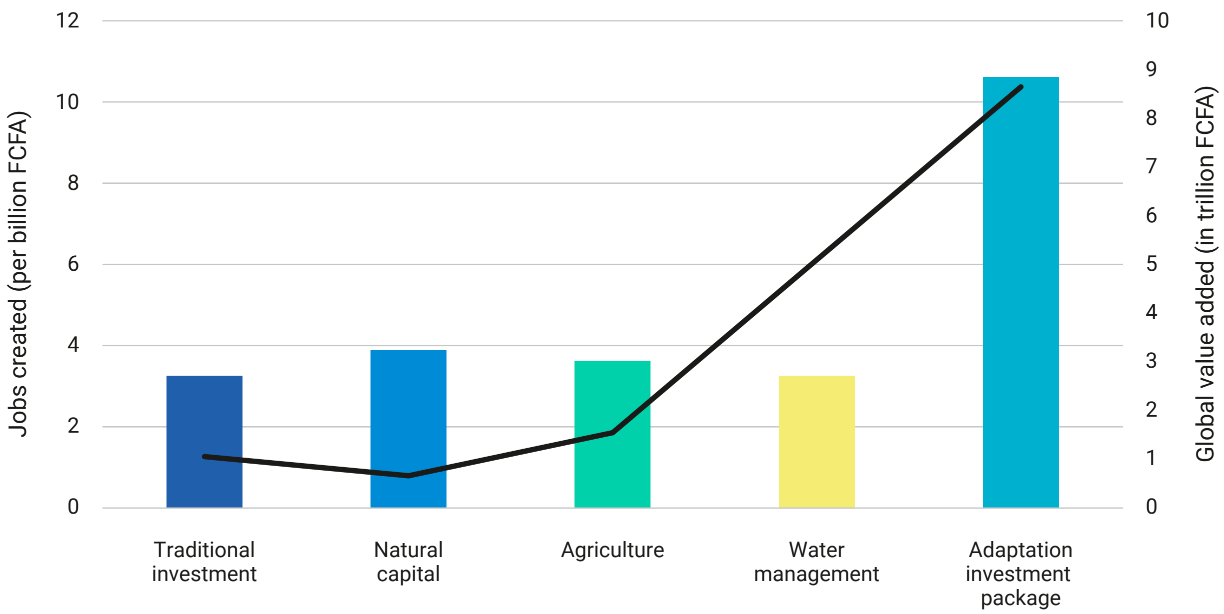
Such adaptation measures will have several co-benefits. Adaptation measures can be enormously cost-effective and have the potential to start a positively reinforcing cycle of benefits. Adaptation measures could help lift people out of poverty, reduce hunger and undernourishment, fight diseases, create jobs, reduce inequality, mitigate the risk of conflicts, and give voice to the most vulnerable. Specifically, in Côte d'Ivoire, adaptation measures could increase the productivity and resilience of smallholder cocoa farmers. There is strong potential to pair adaptive investments in Côte d'Ivoire with several support initiatives in different sectors, including agriculture, fisheries, and forestry, to promote sustainable and efficient practices. Strategically targeted investments in adaptation can help expand opportunities for the labor force, which is currently tied up in informal work characterized by irregular and volatile incomes. These realizable results, in turn, further increase resilience to climate impacts. This chapter presents an analysis of the economic and employment potential of green investments relative to traditional and high-carbon investments in Senegal and Côte d'Ivoire.

Senegal

The Senegal green stimulus package is compared to an investment in the mineral extractive sector. The choice of the extractive sector as a counterfactual is based on the different country's priority plans, especially the "Plan Senegal Emergent" (PSE). This development strategy aims at addressing the medium and long-term social and economic challenges of Senegal to become an emerging country by 2035. This strategy is implemented through several short-term actions plan "Plan d'Actions Prioritaires (PAPs)." The two first PAPs (2014–2018 and 2019–2023) identified the mining sector as one of the high-growth potential sectors, requiring the Government to prioritize investments to develop the sector including gold and phosphate mining and the creation of hub mining.

Our analysis shows that adaptation measures in Senegal would provide the highest returns in terms of jobs and economic value, among the set of green investments. Investment in adaptation initiatives could create 230 percent more jobs within five years (600 percent within 20 years) and 695 percent greater economic value in the long term (within 20 years) relative to the extractive sector stimulus package in Senegal. Climate change adaptation spending is estimated to boost employment by 14,098 job years directly and 16,571 job years indirectly (through supply chains). In contrast, the traditional package would support employment by creating 127 job years directly and 1,251 job years indirectly. (Figure 7)

Figure 7. Total Job Creation and Gross Value Added by Different Investment Packages, Senegal



Source: Author's calculations based on estimates

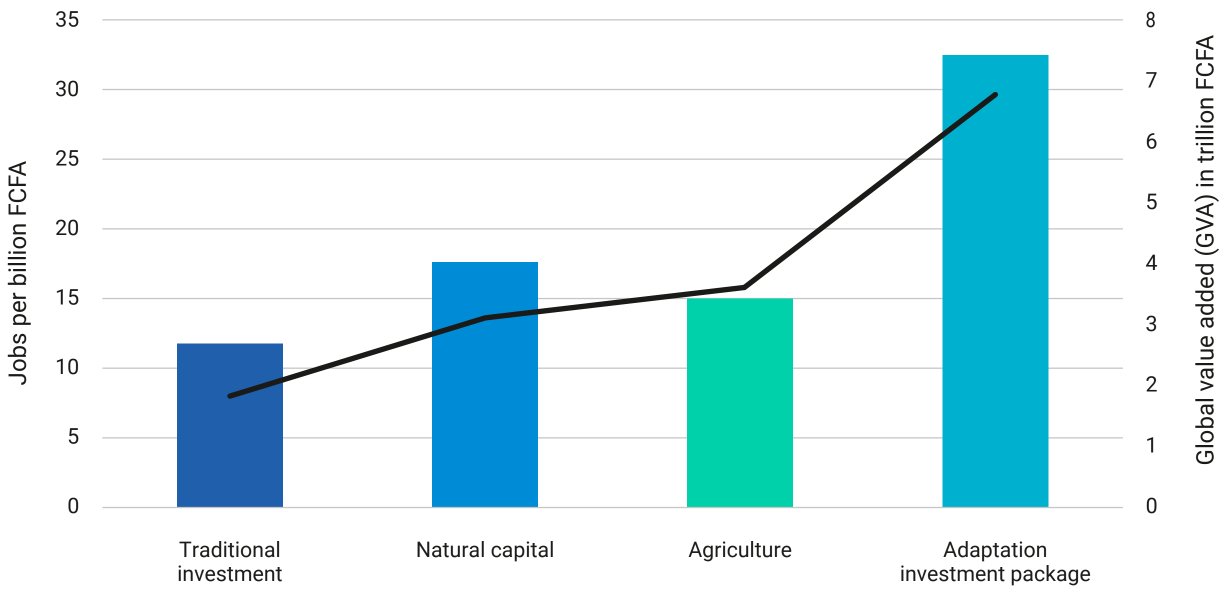
Analysis shows that, compared to high-carbon investments, flood adaptation, wastewater, and water demand management can generate an economic return of 380 percent while coastal protection, aquaculture, reforestation, and resilient seeds could generate more than 100 percent economic return. The potential for development of each of these sectors is now presented in greater detail.

Côte d'Ivoire

The Côte d'Ivoire green stimulus package is compared to an investment in the mineral extractive sector. The choice of the extractive sector as a counterfactual is based on the different country priority plans, especially the National Development Plan (NDP) 2021–2025. The NDP is a national development planning model adopted by the Government of Côte d'Ivoire. This development strategy aims at addressing the medium- and long-term social and economic challenges of becoming an emerging country.

Our analysis shows that among the set of green investments, adaptation measures in Côte d'Ivoire would provide the highest returns in terms of jobs and economic value. Investment in adaptation measures, among several other green interventions, has the highest social-economic returns, generating up to 180 percent more jobs within five years (400 percent within 20 years) and 265 percent more economic value in the long term (within 20 years) relative to traditional investments. Adaptation spending is estimated to boost employment by 84,792 job years directly and 66,926 job years indirectly (through supply chains). In contrast, the traditional high-carbon investment package would increase employment by 1,854 job years directly and 497 job years indirectly.

Figure 8. Total Job Creation and Gross Value Added by Different Investment Packages, Côte d'Ivoire



Source: Author's calculations based on estimates

Analysis indicates that aquaculture and reforestation can generate an economic return of 165 percent in the long term, while resilient seeds, agroforestry, and solar irrigation systems could generate more than 100 percent economic returns compared to high-carbon investments.

Recommendations

Based on the findings of the analysis for Senegal and Côte d'Ivoire, three key recommendations can be derived to unleash the potential of a green economy and ensure economic prosperity and sustainable development:

- **Public finance should mainstream climate investment in order to attract private-sector actors.** Investment in adaptation is no longer an option, but a priority, in order to preserve economic growth, ensure food security and attenuate the detrimental effects of climate change on the coastline, agriculture, and water availability. Governments need to consider a holistic approach to integrating public and private adaptation initiatives. Governments can prioritize public investments in adaptation programs with positive externalities, address market imperfections and policies that make the adaptation of the private sector inefficient, and mobilize revenues for and distribute the benefits of adaptation. Better planning can enable an increase in the share of public investment in adaptation, and/or increase the efficiency of public adaptation initiatives.
- **There is a need for proactive action on innovative finance sources and to work toward eligibility for sustainable bonds for adaptation**. Current adaptation finance flows are insufficient to meet growing adaptation needs on the continent. Innovative climate finance may allow grants or different funding sources to be combined with traditional climate loans, which enables investment in new sectors and facilitates the development of large-scale programs with improved effectiveness, impact, and replicability. Green and sustainable bonds, together with the increased level of transparency that they bring, can help secure market financing for future investments. To be able to attract financing, countries should create enabling conditions and incentives.
- **Promote an adaptation-mitigation approach.** Adaptation measures in mitigation projects could address potential climate risks, making mitigation projects more resilient to a changing climate. Renewable energy, including hydropower, solar photovoltaic, solar individual systems, and onshore winds, have considerable potential to provide energy access to rural communities by increasing interconnected networks. Climate change adaptation was perceived as a project safeguard that would provide benefits to local communities and project developers, as well as global benefits because carbon storage would be more permanent, particularly for forestry projects.


Photo: Fabian Plock/Shutterstock

The Private Sector

The private sector in Africa currently generates two-thirds of the continent's investment, 75 percent of its economic output, and 90 percent of employment. Across multinationals and micro-, small and medium-sized enterprises (MSMEs), climate hazards are expected to increase the costs for private-sector actors by impacting assets and worker productivity and by disrupting operations and value chains. Revenue may also decrease due to changes in demand related to fluctuating population, income, and migration patterns. Finally, as increased costs and reduced revenues are expected to affect cash flow and company performance, unfavorable expected rates of return for investors may affect international investment attractiveness and thus the flow of investment into perceived high-risk countries.

Challenges

Climate hazards are expected to translate into higher costs, ranging from asset restoration to disruptions to the supply chain. First, climate hazards are expected to translate into challenges for workers' wellbeing and safety, as well as higher costs tied to productivity reduction. Second, heat stress, flooding and drought can impair the functionality of and accessibility to on-site infrastructure and capital, translating into higher costs for maintenance and repair and requiring investment in more efficient and resilient technology. For example, South Africa, Zambia, Malawi, Benin, Mozambique, and Kenya have the largest number of businesses reporting detrimental water-related impacts globally, which includes physical damage to property from flooding and extreme weather events. Third, climate hazards may impact upstream and downstream value chains and increase the procurement and distribution costs of companies. Grid inefficiencies and impacts to transport infrastructure driven by climate risks create disruptions that reduce the reliability of utility services and can increase operational and procurement costs. Similarly, climate hazards can disrupt upstream value chains and increase producers' off-site costs when key infrastructure and transport routes or distribution warehouses and services are damaged, inaccessible, or destroyed. For low- and middle-income countries, the World Bank has estimated that globally, disruptions to water, power, and transportation services cause losses of over US$150 billion every year.

Photo: Big Red Design Agency/Shutterstock

Climate hazards are also expected to put pressure on revenues by altering the demand base of the private sector. An increasing number of companies have been considering the impact of climate change on their own operations as climate risks impact their revenues through customer base loss due to displacement, changes in income, or supply-chain paralysis. The World Bank projects that by 2050, climate change may be a driving force for over 100 million Africans to migrate within their countries, away from areas with lower water availability and crop productivity or rising sea level and storm surges.

Additionally, climate change is expected to have an impact on the cost of financing and insurance, which may hamper the ability to fund growth. Over a third of the expected US$2.5 trillion increase in insurance premiums is likely to be driven by climate change. As critical assets and infrastructure are damaged, cascading risks could magnify the economic damage and fiscal impact of climate-related disasters, potentially making affected companies less attractive recipients of investment. The negative effect of physical damage could be exacerbated by a subsequent decrease in funding for recovery and future economic growth, due to perceptions of heightened risk. For example, flooding is expected not only to damage properties but also to raise insurance costs, affect the property values of exposed capital, and in turn reduce property tax revenue for communities, which could hinder socio-developmental gains.

Rising climate extremes are also expected to reduce the availability or increase the price of insurance, increasing the risk of financial instability. In Africa, insurance penetration is already very limited. The insurance market was valued at US$68 billion in 2018, with 80 percent of premiums concentrated in South Africa, and much of the rest in just a few countries, such as Egypt, Morocco, Nigeria and Kenya, mainly involving large corporations. Insurance premiums tend to be high for MSMEs, which in turn struggle to assess and provide insights into residual risk exposure and struggle to lower uncertainty.

Climate-risk assessments can help companies target their risk mitigation countermeasures. Leveraging different climate and socioeconomic scenarios, such as the reports by the Intergovernmental Panel on Climate Change (IPCC), companies can understand their exposure to hazard changes in frequency and intensity. Those must then be translated into direct and cascading operational, financial, and social impacts on companies. However, limitations and lack of granularity in climate and socioeconomic data can be salient bottlenecks in risk quantification. These limitations can range from sparse time series to complex circulation patterns, lack of locally relevant damage functions to assess vulnerability, or lack of asset values across the supply chain.

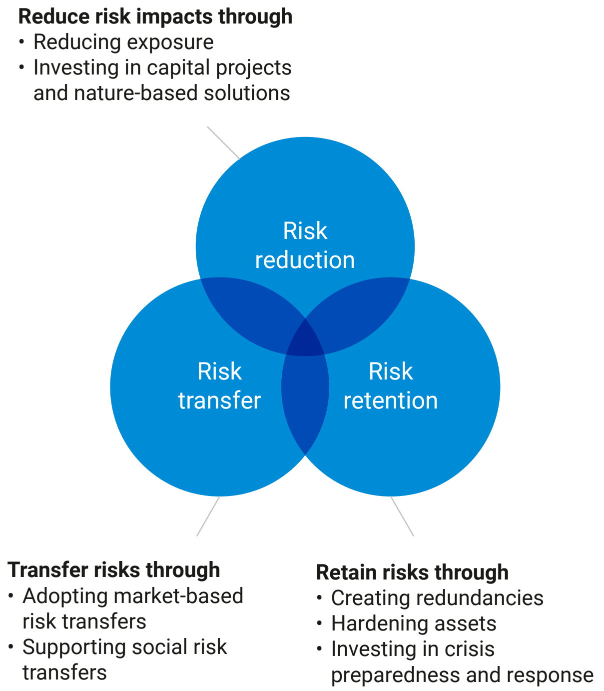
Recommendations

A range of adaptation measures to reduce, retain, or transfer climate-related risks can help private-sector companies navigate their exposure to climate change.

- When it comes to **risk reduction**, companies can reduce their exposure by relocating their sites or supplies away from high-risk areas. In addition, private-sector actors can invest in projects that strengthen the resilience of their capital and infrastructure against extreme weather and climate conditions. Further, the private-sector has additional opportunities to capture co-benefits and reduce its exposure to climate risks by investing in NBS. While it can be costly and take a long time to set up and generate substantial income, preserving ecosystems by leveraging Africa's vast NBS potential can generate added benefits such as an increase in biodiversity, access to the carbon credits market, and support for the security of local communities.
- Regarding **risk retention**, companies can take steps to create redundancies, harden assets, and invest in emergency response. Creating redundancies mainly includes developing distributed and diversified networks to avoid being reliant on a sole origination point for supplies. Hardening assets means fortifying them against climate hazards or developing new products and services that can sustain chronic and physical hazards.
- As far as **risk transfer** is concerned, private-sector companies can leverage different mechanisms. There is a wide array of available investment instruments, risk-financing mechanisms and broader finance-relevant solutions that financial actors are already mobilizing in support of climate resilience across Africa. Financial instruments can be used to finance activities that build physical resilience to climate change impacts, reducing physical risk, and can also be used to respond to risks where physical climate impact cannot or has not been eliminated. Risk transfer mechanisms can be designed to compensate climate-related losses if a contingent variable falls outside an established range (for example a predetermined drop in commodity prices).

In addition, companies could consider embedding climate-risk management into their governance, strategy and risk management processes.

Figure 9. Measures to Negotiate Climate-Related Risks



Source: McKinsey Global Institute staff

Access to Global Climate Finance—The Technical Assistance Program

Many African countries need institutional and technical capacity building with regard to planning for, accessing, and delivering climate finance, including when engaging with multilateral climate funds. To address the problem of the adaptation finance deficit in Africa, Pillar 4 of the Africa Adaptation Acceleration Program (AAAP) is focused on innovative financing. One of its core elements is a Technical Assistance Program (TAP) that aims to reduce barriers to large-scale access to multilateral climate funds in Africa and significantly increase the flow of adaptation finance to the region. This chapter aims to draw the first lessons learned after one year of implementation to measure the progress and achievements of the program, and to identify areas for improvement to achieve more significant impact and sustainability. To this end, the GCA conducted a series of semi-structured interviews using a questionnaire customized to the stakeholders involved in implementing the TAP, including National Designated Authorities (NDAs), officials from different ministerial departments, Accredited Entities (AEs), development partners, and GCA programs.

The needs of African countries for financing adaptation to the impacts of climate change are significant and cannot be covered by a single financial mechanism. Actions to close the adaptation financing gap must therefore target multiple sources, both public and private, international and domestic, while exploiting complementarities. Multilateral climate funds are catalytic in facilitating and accelerating financing in perceived high-risk adaptation projects by providing instruments like first-loss or junior equity, repayment guarantees, and grants to mobilize private investments. Given the central role of the Green Climate Fund (GCF), the unprecedented volumes of funding it offers, the range of financial instruments it provides, and its blended funding strategy, the TAP initially focuses on accessing GCF resources. This is especially true since the same capacity developed to access the GCF will allow access to any other multilateral climate funds. The basic requirements for accessing GCF funding include:

- **Having in place an ambitious and coherent national climate strategy/policy:** Funding requests submitted to the GCF must demonstrate alignment with national priorities.
- **Having in place an NDA and Focal Point:** NDAs are government institutions that provide broad strategic oversight of the GCF's activities in the country and communicate the country's priorities for financing low-emission and climate-resilient development.
- **Identifying AEs through which funding proposals are submitted to the GCF:** Direct Access Entities (DAEs) are to be endorsed by the NDA before applying for accreditation to the GCF.
- **Developing a pipeline of projects that fulfill GCF requirements:** Ideally/increasingly based on the GCF Country Program and relevant Entity Work Program.

Technical Assistance Program (TAP) for Access to Adaptation Finance

The TAP is tackling the main barriers that African countries face in accessing adaptation finance at scale. These include significant gaps in adaptation planning and decision-making; poor technical capacities for adaptation project development and implementation; and lack of valorization of the groundbreaking direct access modality. The TAP includes three inter-related components:

- Building capacities for adaptation finance planning and decision-making, laying the ground for a long-term partnership for adaptation finance mobilization and implementation.
- Strengthening direct access by facilitating new accreditations and supporting the upgrade of existing National Implementing Entities while ensuring complementarity with the international access modality.
- Promoting intersectoral, large-scale, and transformational adaptation projects and programs through inclusive consultative processes aligned with national and regional priorities.

All African countries are eligible for TAP, but in the interests of practicability, a gradualist approach is being adopted, starting with a small number of countries and gradually expanding to others. During the first year of implementation, the TAP has engaged stakeholders in about 12 countries, including Burkina Faso, the Democratic Republic of the Congo, Niger, Nigeria, Seychelles, Côte d'Ivoire, Senegal, and Ghana.

The GCA engagement strategy through TAP aims to foster country ownership and alignment with national priorities, laying the ground for a long-term partnership for adaptation finance mobilization and implementation. In addition, where practicable, GCA encourages the consolidation of isolated sectoral initiatives into large programs and pushes for the acceleration of ongoing processes in line with the objectives and approach of the AAAP.

Lessons Learned and Recommendations

Several African countries have requested GCA support for carrying out a Climate Public Expenditure and Institutional Review/Budget Screening (for example, Côte d'Ivoire and the DRC) or support for the development of a framework and systems for the monitoring, reporting, and verification of climate finance flows (Seychelles). These processes are at different stages of implementation.

Stakeholders and counterparts have found the TAP to be an effective program to create the conditions for improved access to adaptation finance and effective and transformative use of public climate funds, particularly GCF. The TAP core principle of country ownership has also been appreciated. Not only are the work programs built on national priorities, but more importantly, national counterparts are directly and entirely involved in the planning and implementation of activities. The program's openness to partnerships and collaborations was also identified as an asset.

Because the TAP program was launched during the COVID-19 pandemic, initial engagement with countries has been chiefly virtual, which has affected communications, coordination, and practical implementation. The implementation of the initial TAP projects has thus been delayed at times. Fortunately, the TAP is designed to be implemented progressively and flexibly. As lessons are learned, the approach and implementation arrangements are reviewed and updated for more significant impact and efficiency.

The issue of data is a crucial one, both in terms of availability and access. Through interactions with country counterparts, it was found that the confidentiality and sensitivity of some economic data may constitute a significant challenge when undertaking national budgeting and finance activities. Furthermore, the formulation of adaptation project concept notes was impeded by the availability of or access to climatic and socioeconomic data related to the targeted intervention areas.

The areas for improvement identified through interviews with TAP counterparts and partners include:

- **Maintaining a regular presence in partner countries:** The lack of human resources and the fact that institutions sometimes operate in silos can slow down or even compromise the implementation of activities. A presence in the field makes it easier to facilitate consultations between institutions and deal more effectively with deadlocks.
- **Prioritizing integrated multi-year work programs through cross-sectoral consultative processes and in coordination with other GCA programs:** This allows for a more programmatic approach to GCA intervention in each country. This also makes it possible to anticipate procurement plans and save time on recruitment.
- **Developing a roster of experts based on the different components of the TAP:** TAP interventions span multiple areas of expertise and having such a roster in place will save time in recruitment processes.
- **Strengthening partnerships with other readiness providers, with the GCF and the Adaptation Fund (AF) at the forefront:** GCA resources could be used as "seed money," allowing countries to quickly carry out initial studies needed to inform the design of funding proposals. In the same vein, GCA and these Funds could also collaborate on workshops to build the capacities of countries in the preparation of funding proposals. Finally, areas of collaboration could also encompass the piloting of the GCF's "Project-Specific Assessment Approach" (PSSA) once it is operationalized.

Implementing these recommendations should allow GCA to achieve the AAAP's objectives for the TAP program to leverage US$1.55 billion by 2025 through 15 adaptation and resilience projects and programs, with funding from public climate funds. It should also allow for getting six new DAEs accredited to the GCF and the AF, and two existing GCA DAEs having their accreditation standards upgraded.

Photo: European Union (photo by Anouk Delafortrie)/Flickr

SECTION 2—SECTORS

The Africa Adaptation Acceleration Program

The AAAP is Africa's response to the impacts of the climate crisis. This flagship program for Africa has been endorsed at the largest-ever gathering of African Heads of State and Government focused on adaptation. The AAAP delivers on the ground to support African countries for a faster, stronger post-COVID-19 economic recovery based on climate-resilient development pathways. Through AAAP, the AfDB and GCA are mobilizing US$25 billion by 2025 to accelerate adaptation action in Africa through interventions in four priority areas/pillars: food security, resilient infrastructure, youth entrepreneurship and job creation, and innovative climate adaptation finance.

The AAAP is an Africa-owned and Africa-led response to the continent's expressed needs and priorities to reduce its vulnerabilities to climate change as well as harness the opportunities that result from climate change. The AAAP is the translation of the Africa Adaptation Initiative (AAI) into actual projects and programs on the ground. More than 30 African heads of state and other global leaders have rallied behind the AAAP, endorsing it as a key vehicle to operationalize the AAI's mandate. The AAAP builds on the priority areas identified by the countries in their NDCs and NAPs and accelerates momentum through large-scale proof-of-concept investments, innovations, and knowledge and technical assistance initiatives.

AAAP's Four Pillars and Results Achieved as of End-June 2022

The AAAP focuses on four main pillars, and, within them, on specific business lines derived from the NDCs, NAPs, and other national and regional climate change strategies, where action is most needed, and where investments in adaptation and resilience building can yield high dividends to achieve the Sustainable Development Goals (SDGs). The four key pillars and their business lines are:

- **Agriculture and Food Security:** with a goal to scale up access to climate-smart digital technologies, and associated data-driven agricultural and financial services, for at least 30 million farmers in Africa. The program also has the aim of supporting food security in 26 African countries and reducing malnutrition for at least 10 million people.
- **African Infrastructure Resilience Accelerator:** with a goal to scale up investment for climate-resilient urban and rural infrastructure in key sectors such as water, transport, energy, and waste management to help the continent close the infrastructure gap and achieve sustainable development in the face of climate change. The program aims to integrate climate resilience into about US$7 billion worth of infrastructure investments.
- **Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience:** with a goal to support one million youth with entrepreneurship skills and job creation, and to ensure that millions of new jobs being created will support adaptation. The program supports developing skills and knowledge on adaptation, promoting equality and equal opportunities, building the entrepreneurial capacity of African youth, and facilitating access to funding and mentorship to youth-led businesses, half of which will be women-led, in the adaptation space.
- **Innovative Financial Initiatives for Africa:** with a goal to build the capacity of African countries to drive adaptation at a much greater scale by planning differently and accessing the key sources of adaptation finance. In addition, this AAAP pillar aims to support the design of innovative public and private financial instruments, ranging from resilience bonds and debt-for-resilience swaps to aggregation mechanisms for adaptation investment assets and monetization of adaptation benefits.

Since its launch in April 2021, the AAAP Upstream Financing Facility, managed by GCA, has enabled the mainstreaming of adaptation into investments worth over US$3 billion. GCA's interventions with the AfDB, World Bank, and other development partners are delivering high-yielding adaptation dividends and accelerating adaptation impacts through large-scale investments, innovations, knowledge, and technical assistance initiatives. The AAAP Upstream Financing Facility is aligned with the effective regional implementation of the new IMF Resilience and Sustainability Trust, the replenishment of the African Development Fund, and the leveraging of innovation and multi-stakeholder partnerships.

The AAAP Upstream Financing Facility

The technical assistance, policy advice, analytical work, and capacity-building work described in this chapter is supported by the AAAP Upstream Financing Facility housed in the GCA. This Upstream Financing Facility supports transformational adaptation shifts at the country level, the supporting research and monitoring for rapid extraction and replication of lessons, and the policy support to steer the economic directions at the national and regional level.

The AAAP Upstream Financing Facility aims to ensure with high confidence that all AAAP investments are as effective as possible and underpinned by the best data, science, and global practice on adaptation as managed by GCA teams. The GCA-administered Upstream Facility has an influencing funding leverage ratio of 1:100, meaning that every dollar invested in the Upstream Facility influences 100 dollars of resilient investments. In only 18 months of operation, the Facility has already helped prepare US$3 billion of AAAP investments. GCA is mobilizing US$250 million for this Facility over five years to bring the best global and local adaptation practice to every AAAP investment.

Future Plans for the AAAP

As GCA and partners gain experience through project implementation on the business lines, the intention is for GCA to evolve toward new challenges once partners mainstream the tools into their institutions and work programs. The AAAP aims to evolve constantly as African countries' priorities and financial needs are further refined. For example, under the Climate-Smart Digital Technologies for Agriculture and Food Security (CSDAT) pillar, the AAAP will continue to provide technical assistance to identify digital tools to support the mainstreaming of adaptation into investment projects of international financial institutions (IFIs) dealing with agriculture; use the experience gathered so far from ongoing projects to launch new project interventions and partnerships as may be appropriate in the Central and North Africa region; and initiate steps to expand the range of IFIs by engaging in discussions on new projects with other IFIs and DFIs, such as the International Fund for Agricultural Development (IFAD) and the French Development Agency (AFD).

Under the African Infrastructure Resilience Accelerator pillar, the Infrastructure and NBS Program and the Urban and Water Programs will continue to provide technical assistance and capacity-building support to integrate climate adaptation and resilience into infrastructure projects across the African continent. Building on GCA's experiences in Ghana and Bangladesh, the national infrastructure risk and resilience assessments will be scaled up to other African countries, starting with Kenya and Senegal. These national programs will support the prioritization of adaptation investment options to be financed by implementation partners such as IFIs, development partners, and climate funds.

The City Adaptation Accelerator will continue to expand and, based on these learning opportunities, develop a set of tools and methodologies to support urban resilience building. Examples of these tools are: the Locally Led Adaptation Toolkit for Urban Informal Settlements, the Rapid Climate Risk Assessment, the investment prioritization tool, and the climate vulnerability assessment. A similar strategic framework will be developed for the Water Program.

The AAAP will work with MDBs to integrate adaptation and resilience, focusing on NBS, into downstream investment projects. The portfolio will be diversified to further include projects in transport and logistics, urban infrastructure services, infrastructure for agriculture services, renewable energy, and information and communications technology (ICT). This will include the development of innovative solutions in disruptive technologies for infrastructure solutions and in the structuring of NBS investment cases. Further, the Masterclasses on Climate-Resilient PPPs will be scaled up through local institutions to ensure sustainability and reach a wider audience over time while supporting capacity building for AAAP projects.

GCA is gradually expanding its partners, such as the AFD and other financiers, to influence and scale up the mainstreaming of climate adaptation. The AAAP will also have closer interaction with the GCA Research for Innovation team and, through them, with academia to bring the latest science and learning into the AAAP programs. GCA is also calling for partnerships through which the upstream activities of the AAAP will be delivered. This is targeted at African, not-for-profit institutions with an excellent track record of working in the field of Africa's climate change adaptation and resilience.

The AAAP has been set up to serve as a vehicle to mobilize US$25 billion of adaptation investments in Africa. Drawing from this practical experience, GCA will work with partners to scale up the model of AAAP to other regions in the world, including South Asia and Small Islands and Developing States. Also, through the Global Hub on Locally Led Adaptation, GCA seeks to work with institutions that have experience in successfully promoting and scaling up LLA.

Livestock

Livestock plays a crucial role in the economic and social life of Africa, supplying meat and milk for food and commerce, generating a large part of household incomes, fulfilling many functions, and occupying a range of niches within both pastoral and mixed crop-livestock systems. They are especially crucial to smallholder farming and therefore deserve a special focus when it comes to adaptation.

This chapter describes the importance of the livestock sector for Africa; presents the impact of climate change on livestock; presents some of the most promising technical interventions to strengthen adaptation and resilience in the livestock sector; and estimates the cost of adaptation inaction and action in livestock.

Challenges

Livestock accounts for around 55 percent of total household income in pastoral systems in Africa and 35 percent for mixed crop-livestock systems, where animals are also used for tasks like plowing. Rising temperatures, changing precipitation patterns, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa's livestock farmers. Modeling studies suggest that under higher GHG emission scenarios, global cattle production losses from heat stress alone could amount to nearly US$40 billion per year by 2085—equivalent to 9.8 percent of the value of production of milk and meat from cattle in 2005. Under lower


Photo: 001slide/iStock

emission scenarios, losses could amount to nearly US$15 billion.

Rising temperatures, changing patterns of precipitation, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa's livestock farmers. This will not be achieved by a single strategy, but a combination of different interventions. These will include developing breeds that are better adapted to high temperatures, new disease threats and other challenges; matching stocking rates with pasture production; improving the quality of diet; and changing management practices.

The supply of livestock feed will need to adjust to a changing climate. As it is inherently adaptable, options do exist. The major macronutrients required by livestock can come from a range of sources and the feed industry is accustomed to adjusting based on the availability of different commodities. Changes in the climate will inevitably make such adjustments more commonplace in future. For example, shifts from maize to dryland crops such as sorghum and millet will lead to differences in the mix of crop residues available for livestock.

Recent advances in precise phenotyping, genotyping, and related molecular technologies have huge potential to improve the yield and nutritional quality of livestock feed, enhance disease resistance, and improve drought tolerance of forage species. Ongoing breeding efforts are already targeting resilience, and these will need to be intensified. For example, breeding programs will increasingly need to focus on drought tolerance.

Harvesting and managing rainwater can increase water availability and help to maintain feed and forage productivity during the dry season. Small-scale irrigation has enormous potential to smooth seasonal deficits in feed supply and increase overall feed availability in smallholder systems in tropical regions, provided such irrigation is managed sustainably.

The seasonal scarcity of feed supply already poses significant problems, particularly in tropical latitudes, and this is likely to intensify with the increasing incidence of drought and less certainty in growing seasons. To counter this, better feed conservation and storage methods are required, including better use of hay and silage. Creating denser feeds will facilitate storage and transport.

Feed production potential varies both temporally and spatially. It is influenced by agroecological conditions such as temperature and rainfall and this can lead to feed being abundant in geographic zones where livestock production is unimportant. Obvious solutions to this mismatch include the transportation of feed, and its storage for use in periods of scarcity. However, this can be challenging in places where there are poorly developed livestock feed value chains, a lack of business skills, and a lack of mechanization for processing feed. Interventions to enhance feed business development could significantly improve the resilience of livestock production systems to the effects of climate change.

The most direct impacts of climate change can affect the capacity of animals to ward off infection. For example, heat-stressed animals are less productive and have weakened immune systems, although this varies by breed and species. With severe heat stress, mortality can increase. Heat stress can also decrease reproductive capacity and milk yields. Simple interventions to keep animals cool include shelter from roofed sheds or trees; these can be easily incorporated into current mixed and extensive systems. The distribution of disease vectors and pathogens will change significantly with new precipitation patterns and temperatures.

Adaptation of livestock will require a combination of different interventions, some having to do with livestock themselves (breeding, pest management) and others about land management and the development of financial instruments to deal with climate risk.

Although livestock is a key component of mixed crop-livestock systems, most climate change adaptation work has focused solely on the crop side. There is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa. The research base required for building climate-resilient livestock systems is underdeveloped and needs greater support.

A few adaptation actions of direct relevance to livestock systems include implementing early-warning systems (EWS) and adaptive safety nets for farmers in climate-risk hotspots and taking climate services to scale by connecting millions of farmers and agribusinesses to ICT-enabled bundled advisory services by 2030.

Recommendations

- Building climate-resilient livestock systems to cope with climate challenges requires concerted, coordinated action from investors and policymakers at the national and global levels. This will need to be informed by a solid research base that scientists have only started to assemble with the minimal funds allocated so far.
- Researchers need to develop a toolbox of effective adaptation practices, technologies and policies that are robust across different scales, priorities, and climate futures. They must also work with funders and governments to prioritize investments in the livestock sector. It is not just technical inputs that are needed, but institutional change in the way that livestock is viewed by funders and governments. This will require a considerable evidence base. And this evidence and technical support are also needed to enhance monitoring and reporting for national, regional, and continental planning.
- Build capacity at national levels to understand how to prioritize interventions for the livestock sector across development and climate change planning.

- Develop policy to allow livestock development strategies that support rural development and contribute to a restoration economy, including the development of national policies and mechanisms to allow for carbon credit trading and benefit sharing for communities that implement rangeland restoration practices.
- Design and update national and subnational animal feed strategic plans and strategic feed reserves; support predictive livestock EWS and early warning-early action approaches, including for disease; establish feed inventories and feed stores; and promote the establishment of intercommunity landscape grazing plans and natural resource management plans at community and farmer level.

Innovation in Agriculture

More than 60 percent of people in Sub-Saharan Africa are smallholder farmers, and nearly a quarter of Africa's GDP comes from agriculture. Climate-smart agriculture is an integrated approach to managing landscapes, including cropland, livestock, forests, and fisheries, that addresses the interlinked challenges of food security and climate change. Agriculture and land-use changes contribute 25 percent of heat-trapping GHG emissions. Without interventions, this number will likely increase. However, agriculture can also be part of the solution to climate change, with the potential to offset and sequester about 20 percent of annual emissions through improvements in soil management.


Photo: 2016CIAT/GeorginaSmith/Flickr

While the Green Revolution had positive impacts on food security, there were uneven outcomes for human nutrition, crop resilience, and the environment. As a consequence of the focus on staple grains and the adoption of expanded irrigation, the major benefits were in Asia, while Sub-Saharan Africa received fewer investments, particularly in orphan crops.

Challenges

The combination of changing consumer needs and demands coupled with climate and environmental challenges is accelerating the transition to a new way of thinking about agriculture. Meeting these needs and challenges will require a whole-system approach, involving the sustainable intensification of agriculture to increase productivity while minimizing environmental impacts through increased resource-use efficiency.

Advances in breeding technologies and tool development are allowing improvements for multiple traits in the context of overall crop productivity. The extension of these tools to underserved crops that are climate-resilient will be key to meeting future climate adaptation goals.

The wealth of genetic diversity available in public germplasm repositories, including CGIAR genebanks, can provide the basis for improving existing crops, as well as developing new crops, to meet specific and local climate adaptation needs. This will allow a move away from reliance on a few intensively farmed grain crops for food security to a broader collection of climate-resilient crops that includes a greater representation of legumes for smallholder farmers.

Livestock is an important component of any climate-resilient agricultural strategy, accounting for 40 percent of the global value of agricultural output and directly supporting the livelihoods and nutritional security of 1.3 billion people. More than 500 million pastoralists worldwide depend on livestock as a means of income, food security, and asset storage.

These pastoralists are among the most vulnerable to climate change. Conversely, the livestock sector emits an estimated 7.1 gigatons of CO_2-equivalent per year, representing 14.5 percent of human-induced GHG emissions. Improving the efficiency and resilience of livestock supply chains is key to both limiting the growth of GHG emissions and protecting the food security and livelihoods for billions.

Many strategies exist to both minimize the climate impact of livestock and to improve climate adaptation of the livestock sector. Enteric methane produced by livestock is a significant source of GHG emissions. Work to mitigate the sector's emissions is under way through the development of technological solutions, developments in feed additives, and genetic efforts to develop lower methane-producing livestock breeds. Meanwhile, livestock animals are particularly at risk from pests and diseases whose ranges are expanding with climate change. Advances in vector control, vaccines and antimicrobials, and veterinary epidemiological monitoring systems are all under way to help mitigate these emerging threats.

Photo: U.S. Air Force (Senior Airman Kaitlyn Johnson)/Flickr

Capacity building for climate-smart agricultural practices will require incentives and innovative finance mechanisms to lower the upfront cost barriers to adopting new practices and minimize the risk exposure—real and perceived—of smallholders as they adopt new production systems.

Recommendations

Capacity improvements are needed across the whole agricultural value chain if the challenges of climate change are to be met. However, there are some key intervention points that could have immediate impacts on existing strategies:

- Advances in breeding technologies and tool development are allowing improvements for multiple traits in the context of overall crop productivity. The availability of these tools needs to be expanded to underserved crops that are climate-resilient, including the diverse germplasm available in public genebanks.
- A major barrier to expanding digital agriculture is the lack of investment in rural agricultural infrastructure as well as insufficient investment in research and development, agro-innovation (for example, in sensor development) and agricultural entrepreneurship. Expansion of broadband internet availability is needed to support data collection, forecasting, and dissemination of real-time information.
- Filling in gaps in digital data for areas like soils will be important for farmers to be able to access more precise forecasts and solutions to potential climate-related challenges.
- Bundling of digital services is needed so that farmers can receive information as well as possible courses of action, from sources of seed to fertilizers, and funding.
- Improved networking is needed for stakeholders on the research side with downstream users, from extension agents to farmers. As climate-related challenges intensify, the existing tools will need to be adapted and improved to include the information that farmers need to make decisions about what to plant, when to plant it, and what inputs will be needed.
- There is a need for regional networks of scientists such as plant breeders to share knowledge, tools, and equipment, as well as innovative approaches for sharing resources.

- Innovations in energy services to farms are an integral part of adaptation, as energy access sustains the productivity of farmers and herders and serves many other adaptation areas.
- Increased alignment of different sectors on policy, financing, and strategy will be essential to successful implementation of climate-smart agriculture strategies to ensure the resilience of and sustainability of agricultural systems as the impacts of climate change increase.

Incentives will be needed to promote adoption of new climate-resilient strategies. Fostering an enabling environment for the update of these strategies will prove to be a critical step, with a conscious effort needed to link climate-resilient policies, science, and food security within national agricultural implementation schemes.

Effective capacity building will also require a focused gender lens. Women account for about half of the world's smallholder farmers and grow 70 percent of Africa's food. As they are the majority food producers on the continent, research and innovation must keep women as the primary target audience. Any mechanism designed to improve capacity through climate-resilience practices and investments or through the wider enabling environment must prioritize their needs and preferences. Implementation efforts, likewise, must ensure gender-equitable access to new technologies and products to avoid exacerbating gender-based inequalities.

Innovative finance mechanisms are another area for innovation to help farmers and businesses adopt climate-smart practices and technologies. Often the upfront costs, real and perceived, of new practices can prove a roadblock to adoption and implementation while risk mitigation remains a major concern both for businesses and farmers. Finance mechanisms, like innovative insurance or credit programs, that build onto existing financing arrangements with producers will aid in end-user adoption of climate-smart practices and tools.

Advisory services play a critical role in educating farmers and producers on use and adaptation of new technologies. As such, expanded capacity is needed among climate-smart advisory services as a key intervention to help farmers in their transition to more resilient practices and systems. Effective capacity building among climate-smart advisory services in turn allows for the effective distribution of the climate-smart practices and technologies discussed above and is a requisite step in ensuring effective uptake of these innovations and practices by end users.

However, it is important to emphasize that incentives, capacity building, finance, and advisory services may not be sufficient. Numerous programs have failed despite being motivated by good intentions to bring innovative technologies to farmers and herders. It is fundamental to understand preferences, co-create solutions with users, and utilize behavioral science to increase the chances for success in the use at scale of these innovations.

Urban Informality

Sub-Saharan Africa is both the poorest region in the world and the one that is urbanizing most rapidly. Yet Africa's rapid urbanization at low levels of national income, combined with insufficient structural transformation, has also brought major challenges.

This chapter addresses these challenges at the intersection between informality in housing and employment, and climate change adaptation. Following a brief review of the economic and political forces perpetuating the informal city, the chapter presents a discussion of the threats that advancing climate change poses for communities of people living and working informally. A framework is articulated that illustrates the links between climate change threats and informality while also delineating the necessary interventions to address these threats. In doing so, the framework emphasizes that political economy (dis)incentives and limited state capacity impede countries in moving from statements of intent to implementing new policies that would create a more equitable and sustainable city for all. The framework is illustrated with a case study of Accra, Ghana, which epitomizes the challenges of many of the region's urban agglomerations struggling to manage informality and climate change.

Challenges

While informality in employment and informality in housing have different causes and consequences, they are interlinked phenomena with a similar underlying origin: low income. Typically, they operate with little organization and on a small scale. Earnings depend on income after costs of production; they are commonly called "nonwage earnings" or gross profits. In Africa today, about 65 percent of total employment is in the informal sector.

Most African countries are in transition from a mostly informal to a mostly formal economy, but at a disappointing pace. Importantly, Africa's urbanization is not following the historical pattern of today's higher-income countries, where industrialization and the creation of larger formal firms in urban areas fueled urbanization by increasing demand for labor, pulling the working-age population from rural areas and towns into emerging cities.

Most African countries have not been able to match the share of employment or value addition from formal firms that today's high-income countries had at African levels of urbanization. As a result, new wage jobs are not yet employing the majority of the labor force in African cities. The reasons for the African pattern are complex, and include both the natural resource curse, which induces industrialization but does not create formal jobs outside the private sector; and globalization and technology, which make it harder for late industrializers to develop a job-creating manufacturing sector. As a result, both migrants from other parts of the country to Africa's larger cities as well as urban natives are forced to create their own employment by starting a business in the informal sector. Regardless of which factors dominate in a particular context, the important point is that the informal sector is not likely to disappear soon.

A critical factor reducing the supply of informal housing in African cities is a lack of clear and uniform property rights and a well-functioning land market with low transaction costs. Insecurity of tenure, especially in slums that started out as squatter settlements, usually precludes the provision of public urban services such as utilities, garbage pick-up, roads, and even safety. Either the formal legal system or the policies of public utilities may prohibit service provision. But even if a slum is a legal development of an indigenous community, it is often unfeasible for public utilities to provide services because roads and pathways within a slum are not wide enough or suitable for utility infrastructure.

Photo: Moehring/Shutterstock

Our research highlights the need for transformational change within urban areas to meet the coming climate challenges, and to avoid locking in unsustainable practices. In cities such as Accra, with overlapping mandates for action but weak accountability structures, envisaging the planning, financing, and implementation process for transformational change is difficult. Some climate adaptation plans, such as Accra's Resilience Strategy, do articulate objectives and intentions toward the transformational, and recognize the needs and rights of the informal city. But actual transformational change in the current political and economic environment, where informality is often seen as being undesirable and/or illegal, the value of the land where informality takes place continues to rise fueling land contestations, and alternatives to informality are mostly not available, seems improbable. And, if a transformative process does start, it seems unlikely to be inclusive of the needs of the informal city. A deteriorating fiscal environment in African countries such as Ghana limits financing for needed public investments in urban services, further constraining implementation of NAPs.

Local governments within the Greater Accra Metropolitan Area (GAMA) are closer to their citizens' needs. The entities have been assigned many of the responsibilities for the planning, project development, and implementation that effective adaptation strategies involve. Yet these entities have neither the funds nor the capacity to undertake these responsibilities. Thus, plans and frameworks articulated by the national or regional government mostly represent unachievable intentions. This problem is replicated in other African cities, with variations dependent on the degree of decentralization of power and money.

It may be that the most inclusive approaches in the short to medium term will involve minor, low-cost, *in situ* adaptation investments, and increased coping measures. As the example of Accra shows, simply advancing proactive climate change–induced disaster planning could benefit city residents living in communities of informal housing who work on the street or at home. Partnerships between a leading national ministry, the GAMA regional coordinating administration, the Accra Metropolitan Assembly (AMA), and community groups for the purpose of effective disaster management could produce results if they were focused on a limited set of coping outcomes.

Actually recognizing land rights in slums and the right of the informal sector to occupy urban spaces in order to work would itself be transformational, even if it is only step one on a long path toward adaptation. The problem for African cities, especially ones such as Accra and Nairobi, where land rights are highly contested, is that the time clock on climate change is advancing, not slowing. The cost of the current inertia is therefore rising.

City Resilience

Underpinning all climate adaptation solutions—from climate-adaptive planning and infrastructure investment to service delivery, community development, land management, and NBS is a solid sense of the current climate risk context. Cities, especially, are where this downscaled knowledge is needed to inform the prioritization, design, implementation and operations and maintenance (O&M) of localized action.

While climate risks and vulnerabilities abound in African cities, there nevertheless remains a unique opportunity to get things right, as much of Sub-Saharan Africa (approximately 40 percent) remains in the early stages of urbanization. Understanding the climate risk of current and future development through climate-risk assessments can provide the basis for identifying, prioritizing, and implementing low-cost actions that can prevent locking in errors made by other highly urbanized regions of the world. Thankfully, working toward resilience is not cost-prohibitive. Some estimates suggest designing more resilient assets in the energy, water and sanitation, and transportation sectors in low- and middle-income countries would amount to an additional 3 percent in costs.

It is in this context that GCA has developed and implemented its Rapid Climate Risk Assessment (RCRA) methodology, in response to the strong need and demand in Africa's rapidly urbanizing cities. An RCRA for a city gathers key information on climate hazard and risk, the development context, infrastructure bottlenecks, past and current initiatives as well as relevant policies and institutions. To keep costs down and to better ensure time efficiency, the approach relies heavily on globally available free data.

Summary of Resilience Assessments in Five Cities

In its first round, GCA has implemented RCRAs in (a) Antananarivo, Madagascar; (b) Bizerte, Tunisia; (c) Conakry, Guinea; (d) Dodoma, Tanzania; and (e) Libreville, Gabon. The most noteworthy findings from each city resilience assessment, with key takeaways, are summarized in Table 1.

Table 1. Summary Comparison Table of Five African Cities

Factors	Antananarivo	Bizerte	Conakry	Dodoma	Libreville
Population	~3–4 million inhabitants	~150,000 inhabitants	~1.6 million inhabitants	~580,000 inhabitants	~850,000 inhabitants
Key Attributes	Capital city; swampy plain bordered by hillsides	Secondary city; coastal city with extensive shoreline	Capital city; coastal city situated on low-lying wetland peninsula	Capital city; low density; semi-arid plain with highly impermeable soils	Capital city; coastal hilly city with developments in marshy valleys
Informal Sector	~70%	Unknown	~67%	~67%	~80%
Key Hazards	Floods; landslides; increasingly frequent droughts and cyclones	Floods; sea-level rise; coastal erosion; wildfire; drought; water scarcity and salination; extreme heat	Floods; sea-level rise; coastal erosion; cyclones; water scarcity	Extreme heat; drought; water scarcity; floods	Extreme rainfall; floods; sea-level rise and coastal erosion
Key Risks	Displacement and loss of lives; food insecurity; damages to buildings and infrastructure; negative health; increased rural-to-urban migration	Loss of economic assets and activity (e.g. beaches and tourism, fishing); damage to buildings and infrastructure; adverse health outcomes	Loss of economic assets (e.g. land, beaches); increased water scarcity; destruction of ecosystems and fisheries; adverse health outcomes	Loss of agricultural productivity, soil fertility and incomes; increased waterborne disease; adverse health outcomes; food shortages	Damage to infrastructure; displacement; post-flood disease; adverse health outcomes
No-regrets Measures Identified	Strengthening adaptive capacity; disaster evacuation planning; climate-resilient water and sanitation infrastructure; nature-based flood risk reduction	Stormwater drainage management; rainwater-harvesting; resilient urban planning; resilient mobility; sustainable forest management	Climate-resilient urban and land-use planning; nature-based solutions; stormwater drainage management; improved sewerage and solid waste management; water management; coastal protection	Climate-resilient farming and water management; improved solid waste management; urban greening; climate-resilient infrastructure; flood defenses	Flood prevention; improved solid waste management; climate-resilient water and sanitation infrastructure; urban greening
Institutional Mandates for Climate Adaptation	Strong	Medium	Limited	Medium	Limited

Recommendations

- **Recognize the value of qualitative data.** RCRAs found that generating any kind of data (even qualitative) is better than no data at all. Using an RCRA opportunity to ask consultants/firms to gather as much qualitative data as possible can be useful to help provide more context to inform existing and future quantitative work. The efficiency resulting in doing a desk review further ensures that future analytical work builds on what is already there. Thus, dedicating time to mapping the literature can prove a huge efficiency gain, and should be commended for its contribution in itself. Often, the information resulting from an RCRA is sufficient to begin project scoping within a city, whereby challenges are identified that can be further investigated during project identification and prioritization. By mapping the gaps and prioritizing need, future, more in-depth engagement can be better tailored, based upon strategic need. This can be pursued in a future, more in-depth, focused and strategic climate-risk assessment.

- **Consult and bring on board entities that have public investment decision-making power, early in the process.** This ensures that the needs, incentives, and challenges faced in infrastructure investment can be better reflected in an RCRA meant to inform actual investment. Getting the buy-in of investment-able entities further helps ensure findings from RCRAs continue onto more long-term outcomes.
- **Conducting RCRAs where there is strong local government appetite for investment can be a critical enabling factor for a well-informed assessment.** The success of an RCRA process is often best enabled when there is a strong local champion, who can help in framing the local context as well as making the time within their already full work program to secure the contacts and clearances needed to secure information and data. This is often the case when the local municipality in itself is interested in seeking climate adaptation investment. Even during the process of procuring consultant services, GCA can begin discussion with local municipal counterparts about data requirements, so that the process of securing data is more advanced by the time the consultant is contracted. Often data can be made available for free, provided that there is enough notice. A strong local champion within the municipality can also help in the generation of data.
- **Informality represents a significant portion of urban economies in the developing world and must be understood if climate adaptation activities are to be effective.** Experience from the RCRA process has demonstrated the importance of identifying a socially focused focal point early in the process (e.g. a university, researcher, NGO, social development organization, local knowledge institute) that can be useful in answering questions pertaining to informality or making the contacts needed to gain this perspective. A semi-structured interview with a well-informed set of socially focused counterparts can serve as a critical input to an RCRA—to at the least get a finger on the pulse of critical items to consider when mapping hazard and risk (and their potential effects and impacts on the informal economy).
- **Dedicate time and space for reflective learning and experience exchange:** Taking a dialogue and learning approach can increase connectivity of the city actors to fit the new climate realities. The connections do not necessarily need to be solid or formal, but climate adaptation works across sectors and line budgets, and coordination and collaboration are needed to pool resources and efforts. For example, many of the recommended no-regret measures (e.g. cleaning up drainage from improved waste management) are part of existing measures in a city, and often not traditionally identified as climate adaptation; the RCRAs provide an important opportunity for providing an additional rationale to prioritize these actions on the urban agenda, as they contribute to resilience. As such, the RCRAs can provide a mandate for increased coordination and dialogue across sectors, benefiting existing actions on the sustainable development agenda such as climate-adaptive waste management.

Moving forward, the GCA RCRA methodology has been further fine-tuned based upon implementation experience shared by both the supervision team and firms. These changes will be reflected in the implementation of GCA RCRA methodology in a second batch of African cities.

Nature-based Solutions in Agroforestry

This chapter reviews a particularly important category of NBS for Africa: agroforestry. It presents a deep dive into agroforestry as NBS in Africa, with a specific review of lessons learned from programs that did not achieve their full potential. It also proposes institutional and policy changes needed to make agroforestry an effective solution to climate adaptation and multiple other benefits.

NBS are being applied widely across Africa including in water security, human health, livelihoods, disaster risk reduction and climate change mitigation and adaptation. They are a core component of the AAAP, the Green Cities Initiative, and the West Africa Coastal Areas Management Program (WACA). There is a huge potential for NBS in Africa. NBS are best planned at a landscape scale and designed to meet critical needs both now and under future climates. NBS also tend to create job opportunities

Photo: P. Kimeli (CCAFS)/Flickr

for local people and encourage local ownership of the outcomes.

NBS can be combined with "hard" interventions such as re-contouring landscapes or canal construction to assist in managing water flow (these are often called green-grey solutions). The important point is not to jump immediately to an engineered solution to the problem, but to integrate both green and grey solutions from the outset, while also looking more widely at actions that will provide additional benefits to communities and help maintain biodiverse and healthy ecosystems.

Agroforestry, a land management practice where trees are grown around or among crops, pastureland or homes to provide shade, shelter, fertilizer, fuel, food, fodder and other products, is an important NBS that fits well with African farming systems, skills and livelihoods. Many have simply called for more agroforestry and the planting of more trees. But agroforestry solutions must be carefully tailored to location, to existing livelihoods, community skills and priorities, and to local markets.

Despite lamentably poor financial support African scientists are tackling questions of finding the best solutions—site selection, farming system, species selection, etc.—but there is a need to blend this knowledge with that of communities to find solutions that fit the physical location and the communities' priorities. This requires a true co-production of solutions. This will require new modes of continuous learning, better mechanisms for financing multiple agroforestry projects, and possibly re-creating forms of governance based on traditional multilayered structures rather than the currently dominant top-down structures. Many smallholders will also need external knowledge and financial support to make the transition from their current practices and turn to or retain cropping systems integrated with natural resources.

It is essential to continue building the case for NBS as a critical adaptation measure, to set goals, and to seek financial support. However, it is equally important to mobilize the necessary support to identify which actions are cost-effective and most beneficial for both the farmers engaging in NBS and the ecosystems on which they are based. There are many examples of poorly designed efforts that are likely to undermine the goals of development, biodiversity maintenance, mitigation and adaptation.

Each type of project (agroforestry, catchment protection, barriers to desertification, or cooling villages and even cities) and each region will need to ask local questions of how to match an NBS with the needs and skills of local communities, as also questions such as where to establish agroforestry and where to conserve or regenerate forests, and what type of plantings and with which species. To answer these questions traditional and local knowledge must be brought together with wider scientific knowledge in a true co-production of workable solutions.

Blue Economy

The Blue Economy of coastal countries in Africa is critical for their development. The potential of sustainable and integrated management of coastal and marine resources can be immense in areas such as job creation, poverty elimination, and prosperous coastal urban and rural development. The Blue Economy includes critical sectors such as tourism and fisheries, and holds enormous potential for future sectors such as blue energy, ocean mining, and blue carbon. According to the African Union, the Blue Economy of the continent generates nearly US$300 billion and supports 49 million jobs.

However, Africa's Blue Economy is currently facing enormous challenges, from overexploitation of fisheries to coastal erosion. The pollution and the loss of coastal and marine biodiversity are putting substantial pressure on economic sectors that depend on a healthy environment. This chapter reviews the climate risks to the African Blue Economies, the status of Blue Economy strategic development in African countries, and adaptation measures necessary for the sustainable development of African Blue Economies.

Institutional Development of Africa's Blue Economies

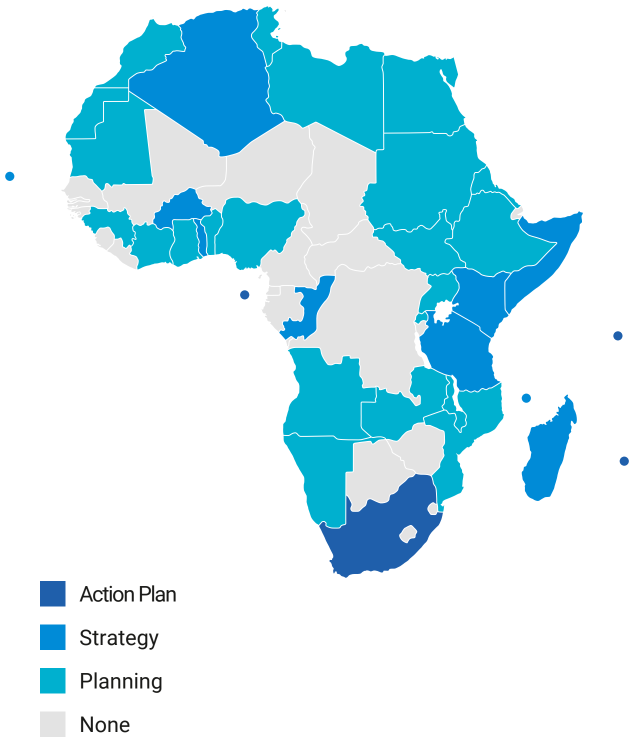
For this chapter, the status of institutional development of Blue Economies in Africa was analyzed. The analysis showed that 10 coastal countries have no strategic or policy documents guiding their blue economies. An additional 16 countries have indicated that they intend in the future some form of Blue Economy planning or policies. This means that, in total, 26 of the coastal countries, or about two-thirds, have no formal strategies or policies on their Blue Economies. Eight countries have drafted and published official Blue Economy strategies, and only four additional countries have drafted action plans for their strategies. No African

Photo: Salvador Aznar/iStock

country has a holistic Blue Economy policy passed into law, with regulatory tools for Blue Economy development over the long-term future.

The assessment also shows that the island nations of Seychelles and Mauritius are the most advanced in their institutional approach to the Blue Economy, given the significant role in the overall economy. Both nations have an active Blue Economy coordinating unit (the Ministry of Fisheries and Blue Economy in the Seychelles, and the Ministry of Blue Economy, Marine Resources, Fisheries and Shipping in Mauritius). Few countries in Africa have put systems in place for blue financing, the most developed of which is the Seychelles.

Figure 10. Institutional Status of the Blue Economy in Coastal African countries as of June 2022



Source: Authors

However, regional and overseas bodies have played a notable role in supporting Blue Economy development across the continent. The United Nations Economic Commission for Africa (UNECA) was instrumental in the drafting of the Blue Economy strategies and action plans of several African states. Furthermore, it has pioneered the construction and application of the Blue Economy Valuation Toolkit in African countries. The African Union has developed and promoted a Blue Governance Framework for the implementation of the African Blue Economy Strategy. Several African Regional Economic Communities (RECs) have drafted Blue Economy strategies. As the natural resources critical to blue economies (e.g. river deltas, large marine ecosystems, and fish stocks) are often shared by several countries, RECs have a unique opportunity to contribute to shared resource management and encourage such management to follow sustainable Blue Economy principles.

Adaptation in Blue Economy Policies

The most important approaches to enhance adaptation of Blue Economies include climate-informed coastal and marine spatial planning (MSP); protection of marine and coastal ecosystems; and rehabilitation and restoration of marine and coastal areas.

For the 12 African coastal countries that are implementing Blue Economy strategies or action plans, two (Mauritius and Seychelles) recognize the severity of climate change and have practical activities for adaptation. Four countries (Algeria, São Tomé and Príncipe, Somalia, and Togo) have some planning for adaptation responses included in their Blue Economy action plan or strategy. Four countries (Comoros, the DRC, Madagascar, and Tanzania) recognize the threats of climate change and the need to respond accordingly but have little to no planning or activities in place to do so.

When looking at NDCs, there is a general tendency of these documents to focus more on land-based spatial planning than marine planning, despite most countries recognizing the potential devastating impacts that ocean-related climate change impacts could have on the environment and people.

In sum, Blue Economy development varies considerably across Africa. There are however countries with excellent progress toward climate-smart Blue Economies that include drafting and implementation of strategies and action plans in areas such as spatial planning and MSP; protection of marine and coastal habitats; restoration, NBS and ecological engineering.

Photo: Africanway/iStock

Coastal Erosion

Coastal erosion is the result of several processes that occur naturally, typically driven by the combined action of waves, currents, wind, tides, and mass wasting processes. As a result, some sections of the coast are gaining land (accreting), while others are losing land (eroding). Coastal erosion is exacerbated by the effects of anthropogenic climate change, namely sea-level rise and an increase of waves and extreme events. It is also harshly impacted by human activities such as sand mining, development of coastal infrastructure, inland river damming, and mangrove removal, all of which can significantly alter natural processes.

This chapter focuses on adaptation to coastal erosion in two regions of the African continent: West Africa and North Africa. These regions, specifically from Mauritania to Gabon in West Africa and the Maghreb in North Africa, were selected since they are experiencing most of the coastal area changes adjacent to seaports observed in the continent. It presents a deep dive for the two focus regions, including the state of the coast and intervention examples.

Challenges

Coastal erosion rates on the West and North African coast are among the fastest in the world. Africa's coastal zones are highly vulnerable to these changes because of the presence of extensive and densely populated low-lying deltas with poor planning, limited levels of protection, and minimal EWS.

In West Africa and North Africa, anthropogenic pressures are the main drivers of coastal erosion, primarily due to the presence of large ports and river dams. Africa's ports are tremendously important as drivers of Africa's economic growth, but their activities could negatively impact Africa's coast and ecosystems if appropriate care is not taken. Many African deep-water ports were built without sufficient considerations of the potential impacts to adjacent communities and ecosystems. The lack of adaptation over the years has resulted in creating significant hazards for people, the built environment, and infrastructure, and the natural environment.

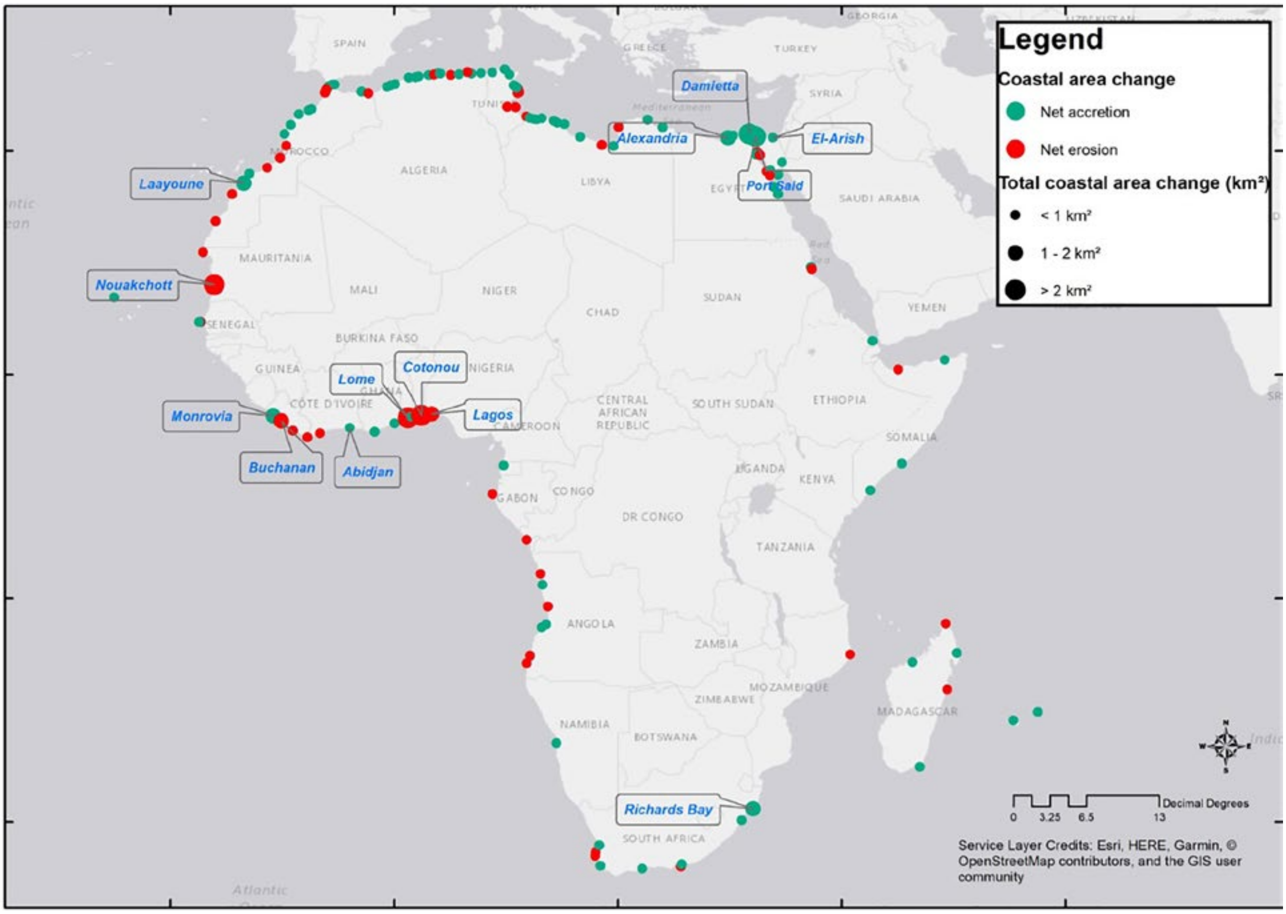
At least 13 large ports in Africa are characterized by severe erosion on beaches adjacent to them. Most of these ports are in the West and North Africa region, located in open coastlines with significant alongshore sediment transport, and represent the top 10 percent hotspot ports in Africa, in terms of gross historic coastal area changes.

Of these, the most significant example is certainly the port of Nouakchott, in Mauritania, which over the course of the last 30 years has experienced extensive beach erosion downdrift of the port, in the order of 20 meters per year.

The presence of large river-transversal barriers, such as dams, also play an important role in coastal erosion as they block fluvial sediment transport and lead to coastal sediment deficit and shoreline recessions. Due to the interconnectedness of river mouths and deltas to upstream river basins, variability of sediment supply caused by its interception by dams can result in coastal sediment deficits on the coast. Such sediment deficits resulting from dam construction have been observed in the Nile Delta, the Yangtze Delta, the Mekong Delta, and the Ebro and other Mediterranean deltas. This issue is significant for Africa, especially considering that several large dams were built across the continent in recent years, all with limited or nonexistent plans to manage sediment transport, and that numerous new ones are planned in the coming years.

Without major planning and climate adaptation efforts, more catastrophic impacts to people, infrastructure, and the environment are expected along most of Africa's low-lying coast. It is therefore critical to implement efficient but inexpensive solutions, starting with no-regrets measures like NBS, and thereby set the basis for further adaptation efforts.

Figure 11. Geographical Overview of the Gross Coastal Area Changes adjacent to 130 African Seaports



Note: The size of the dots represents the gross beach area change. The colors represent whether this change is dominated by accretion (green) or erosion (red).

Source: de Boer et al. (2019)

Recommendations

- **Multi-stakeholder cooperation is required to overcome institutional and governance barriers,** as well as to accelerate the mobilization of finance and the implementation of solutions implementation. Joint public and private initiatives related to transboundary sustainable and resilient coastal management, such as the World Bank's WACA, must be expanded upon and supported. Participatory legal and institutional reforms are to be implemented to ensure transboundary Integrated Coastal Zone Management (ICZM) schemes can be prepared, and identified solutions executed.
- **Improve access to data.** To effectively address the problem of coastal erosion, the problem itself must be understood in all its complexity. Access to data must be improved so that erosion hotspots can be clearly identified and studied. The use of communities' local knowledge, interdisciplinary scientific studies and technicians' operational know-how is also recommended, as it promotes the acceptability, efficiency and sustainability of management solutions envisaged.
- **Promote holistic and multisectoral investments that support a green, resilient, and inclusive development, and the use of NBS on land and sea.** Countries affected by coastal erosion can increase the natural protection provided by coastal vegetation cover and ecosystems through planting or restoring mangroves, dunes, seagrass fields, coral reefs, wetlands and other natural vegetation and ecosystems in coastal zones. These NBS are not only cost-effective options that can help address coastal erosion and other forms of coastal degradation, but they can also be used to boost the health of coastal and marine ecosystems and their performance. If suitably planned, NBS can enhance the provisioning to coastal communities, including food, fuel, timber, and other material provisioning, and support ecosystem services like carbon sequestration, climate regulation, water purification, and biodiversity.
- **Address the problem of coastal sediment deficit because of dams.** The damming of rivers often has the unintended consequence of reducing sediment fluxes to the coast. One option to restore the sediment transport deficit is to alter dams to reduce the amount of sediment that they trap, or to completely remove redundant dams or in-river structures altogether. For this, it is necessary to better assess the volume of sediment trapped behind existing and planned dams and the opportunities of effective sediment management to support coastal protection. This transboundary information, which should be included in the ICZM schemes, should be joined with institutional and financial reforms to encourage relevant stakeholders to take actions to directly restore sediment budget deficits and promote beach accretion.
- **Adopt a flexible approach during policy and program implementation.** It is necessary to adopt a flexible approach to ensure management plan objectives can be re-evaluated and activities adjusted according to the evolution of the risk environment. Some options could include a combination of short-term effectiveness, for example protecting infrastructures with a dike, with long-term effectiveness, such as the relocation of the infrastructure.

Photo: Sylvain Cherkaoui/Panos Pictures


Photo: 2016CIAT/Georgina Smith/Flickr

SECTION 3—CROSS-SECTORAL THEMES

Locally Led Adaptation

LLA is being widely recognized as an effective, efficient and equitable paradigm of delivering adaptation action. This approach to adaptation is about ensuring that local people have individual and collective agency over defining, prioritizing, designing, monitoring and evaluating adaptation actions. LLA ensures that mechanisms for managing risks are aligned with local contexts, embedded within local institutions, deliver a high return on investment, and result in outcomes that are more equitable than “business as usual” approaches.

For Sub-Saharan African countries, where over 60 percent of the population are smallholder farmers and where over 55 percent of the urban population live in informal settlements, LLA holds the promise of unlocking variegated responses to highly localized risks in contexts marked by deficits in formal governance machinery. This chapter highlights the growing momentum toward LLA in Africa. It outlines the rationale for LLA and explains how LLA has been operationalized through different financial delivery mechanisms in Africa. It presents the enabling conditions for LLA, along with notable LLA case studies from across the African continent, before discussing some of the challenges faced in scaling up LLA in Africa. It concludes with lessons for governments, funders and civil society on how they can scale up LLA in Africa.

Over 80 entities spanning international organizations, national governments, multilateral organizations, bilateral institutions, non-governmental organizations, climate funds, private-sector companies and social enterprises have now formally endorsed the Principles for Locally Led Adaptation and committed to operationalizing them in different ways. The LLA Principles are outlined in Table 2.

Table 2. Principles for Locally Led Adaptation

Principle 1: **Devolving decision-making to the lowest appropriate level** ensures that those most affected by climate change have agency over decisions about adaptation finance and programming that will affect them.
Principle 2: **Addressing structural inequalities faced by women, youth, children, people with disabilities, people who are displaced, Indigenous Peoples, and marginalized ethnic groups** entails actively recognizing and redressing the power dynamics, imbalances, and development deficits that create vulnerability, poverty, and marginalization.
Principle 3: **Providing patient and predictable funding that can be accessed more easily** requires that funding mechanisms be simplified, and finance provided over longer, more predictable timescales to enable greater access to funding by local actors, support adaptive management and learning, and adequately strengthen local institutions.
Principle 4: **Investing in local institutions to leave institutional legacies** means building and strengthening local institutions by building capacity to understand climate risks and uncertainties, capacity to generate resilience solutions, capacity to facilitate and manage adaptation initiatives, and capacity for local fiduciary responsibility and management so that these institutions can provide grants and loans to other local actors for local adaptation actions.
Principle 5: **Building a robust understanding of climate risk and uncertainty** supports locally led adaptation by ensuring that interventions reflect understanding of local climate risks, current resilience-building practices, and uncertainties about direct and indirect climate impacts on local communities, as well as provide access to appropriate tools to handle uncertainties.
Principle 6: **Flexible programming and learning** recognizes that it is important to maintain budget and programmatic flexibility as well as space for adaptive management and learning.
Principle 7: **Ensuring transparency and accountability** requires that decision-making and governance structures are made explicit, so it is clear which decisions are made at what level of the organization and by whom. It also should be ensured that financing flows are made transparent and can be publicly tracked, and ultimate accountability should be to local actors themselves.
Principle 8: **Coordinated action and investment** by donors, aid agencies, and governments recognizes the need for multiple levels of coordination, horizontally among communities and across sectors and vertically across levels of government and policy processes.

Challenges

There are several options for deploying LLA on the ground. Broadly, in countries with mature state machinery, strong democratic institutions and institutional structures for devolution, LLA might be best supported by government-led national financing mechanisms, whereas mechanisms that rely on civil society organizations or constituent-based organizations might be more appropriate in fragile contexts.

Transitioning to this mode of adaptation action requires an enabling environment with a few key components. There is a need for capacity building, as local actors often may not have a complete appreciation of the full spectrum of climate risk and can struggle to access, manage and deploy adaptation finance, and for patient institutional support over long timeframes.

Effective LLA also requires institutions that can access climate finance and channel it to relevant programs, projects or investments. Many countries in Africa have strong national institutions to access and/or deliver climate finance, including national funds and government agencies such as Ethiopia's Climate Resilient Green Economy (CRGE) Facility and FONERWA in Rwanda. In countries where these institutions do not exist, international funders should support governments with patient finance to develop them.

Putting local communities in a leadership position within a process of adaptation that tackles structural drivers of risk through strengthening local institutions may indeed be more complex and, in certain cases, have higher upfront costs than top-down, technocratic interventions. However, the evidence on returns on investment from adaptation initiatives that focus on the agency of communities suggests that the benefits far outweigh the costs.

Recommendations

- International funders should provide finance to establish and/or strengthen institutions that can channel adaptation finance at the local level.
- International funders should significantly scale up the volume of climate finance that they deliver through LLA mechanisms.
- International funders—in particular global climate funds—should create channels for providing

finance directly to subnational governments and institutions.

- International funders should significantly increase finance to constituency-governed organizations that provide some of the most locally grounded adaptation solutions.
- Countries with devolved governance systems should establish subnational adaptation planning and investment processes so that climate action is downscaled to local governments.
- In countries without devolved government systems, governments should build the capacity of national climate finance institutions to deliver finance in line with the LLA Principles.
- Where governments deliver local-level development programs with adaptation co-benefits, these should be aligned with the LLA Principles.
- Governments should explore the possibility of creating and/or capacitating subnational climate funds and institutions that can access adaptation finance.
- Civil society organizations should expand the coverage of tried-and-tested LLA delivery mechanisms, while also deepening support so that they are longer-term and more predictable.
- Large-scale NGOs that deliver finance through traditional international financing modalities should aim to mainstream the LLA Principles into programming in order to improve accountability for local constituents.
- The private-sector contribution to LLA remains under-researched and there is a need to better understand how this vitally important group of stakeholders can support LLA.

Education

The relationship between climate change, adaptation and education is complex and bidirectional. Climate change undermines educational attainment in Africa by damaging already fragile infrastructure and increasing the vulnerability of educators and learners, negatively affecting their ability to educate and learn. But education is also a key climate adaptation solution for Africa because it enhances the adaptive capacity of people, and especially children, by building critical green skills for adaptation action.

In Africa, schools and other learning institutions are synonymous with developmental progress. They represent possibilities for children and provide nations with the human capital needed to drive toward a better future–a future under climate

Photo: CECIL BO DZWOWA/Shutterstock

change. Indeed, schools connect people and places and offer hope, shelter and humanitarian assistance in a time of disaster. They are pathways for knowledge, skills and cultural exchange across diverse African communities, and thus they are essential in efforts toward strengthening climate resilience and adaptation.

Despite its strategic importance to adaptation efforts, however, education has been overlooked by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), and more broadly in the formulation of climate and adaptation strategy on all levels. This chapter argues for a greater recognition of the need to adapt education systems themselves, but also to recognize education itself as a critical and central strategy for climate adaptation in Africa. It highlights the challenges faced by the education sector in adapting to climate change impacts and the need for greater investment in education to fully realize its potential as an adaptation solution. It assesses the state of education in Africa today and makes a case for education as an important building block of adaptive capacity. It maps out four strategies to accelerate the project of education for adaptation in Africa.

Challenges

Education is a heavily climate-impacted sector in Africa. It is also a key building block of adaptive capacity. However, investment in education is low in Africa, creating a significant barrier for climate adaptation. Despite growing evidence about the synergies between education and adaptation, education has also not been central to climate and adaptation strategies.

Climate-related disruptions to the education sector have far-reaching negative effects on the adaptive capacity of climate-vulnerable populations in Africa. As many as 25 of the 33 countries where children shoulder extremely high vulnerability to climate shocks are located in Africa. A wide range of impacts of climate change on education infrastructure, educators, and learner outcomes have been identified. The relationship between climate change, vulnerability and education is summarized in Figure 12.

Figure 12. The Relationship Between Climate Change, Vulnerability and Education

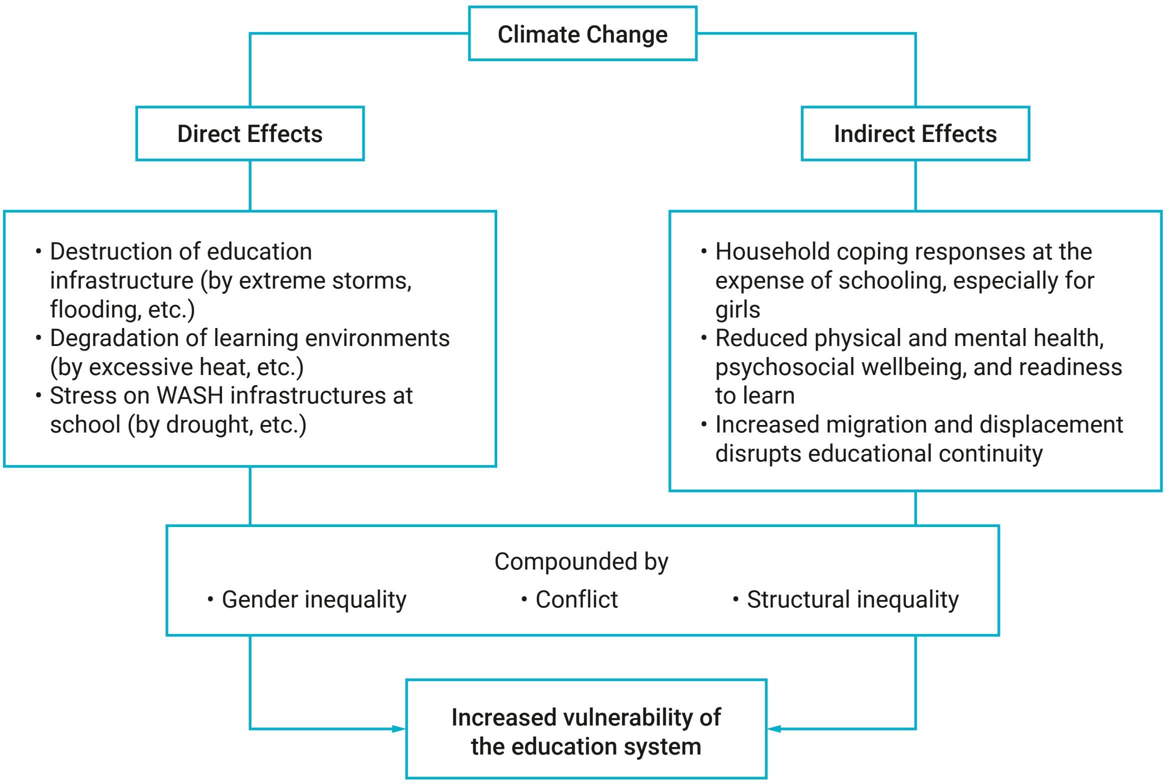


Photo: Dietmar Temps/Shutterstock

The direct impact that climate change has on African education systems is most visibly manifested in the destruction of education infrastructure by sudden-onset climate-related disasters like extreme storms and flooding. The indirect impacts of climate change impair educational attainment, especially for girls. The Malala Fund estimates that climate disruptions will mark an abrupt end to schooling for at least 12.5 million girls every year globally.

Recommendations

Making education systems climate-adapted and ensuring that investments in education can in turn drive adaptation will require action across four distinct areas.

- Data, diagnosis, and improved planning must underpin greater integration of education in adaptation strategies.
- Education infrastructure must be adapted to be more resilient itself and to act as a driver of resilience.
- The education workforce must be supported and strengthened to play its role in educating young people and preparing them to be the climate-adapted workforce of the future.
- Education content and pedagogy must be oriented toward instilling climate literacy and a breadth of green skills for adaptation in all learners.

To make progress on the four levers described in the previous section, a regional effort in the form of an "Education for Adaptation Activator (E4AA)" Alliance is urgently needed. The proposed objectives of the Alliance would be threefold: to bring stakeholders together to establish an irresistible case for education for adaptation; to support countries to identify and activate effective education for adaptation efforts across the four areas identified above that could be localized and scaled; and to build a global movement that champions education for adaptation. Africa, as the continent with the fastest-growing youth population, could lead this Alliance.

Building on existing education, workforce, and climate science datasets, the E4AA Alliance should not only work to fill critical data gaps on education for adaptation, but also create a first-of-its-kind model for calculating the transformative potential of education in building the specific and adaptive capacities for climate resilience. By 2025, the E4AA Alliance could work with 10 of the most vulnerable countries (members of the Climate Vulnerable Forum, with an initial focus on Africa) to ensure adaptation education and adapted education systems are a key part of their NAPs.

Again, by 2025, the Alliance could work with 10 education providers with community reach and expertise across Africa and a coalition of youth in Africa to develop localized adaptation education tools and content based on climate change education design principles and indigenous knowledge. The E4AA should develop global climate resilience and adaptation education tools that can be localized to support implementation of education for adaptation.

Institutional Arrangements For Adaptation

The 2015 Paris Agreement put forward a global goal of "enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change" (Article 7.1). This chapter first describes and highlights the utility of toolkits for assessing institutional arrangements, namely the World Bank's Climate Change Institutional Assessment (CCIA) and the Capacity for Disaster Reduction Initiative's Digital Tool for Disaster Risk Reduction Capacity Diagnosis and Planning. It presents an analysis of the institutional arrangements described in 10 selected African country NDCs or NAPs. It also highlights the benefits of embedding disaster risk reduction (DRR) and disaster risk management (DRM) into a country's institutional framework.

Challenges

Setting up an institutional framework for climate governance is crucial to plan, legislate and manage the implementation of adaptation actions in a country. For Africa, progress has been made in setting up the institutional arrangements, but challenges remain when it comes to setting clear roles, mainstreaming finance and disaster disk reduction considerations throughout the process, and having a monitoring system in place for measuring progress and contributing to transparency, among others.

The NDCs enhancement mechanism provides an important opportunity for African countries to establish clear institutional arrangements to support the successful implementation of adaptation actions and to increase the transparency of their climate adaptation communication. Nevertheless, some countries still state the need for capacity building and finance to support the process.

Seven African countries have submitted an INDC and 46 have submitted updated NDCs. Of these, 25 describe their institutional and governance framework in a more detailed manner, 11 do not explicitly mention an institutional framework in place, and 17 signal the intent of developing, adapting, or reinforcing an existing one that is not described with details.

Joint responsibility between the leading institution of climate change adaptation activities and finance ministries can reinforce alignment with national budget frameworks and help to attract international climate finance. For Africa, finance ministries are generally included in some parts of NDC/NAP institutional arrangements as budget holders and financing procurement institutions rather than as co-leads.

Tools for Assessing Institutional Arrangements

The World Bank has developed the CCIA as a tool to identify the strengths and weaknesses of a country's institutional framework for addressing the governance challenges that climate change poses. The assessment tool is for government officials participating in policy, planning, implementation, and finance. It can be used by governments at any stage of the development of their climate change institutional framework. The CCIA is being used in the World Bank's new Country Climate and Development Reports (CCDRs). These are new core diagnostic reports that integrate climate change and development considerations that will help countries prioritize the most impactful actions that reduce GHG emissions and boost adaptation.

The CCIA focuses on five pillars crucial to consider when designing and planning the institutional arrangements for climate governance of a country, which are: organization; planning; public finance; subnational governments and state-owned enterprises; and accountability.

The World Bank emphasizes that the government institutions should coordinate to carry out climate change policy based on medium- and long-term plans and goals. Additionally, vertical and horizontal intergovernmental coordination arrangements, alignment of national policy with international commitments, and a solid accountability system are crucial factors for a well-structured institutional framework.

Recommendations

- The climate adaptation institutional frameworks in Africa have, for the most part, set up institutional arrangements. There is still work to be done on mainstreaming finance and disaster-risk reduction considerations throughout the process. It is also important to clarify roles of different agencies. As African countries improve their NDCs, clarifying the institutional arrangements would be an important area.
- Ensuring joint responsibility between the lead institution of climate change adaptation activities and finance ministries can strengthen alignment with national budget frameworks. Integrating climate strategies, plans, and policies into the fiscal and public financial management systems can allow countries to maximize resource expenditure and their impact.
- An effective Monitoring, Reporting and Verification (MRV) system is crucial for NDC transparency and accountability. It is a necessary tool for countries to successfully implement adaptation measures, to monitor their effectiveness, and for attracting and facilitating access to climate finance.
- Strengthening the five CCIA pillars when designing and planning the institutional arrangements for climate governance can help to establish clear institutional arrangements to support the implementation of adaptation actions.
- Aligning disaster-risk policy frameworks with climate adaptation institutions and frameworks instruments is imperative, especially for African countries, which are hardest hit by climate-related disasters.

Youth and Entrepreneurship

MSMEs are leading engines of job creation in Africa and account for a large part of economic output for the continent. SMEs constitute 95 percent of Africa's private sector and provide an estimated 80 percent of jobs across the continent. At least 44 million formal MSMEs existed in Sub-Saharan Africa alone in 2018. Their growth, however, is considerably constrained by a lack of access to finance and markets, with 51 percent of the businesses requiring more finance than they have access to. Climate change also poses a threat to business growth and employment in Africa, with negative impacts already seen in the form of job losses, destruction to business assets, forced migration, disruptions to transportation routes and access to markets, risks to occupational safety and health affecting labor productivity, and reduced demand resulting from economic shocks.

Climate adaptation responses can, however, protect existing jobs, drive green job creation for adaptation, support the provision of other employment-related benefits such as healthcare and social protection, and provide opportunities for new economic activity and investments.

There is a considerable opportunity in mobilizing private-sector actors for adaptation efforts in Africa. Collaboration and partnerships within the private sector (and with other stakeholders) can not only build resilience within the private sector, but can generate adaptation and resilience benefits for society at large. This is especially true of MSMEs, given that they make up a significant part of the

Photo: Tommy Trenchard/Panos Pictures

continent's private sector. Further, MSMEs are uniquely positioned to develop locally relevant and effective adaptation solutions, which in turn can significantly build the resilience of the communities in which they operate. Identifying potential business opportunities, incentivizing MSMEs, and promoting local entrepreneurship is thus crucial for creating employment opportunities and generating economic and social output in Africa.

As the most educated generation ever in Africa, African youth today have high economic ambitions and provide an untapped potential to build resilience through their innovativeness, energy, and entrepreneurship. Indeed, Africa's large and growing young population, estimated at over 1.4 billion in 2022, is one of the continent's most valuable assets for growth. Unlocking the untapped potential of youth in Africa to build resilience through innovative solutions and entrepreneurship can drive transformation adaptation at scale across Africa. It is important to engage and support young people in key investments and adaptation policies, increase accessibility of financial instruments, increase the visibility of private-sector adaptation action in Africa, and to incentivize MSMEs through policies and by creating an enabling environment for entrepreneurship.

The Youth Adaptation Solutions Challenge

The Youth Adaptation Solutions Challenge is an annual competition and awards program for youth-led enterprises jointly organized by GCA and AfDB under the YouthADAPT pillar of the AAAP framework. The competition targets young entrepreneurs between the ages of 15 and 35 and MSMEs in Africa that have demonstrated proof of concept, offer innovative solutions to climate adaptation and resilience, and have been operational for at least two years with a potential to scale up operations. The first winners of the Youth Adaptation Solutions Challenge were presented at COP26 during a dedicated award ceremony for the challenge. Over 2,000 applications were received from which 10 winners were awarded. Winners receive seed funding of up to US$100,000 to develop their innovation and receive tailored business development training through a 12-month incubation and acceleration program.

The awarded enterprises target crucial environmental, social, and economic sectors affected by climate change and present clear value propositions to scale up for higher impact as well as to create employment opportunities across Africa. The challenge also has a strong focus on women, with at least 50 percent of selected businesses being women-owned.

The Accelerator Program

A comprehensive gap analysis of each of the winning enterprises was undertaken by the Kenya Climate Innovation Center (KCIC), with the collaboration of GCA and AfDB, to identify individual needs and provide targeted incubation and mentorship support. The gap analysis was done by conducting interviews, reviewing business plans, and using KCIC and AfDB gap analysis and climate adaptation tools. Some of the most frequently mentioned needs included making the businesses ready to attract investors, the need for digital marketing, and climate-risk management.

During the implementation phase, training is provided as a bundled service, allowing for networking and information sharing among the enterprises on the best practices with a pan-African view, which then integrates into their respective business processes. To provide the entrepreneurs with the necessary tools for scaling up their businesses, training workshops were given on the topics of cash flow management, budgeting, fundraising, and digital marketing. Later, to mainstream adaptation into their businesses, training workshops were conducted on understanding climate change, adaptation fundamentals, adapting SMEs to a changing climate, and the adaptation finance landscape.

The Accelerator program is implemented alongside grant provisions released in tranches determined by milestones achieved. The Youth Challenge provides the winners with a sustainable funding model and an expert mentorship component—allowing them to access funding and training to support their short-term goals while also creating an environment for accessing funds that will help them unlock their long-term goals.

Business Challenges

The YouthADAPT challenge has helped the winners address some of the challenges they have faced since the inception of their enterprises. The grant, training sessions, and mentorship have all contributed to unlocking new possibilities for scaling up their businesses and impacting the lives of more people in their communities. The three main ways the YouthADAPT Accelerator program has helped them are: funding for scaling up, training for impact, and investor readiness. The main challenges that young entrepreneurs face while launching and growing their businesses are:

Limited financial resources and difficulties in accessing and securing funding. Access to finance is essential to be able to fund adaptation innovations. Young entrepreneurs had difficulty navigating loan systems that require collateral at levels that are unfeasible for them.

Need for business development and operational skills. Winners expressed the need for in-house capacity building for business development skills such as project management, financial management, tracking daily activities, bookkeeping, budgeting, writing, implementing company policies and procedures, and marketing, to name a few.

Knowledge gaps. Several entrepreneurs expressed the need for climate experts trained on adaptation and resilience strategies, which would help them disseminate climate knowledge to their customers, smallholder farmers, local municipalities, and the wider community.

Uncertainty of climate impacts. The winners have already experienced negative impacts of climate risks on their business, both directly and indirectly. There is great uncertainty surrounding how climate risks will impact their businesses in the future. This is particularly true for young entrepreneurs in the agriculture sector, which in Africa is predominantly rain-dependent and highly vulnerable to climate impacts. This makes the implementation of adaptation strategies even more critical.

Changing farming and customer behavior. Being agents of behavioral change is challenging in itself. Some winners reported initial reluctance from the communities in which they operate in first accepting and then implementing new behaviors, such as adopting new technologies. Sustaining long-term behavioral change is another challenge requiring interventions and strategies that maintain motivation.

Operational context. Other contextual conditions that posed challenges for the winners to launch and grow their businesses include receiving little help from local municipalities, lack of infrastructure such as poorly constructed roads and unreliable access to electricity, difficulties obtaining the necessary certificates and licensing, government regulations such as on drone usage, and not having structured markets.

Recommendations

Reflecting on the challenges and barriers they have faced in launching and growing their businesses, the winners provided their insights into how African governments can support young entrepreneurs through policy actions and programs. There are three main recommendations:

- **Access to funding:** Make access to financial capital easier for young entrepreneurs. This includes simplified loan systems and processes; making grant and funding opportunities more visible; lowered interest rates that are flexible and adjusted according to revenue at different periods; and more flexible and feasible collateral requirements.

- **Create tax incentives:** Encourage youth entrepreneurship by lowering tax barriers that severely inhibit growth. This could include providing early-stage tax cuts until the company starts making a profit; offering adaptation tax rebates; reduced or zero-rate taxes on farm inputs such as seeds and equipment; and tax holidays or exemptions.
- **Facilitate access to knowledge and capacity building:** Equip young people with tools to successfully implement their adaptation innovations through training and mentorship programs; business incubators; training in digital technologies; access to networks of young entrepreneurs around the world; knowledge exchange between young businesses and established companies; vocational training programs; and climate change awareness-raising campaigns. Create synergies between government, NGOs, and the private sector.

Security

Climate change impacts create novel security threats and also interact with existing social, political, and economic conditions and vulnerabilities. Climate-security analysis seeks to understand these risks as well as identify opportunities to prepare for and to prevent complex climate-related security risks. This chapter presents a climate-security adaptation framework to better understand the climate and security nexus and support the "security-proofing" of climate adaptation planning. The framework consists of five steps:

1. Identify areas of climate-security risk through an analysis of climate-conflict pathways.
2. Assess climate-security risk through forecasting and EWS that combine security and climate risks.
3. Develop conflict-proof adaptation planning.
4. Translate climate-security risk assessments into localized action.
5. Climate-proof the role of local security sectors.

Photo: Yuzu2020/iStock

Challenges

The security landscape in Africa is evolving in response to rapidly shifting climate conditions. Integrating climate and security action is critical for adapting to the unprecedented challenges of a climate-changed world.

Up to half of all African countries have been identified to be vulnerable to climate change and are regarded as very fragile. Currently, eight of the top 10 countries impacted by climate change are in Africa, six of which are also currently experiencing armed conflict. Overall, the Sahel and Horn of Africa regions as well as the countries to the south of these regions are most vulnerable to climate-induced risks as they already have a precarious starting point through state fragility and ethnic fractionalization.

Access to water, food, and energy is threatened by climate change trends like decreased rainfall, rising temperatures, and extreme weather events, leading to a loss of crop productivity, and leaving the continent exposed to further unrest. Multiple regions in Africa have seen an increase in conflict between herders and farmers as climate-induced changes through droughts, wildfires and heatwaves decrease grazing lands and available natural resources.

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Recommendations

- Developing a conflict-sensitive climate adaptation strategy and a climate-sensitive security strategy requires a deep understanding of the climate-security nexus and of the ways in which this applies to the local context. Research on the climate-security nexus has identified several pathways by which climate change impacts can produce social, political and economic conflict. Many of these pathways have a direct application to Africa, and specific combinations of them can be identified in particular regions. Understanding these pathways and identifying vulnerable regions can facilitate the development of more specific data tools to predict and anticipate climate-security risks in Africa.
- The design and deployment of EWS is an indispensable part of dealing with climate-security risk. Based on triangulated research methods involving local communities and climate-security practitioners, an effective EWS can be developed that informs the development of adaptation programs to address climate-security risks. EWS should rely on local actors and their knowledge in order to prevent maladaptation and to not enhance or exacerbate existing vulnerabilities of local and marginalized communities. Any action informed by EWS must be carefully evaluated to avoid unsustainable choices, unintended consequences for local communities, or escalations of humanitarian crises.
- Regional institutions in Africa have begun to integrate climate-security risks into their policy frameworks, but urgency is required in translating those frameworks into action, especially by building on the strengths of local security actors. The United Nations Office for West Africa and the Sahel (UNOWAS) and the African Union have both demonstrated strengths in the development of EWS and policy frameworks to understand climate-security risks. However, it is important for regional institutions to move from assessment into action to ensure adaptation for communities in practice.

Local security actors can play an important role in the application of adaptation strategies on the ground, as they are often the first and best equipped to respond to increasing climate risks.

- Translating climate-security assessment into action requires participatory engagement through, for instance scenarios exercises, training and dialogue, and co-creation with local communities. These tools can help to eliminate gaps in data dissemination and climate adaptation action, especially for vulnerable and/or disconnected communities.
- Local communities should have a leadership role in responding to EWS. Robust systems for information sharing exist at the local level, yet they are often misunderstood or underappreciated by regional or state institutions. However, when those local information-sharing systems are utilized, they can be very effective at mobilizing communities to action and doing so at a low cost. Therefore, another starting point for more security-proof adaptation policies is Local Adaptation Plans of Action (LAPAs), which can then help to shape broader NAPs.

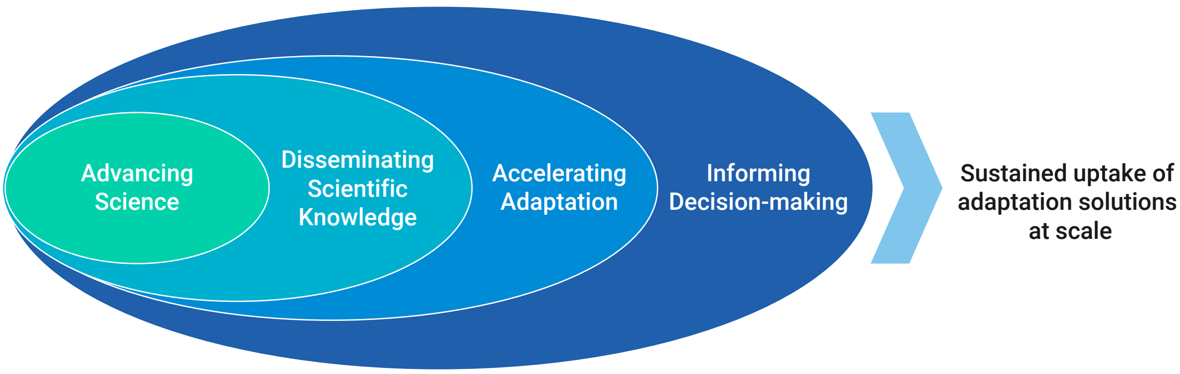
The Unfinished Research Agenda In Adaptation

Countries in Sub-Saharan Africa are particularly vulnerable to climate change because multiple biophysical, political, and socioeconomic stresses interact to heighten the region's susceptibility and constrain its adaptive capacity. Adaptation, defined by the IPCC as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities," is needed to manage current climate impacts and will be increasingly vital as the world continues to warm. Adaptation can take place at a number of scales, from local to global, addressing climate-related problems at that particular level, and making use of capacities available to that particular group of actors.

Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits. However, adaptation progress is unevenly distributed with observed adaptation gaps. Also, many initiatives prioritize immediate and near-term climate-risk reduction. To increase the efficiency and effectiveness of adaptation, integrated, multisectoral solutions that address social inequities, differentiate responses based on climate risk, and cut across systems are vital.

Adaptation is a complex and multifaceted subject that is evolving rapidly as climate change impacts the world in ever more challenging ways. Hence there is a large research agenda to fill in present and future knowledge gaps on adaptation, spanning the disciplines of climate science, economics, psychology, and other social sciences. However, adaptation research needs to go beyond assessing risks and identifying impacts and instead take a problem-focused and systems-oriented approach, pursuing user-centered solutions with a clear line of sight between research and its application. Figure 13 visualizes the theory of change of adaptation research for impact.

Figure 13. Theory of Change of Adaptation Research for Impact



Adaptation Research: Insights and Recommendations

For adaptation to be effective, it requires knowledge of current and future climate-related risks. However, there is a dearth of climate-risk data and models for actors seeking to invest in adaptation, particularly at a more granular level. Conducting vulnerability assessments and providing local climate projections can help formulate a clear climate rationale and identify where adaptation is needed the most. Informality characterizes a significant portion of urban and rural economies across the African continent and must be understood if climate adaptation activities are to be effective.

One of the most important but difficult challenges is to gain a better understanding of adaptation to more extreme forms of climate change, such as those associated with 3 to 4°C of mean surface warming. It is clear that those higher levels of warming could be extremely disruptive and adaptation strategies would have to change, perhaps fundamentally so. Empirical analysis is by design restricted to the relatively modest levels of climate variation observed in the recent past. Artificial intelligence is increasingly being used to expand the realm of future climate scenarios.

Researchers need to ensure that scientific knowledge is packaged in a comprehensible manner and disseminated to the broader public. Knowledge sharing among different stakeholders will help reduce transaction and information costs and involve the public and private sectors in identifying vulnerabilities as well as adaptation solutions. Data collection and analysis can also be empowering. Involvement of communities in data gathering and geographic information system mapping can help them to understand and articulate their needs and challenges better, and to negotiate more effectively with governments.

The effectiveness of strategies for adapting to climate change depends on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution. Research needs to contribute to an understanding of all three.

Collective action is at the heart of many decisions regarding the management of natural resources, which are a key locus of adaptation. Greater insight can be gleaned on how collective action is central to adaptive capacity at various scales by case-specific research.

Making adaptation decisions can be complex, requiring careful consideration of multiple factors and perspectives, and balancing different priorities over different timescales. Societies are said to only be at the start of a learning process that will continue for decades. Decisions on adaptation are made by individuals, groups within society, organizations and governments on behalf of society. But all decisions privilege one set of interests over another and create winners and losers. Mainstreaming adaptation refers to the process whereby climate change concerns become an integral part of decision-making and influence the ways in which actors perceive the problem and consider climate change in their day-to-day activities.

At the macroeconomic level, successful adaptation policy would reduce tradeoffs across sectors and promote synergies; reduce under- and overreaction by departments, organizations, or ministries in response to climate change impacts; prevent inefficient investments of (scarce) resources; and promote coherence and consistency in implementing actions on the ground.

For decision-makers to be able to move from predict-to-act to risk-of-policy approaches, researchers need to assess the effectiveness of adaptation policies at the sector level, including the performance of adaptation measures under different climate scenarios, and then integrate these results in economy-wide models where they can also make linkages to the mitigation agenda. Such economy-wide models would also allow policymakers to assess impacts of adaptation strategies on poverty reduction and employment generation, which are important considerations from an equity point of view. The Comprehensive Africa Agriculture Development Program (CAADP) provides a good guide for the risk-of-policy approach.

At the local level, adaptation preferences have been found to be rather heterogeneous and conditioned by a host of social factors across the African continent. Case studies reveal that local preferences consistently supported the need for both autonomous and planned adaptation; a mix of hard and soft measures; and awareness of the importance of pursuing both collective and individual adaptation measures.

In addition, the adaptation strategies perceived to be most effective were those that addressed underlying drivers of vulnerability, rather than those that focused on climate change alone. Further research is required on adaptive behavior at the local level, for example the farm household, so that simulations run on that level can inform and predict the workings of the overall economy. Insights in adaptive behavior could also inform policy measures designed to build adaptive capacity of the more vulnerable.

Decision-making for scaling or replication of adaptation actions needs to be informed by learnings from adaptation actions on the ground. Several projects have already introduced adaptation solutions, for example a climate-smart adaptation technique or providing weather index-based insurance to farmers, but an intervention bias, the pilot or experimental nature of such initiatives, and a lack of methodologically sound impact studies, makes it difficult to draw lessons from these. Impact evaluation, which includes identifying impact pathways of adaptation actions, would shed light on the limits to adaptation and reduce the risk of maladaptation pathways.

To summarize, to achieve sustained uptake of adaptation solutions at scale, research efforts need to produce and ensure dissemination of comprehensive and disaggregated information on climate risks, to identify context-relevant adaptation solutions with high potential for uptake, and to develop decision-making tools that enable scaling. What is more, these various elements need to speak to each other.

Photo: Simon Townsley/Panos Pictures

Climate Risks in Africa

Photo: Martchan/Shutterstock

KEY MESSAGES

- Climate change acts as a risk multiplier, amplifying the intensity of extreme weather events, increasing unpredictability, and exacerbating vulnerabilities. Both the changing realities of climate in Africa today and modeling of future outcomes show that Africa is one of the most vulnerable regions in the world to climate risk.
- Africa has been substantially impacted by natural disasters, which are set to increase in severity and frequency. Between January 2021 and September 2022, approximately 52 million people (around 4 percent of the African population) were impacted either by drought or floods, deeply affecting African livelihoods.
- African food systems are particularly vulnerable to climate extremes and shifts in weather patterns, as food production is largely dependent on rainfed agriculture and pastoralism. Considerable negative impacts of a changing climate are also expected for marine and inland fisheries.

- Water-dependent sectors across Africa are largely and negatively impacted by extreme variability. Extreme hydrological variability will progressively amplify under all climate change scenarios (relative to the current baseline), depending on the region. Projections of the number of people who will experience water stress by the 2050s vary widely, with potential decreases or increases by hundreds of millions. This requires planning under high uncertainty.

> **"Africa is suffering enormously from the devastating effects of climate change. This is serious in the Horn of Africa, due to the droughts in East Africa. In the past two years, we've barely had rains. This has serious implications for food security, has decimated a lot of livestock, affecting the livelihoods and incomes of pastoralists, and causing displacement of population as they search for water. To say that Africa, which suffers losses of $7 billion to $15 billion per year and could rise to $50 billion per year by 2014, is clearly the most vulnerable region of the world is not in any way an exaggeration."**
>
> **H.E. Sahle-Work Zewde**
> President of Ethiopia

Photo: Curt Carnemark/World Bank

INTRODUCTION

The “Present and Projected Climate Risks for Africa” chapter in the *State and Trends in Adaptation 2021* (STA21) report gave an overview of the observed climate trends and modeled projections of the physical processes that determine changes in the climate system for Africa.[1] It also provided an overview of the climate-related disasters now experienced across the continent and the resulting human and economic losses. It then presented trends in near-surface (2 meters) air temperature and sea levels, followed by a brief overview of projections presented by Working Group I of the Intergovernmental Panel on Climate Change (IPCC) in the Sixth Assessment Report, which were derived from a new modeling effort.[2]

To reprise a key message from STA21, although Africa has historically contributed a very small share of global greenhouse gas emissions, it is highly vulnerable to anthropogenic climate change and is already experiencing widespread losses and damages. Surface temperatures are increasing across all African regions, and the continent is warming faster than the global average over both land and the oceans.[3] Agriculture, which is mostly rainfed and employs a majority of the workforce across Sub-Saharan Africa, mainly as smallholders, is particularly vulnerable to climate variability and to escalating climate change impacts.

With projected increases and intensity of high-warming scenarios of heatwaves, heat stress, droughts, and flooding for some parts of Africa, STA21 emphasized the need and urgency to adapt. Importantly, it highlighted that adaptation is particularly urgent for Africa, as many small changes in weather patterns resulting from climate change can gradually erode food system productivity, causing losses of assets through events too small to attract global or even national attention. Such changes affect people’s wellbeing and can counteract efforts to alleviate, or can even push people back into, poverty. Furthermore, STA21 pointed to the vital need for significant additional investment to improve systematic weather and climate observations, as climate-related research in Africa faces severe data constraints.

This chapter provides an update on new climate data published since STA21. This includes, among others, the World Meteorological Organization (WMO)’s State of the Global Climate 2021,[4] the multi-organization synthesis United in Science 2022,[5] the latest data from the Emergency Events Database (EM-DAT),[6] and IPCC Working Group II’s contribution to the Sixth Assessment Report, released in February 2022. The latter examines the interactions between the physical changes analyzed by Working Group I and the exposure, vulnerability, and adaptive capacity of social and biophysical systems, with a dedicated chapter for Africa.[7]

This chapter first provides an overview of climate-related disasters experienced in Africa in the last year, followed by a closer look at high-impact events across the continent. It then summarizes temperature and precipitation data for the different regions in Africa. Lastly it outlines the expected impacts of physical changes to the climate system, highlighting the critical interconnection between climate change, society, and nature for climate-resilient development.

NATURAL HAZARDS IN AFRICA

Africa is substantially impacted by natural hazards, which are set to increase in severity and frequency with climate change. The EM-DAT database is a global, comprehensive, and readily accessible record of disasters maintained by the Centre for Research on the Epidemiology of Disasters (CRED).[8] It shows that from January 2021 to September 5, 2022, more than 54 million people were affected by disasters linked to storms, droughts, wildfires, floods, and landslides in Africa (Table 1). Drought-related disasters affected the most people in Africa over that period, followed by floods. Eastern Africa has been hit the hardest by climate-related disasters, with a total of more than 33 million people who were injured, affected, or killed. In North Africa, the greatest impacts were from floods and wildfires.

In the past decade, most disasters triggered by natural hazards globally were caused by extreme weather and climate-related events such as heatwaves, floods, and storms. This number has been increasing since the 1960s and has risen almost 35 percent since the 1990s.[9] As recorded by EM-DAT, in the period 2011 to 2020, the main types of disasters that have affected Africa were droughts and floods. On average, approximately 13 million people in Africa per year were impacted by droughts over that period, and 3.5 million were impacted by floods (Table 2).

Climate change acts as a risk multiplier, amplifying the intensity of extreme weather events, increasing unpredictability, and exacerbating vulnerabilities. To minimize the impacts on livelihoods and make African countries more resilient in the long run, STA21 called for adaptation to climate change to be mainstreamed into policy and strategies.

Table 1. Summary of Climate-related Hazards and their Impacts per Region in Africa (January 2021 to September 2022)

	Disaster type					
	Storm	**Drought**	**Wildfire**	**Flood**	**Landslide**	**Total impacted**
Eastern Africa						
Total deaths	400	2,000	NA	200	NA	3,000
No. injured	600	NA	NA	100	NA	700
No. affected	1,967,000	30,455,000	NA	990,000	NA	33,411,000
Central Africa						
Total deaths	26	NA	NA	108	5	100
No. injured	NA	NA	NA	300	NA	300
No. affected	NA	2,100,000	30,000	820,000	100	2,950,000
Northern Africa						
Total deaths	NA	NA	100	200	NA	289
No. injured	NA	NA	200	500	NA	738
No. affected	16,000	18,000	44,000	1,377,000	NA	1,455,000
Southern Africa						
Total deaths	10	NA	NA	550	NA	600
No. injured	27	NA	NA	4	NA	30
No. affected	14,600	12,000,000	NA	125,000	NA	12,140,000
Western Africa						
Total deaths	17	NA	NA	300	NA	300
No. injured	100	NA	NA	300	NA	400
No. affected	17,000	4,446,000	NA	393,000	NA	4,856,000

Notes: NA, data not available; No., number.

"No. affected" refers to the number of people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation, and medical assistance. Numbers were rounded up or down to the thousands.

Source: EM-DAT data for Africa, January 1, 2021, to September 5, 2022.

Table 2. Climate-related Hazards and their Impacts per Region in Africa (Yearly Average of the Period 2011–2020)

	Disaster type					
	Storm	Drought	Wildfire	Flood	Landslide	Total impacted
Eastern Africa						
Av. total deaths	200	NA	NA	300	100	600
Av. no. injured	1,000	NA	NA	300	17	1,200
Av. no. affected	724,000	6,562,000	NA	1,272,000	17,000	8,574,000
Central Africa						
Av. total deaths	NA	NA	NA	100	30	100
Av. no. injured	7	NA	NA	100	5	100
Av. no. affected	1,500	833,000	5,700	243,000	NA	1,083,000
Northern Africa						
Av. total deaths	13	NA	5	100	2	100
Av. no. injured	14	NA	1	100	NA	100
Av. no. affected	15,000	760,000	200	525,000	NA	1,300,000
Southern Africa						
Av. total deaths	4	NA	1	36	NA	41
Av. no. injured	26	NA	NA	32	NA	58
Av. no. affected	1,400	876,000	NA	88,000	NA	966,000
Western Africa						
Av. total deaths	11	NA	0	200	100	300
Av. no. injured	17	NA	NA	400	11	400
Av. no. affected	4,500	3,896,000	NA	1,342,000	1,200	5,244,000

Notes: Av, average; NA, data not available; no., number.

"Av. no. affected" refers to the average number of people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation, and medical assistance. Numbers were rounded up or down to the thousands.

Source: EM-DAT data for Africa, January 1, 2011, to December 31, 2020.

Several high-impact extreme weather events, such as heavy rain, droughts, heatwaves, and storms, occurred across Africa in 2021 and 2022, leading to flooding, landslides, wildfires, and avalanches. Table 3 presents the most impactful events, as catalogued by the WMO.[10]

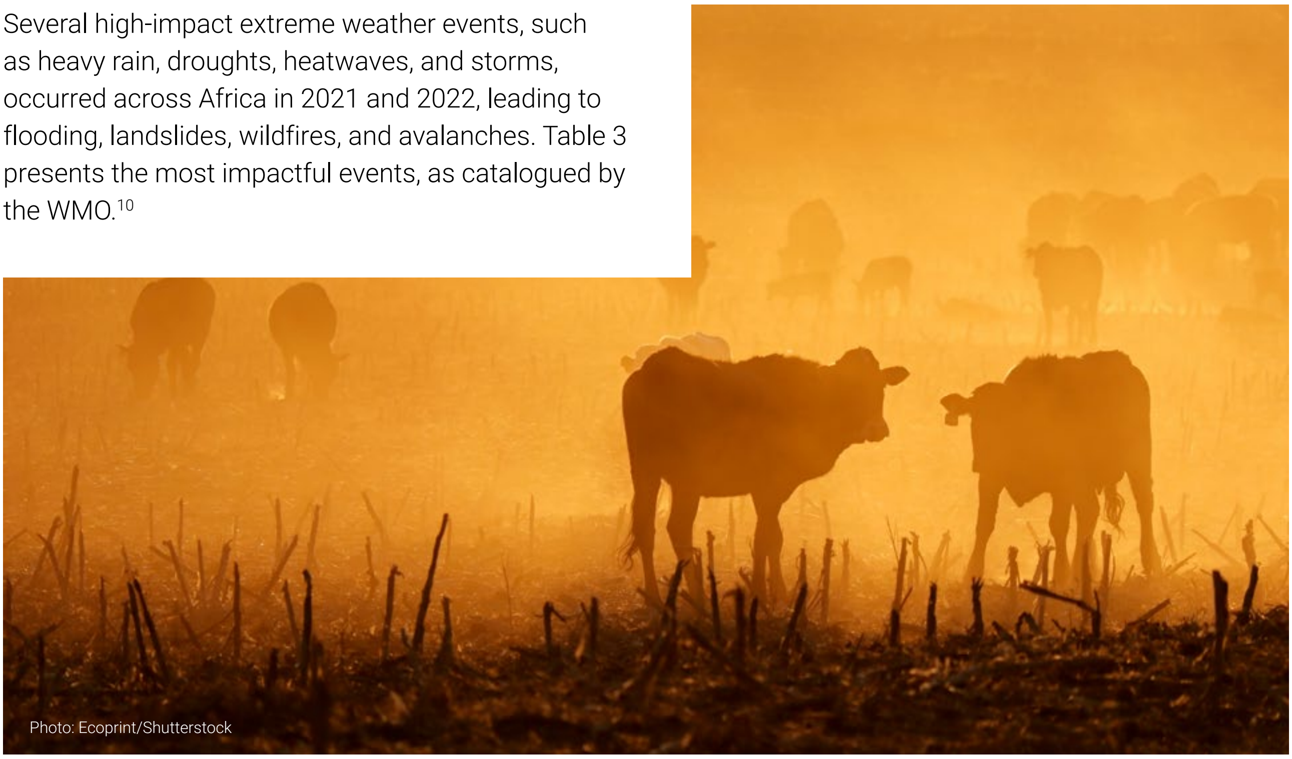


Photo: Ecoprint/Shutterstock

Box 1. Impacts of Wildfires on Vulnerable Populations

Wildfires can affect multiple sectors of the economy through their impact on crops, ecosystems, and human health. According to the data provided by the Global Facility for Disaster Reduction and Recovery (GFDRR) through the platform Think Hazard,[12] large parts of Sub-Saharan Africa and some in North Africa show a high risk of wildfires—meaning a greater than 50 percent chance of encountering weather that could support a significant wildfire. The smoke produced by wildfires increases CO_2 emissions, significantly reduces air quality, and harms human health in multiple ways.[13] For instance, a 2020 study estimated that long-term exposure to particulate matter contributed to about 15 percent of COVID-19 mortality worldwide.[14] There is a need to better understand the specific health impacts of wildfires on the continent and the adaptation measures that can reduce risk and enhance the resilience of vulnerable populations.


Photo: Cathy Withers-Clarke/Shutterstock

Table 3. High-impact Events in 2021 and 2022

Event type	Countries or region affected	Description
Wildfires	Algeria, Morocco, and Tunisia	Major wildfires occurred across many parts of the Middle East and North Africa (MENA) region, with Algeria badly affected. Over 40 deaths occurred in the Algerian fires. Tunisia and Morocco also experienced significant wildfires.
Precipitation variability	Southern Africa, the Greater Horn of Africa region, Madagascar	Large regions with a rainfall deficit included parts of Southern Africa. Both the wet seasons (April to May and October to November) were drier than usual in the Greater Horn of Africa region. It was at least the second year in a row with below-normal rainfall for Madagascar. Across the Horn of Africa heavy precipitation was linked to recent outbreaks of desert locusts, affecting up to 2.5 million people in 2020 and another 1 million in 2021.
Floods	Niger, Sudan, South Sudan, Mali, Burundi, South Africa, and Zimbabwe	Significant flooding was reported, especially in Niger, Sudan, South Sudan, and Mali. In Southern Africa, much of which had been experiencing long-term drought, rainfall during the 2020/2021 rainy season was above average in some regions, including northern South Africa and Zimbabwe, with some flooding reported.
Drought	Greater Horn of Africa region (particularly Ethiopia, Somalia, and Kenya), Madagascar	Drought developed during 2021 into 2022 in the Greater Horn of Africa region, particularly affecting Somalia, Kenya, and parts of Ethiopia, after three successive below-average rainy seasons. The October–December rainy season was especially poor, despite some rains in Kenya late in the season. A severe drought, which has persisted for at least two years, continues to affect southern Madagascar. There were significant food security issues in the area, with 1.14 million people classified by the World Food Programme as needing urgent assistance as of August 2021.
Tropical cyclones	Mozambique, South Africa, Zimbabwe, Eswatini, Madagascar, and Malawi	In 2021, Cyclone Eloise contributed to flooding in Southern Africa, with damage and casualties reported in Mozambique, South Africa, Zimbabwe, Eswatini, and Madagascar. In January 2022, Cyclone Ana brought heavy rain, strong winds and flooding to Madagascar, Mozambique, Malawi and Zimbabwe. It was followed by Batsirai, an even stronger tropical cyclone. As a result of these storms, tens of thousands of people were displaced, infrastructure was destroyed, and flooded farmlands further exacerbated food insecurity.

Source: WMO, 2022.[11]

Table 4. Trends and Projections of Temperatures and Precipitation by Region in Africa

North Africa		
Temperature	Trends	Seasonal and mean annual temperatures have increased at twice the global rate. Since the 1970s, increasing temperature trends have been between 0.2°C per decade and 0.4°C per decade, especially in the summer.
	Projections	At 1.5°C, 2°C and 3°C of global warming above pre-industrial levels, mean annual temperatures are projected to be 0.9°C, 1.5°C and 2.6°C warmer than the 1994–2005 average, respectively. Warming is projected to be higher in summer.
Precipitation	Trends	Mean annual precipitation has decreased over most of the region between 1971 and 2000. Aridity (the ratio of potential evaporation to precipitation) has increased due to decreases in precipitation.
	Projections	At warming levels of 2°C and higher, mean annual precipitation is projected to decrease, with the most pronounced decreases in the northwestern parts of the region.
West Africa		
Temperature	Trends	Seasonal and mean annual temperatures have increased by 1–3°C since the mid-1970s, with the highest increases seen in the Sahara and the Sahel. Heatwaves have become hotter and longer in the 21st century compared with the last two decades of the 20th century.
	Projections	At 1.5°C, 2°C, and 3°C of global warming above pre-industrial levels, mean annual temperatures are projected to be 0.6°C, 1.1°C, and 2.1°C warmer than the 1994–2005 average, respectively.
Precipitation	Trends	Extreme heavy precipitation indices show increasing trends from 1981–2010. Increasing high-flow events are seen in large Sahelian rivers and small to mesoscale catchments, leading to flooding. Droughts have increased in frequency since the 1950s.
	Projections	Projections show gradients of decrease in the west and increase in the east, with the magnitude of change increasing with higher warming levels. The duration of meteorological droughts in the western parts of the region is expected to increase from approximately two months (during 1950–2014) to approximately four months (in the period 2050–2100) under the RCP8.5 and SSP5-8.5 scenarios.
Central Africa		
Temperature	Trends	Mean annual temperatures have increased by 0.75°C–1.2°C since 1960. Due to observational uncertainties, there is medium confidence in observed trends of increasing number of heat extremes over the region.
	Projections	At 1.5°C, 2°C and 3°C of global warming above pre-industrial levels, mean annual temperatures are projected to be 0.6°C, 1.1°C and 2.1°C warmer than the 1994–2005 average, respectively.
Precipitation	Trends	Due to a lack of station data over the region, there is large uncertainty in the estimation of observed rainfall trends and low confidence in extreme rainfall changes. There is some evidence of drying since the mid-20th century through increased precipitation deficits, decreased mean rainfall, and increases in drought, especially in the southern and eastern parts of the region.
	Projections	At 1.5°C and 2°C of global warming there is low confidence in projected mean rainfall change. At 3°C and 4.4°C warming, an increased mean annual rainfall of 10–25% is projected, with increasing intensity of extreme precipitation.

Temperature and Precipitation Trends and Projections

The El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), and Southern Annular Mode (SAM) are the primary large-scale drivers of seasonal and interannual climate variability in Africa. In eastern Africa, ENSO and IOD particularly affect the June–July–August–September and October–November–December (short rains) seasons.

El Niño is associated with negative rainfall and positive temperature anomalies in Southern Africa. The opposite is true for La Niña.[15] La Niña is also associated with drier-than-normal conditions in East Africa, especially in Kenya, Ethiopia, and Somalia, which experienced consecutive below-average rainfall seasons in late 2020, early 2021, and late 2021.[16] The SAM influences rainfall in southwestern Africa, with positive SAM modes generally associated with lower

East Africa		
Temperature	Trends	Mean temperatures have increased by 0.7°C to 1°C from 1973 to 2013, depending on the season, with the greatest increases seen in northern and central parts of the region.
	Projections	At 1.5°C, 2°C, and 3°C of global warming above pre-industrial levels, mean annual temperatures are projected to be 0.6°C, 1.1°C, and 2.1°C warmer than the 1994–2005 average, respectively.
Precipitation	Trends	The short rains (October–November–December) over equatorial East Africa have shown a long-term wetting trend from the 1960s to present, while the long rainfall season (March–April–May) has shown a long-term drying trend between 1986 and 2007. Since 2005, drought frequency has doubled from one in every six years to one in every three years.
	Projections	At 1.5°C and 2°C global warming, higher mean annual rainfall is projected, particularly in the eastern parts of the region. At 2°C and higher, heavy rainfall events are expected to increase. There is low confidence in projected mean rainfall change during the long rainy season. Drought frequency, intensity and duration are projected to increase in Sudan, South Sudan, Tanzania and Somalia, and to decrease or not change in Uganda, Kenya, and the Ethiopian Highlands.
Southern Africa		
Temperature	Trends	Mean annual temperatures have increased by between 1.04°C and 1.44°C during 1961–2015, depending on the observational dataset.
	Projections	At 1.5°C, 2°C, and 3°C global warming above pre-industrial levels, mean annual temperatures are projected to be 1.2°C, 2.3°C, and 3.3°C warmer than the 1994–2005 average, respectively.
Precipitation	Trends	Mean annual rainfall has increased over parts of Botswana, Namibia, and southern Angola by 128–256 mm during 1980–2015, and decreasing precipitation trends have been detected in parts of South Africa since the 1960s. Extreme precipitation events have increased in number and intensity over the last century.
	Projections	A decrease by 10–20% in mean annual rainfall is projected in the summer rainfall region. At 1.5°C and higher levels of global warming, dryness is expected to increase in the summer rainfall region. At 1.5°C global warming, increases in drought frequency and duration are projected over large parts of the region. At 2°C, unprecedented extreme droughts (compared with the 1981–2010 period) are projected.

Source: Authors' summary of observed and projected temperature and precipitation patterns in Africa from the IPCC Sixth Assessment Report.[18]

levels of seasonal rainfall. There is some indication that extreme ENSO events and extreme IOD phases may increase in frequency due to climate change.[17]

The "Present and Projected Climate Risks in Africa" chapter in STA21 provided an overview of the observed trends and projections of temperatures and precipitation for the continent as a whole. Table 4 presents a summary for each region of Africa.

Photo: fivepointsix/Shutterstock

WHAT THE PHYSICAL CLIMATE CHANGE DATA MEAN FOR ADAPTATION IN AFRICA

The "Present and Projected Climate Risks in Africa" chapter in STA21 outlined the expected physical changes in the climate system for the continent. Building on that, this section highlights what these physical changes could mean for livelihoods and adaptation in Africa. It synthesizes and summarizes some of the latest climate-related reports since STA21's publication, including the IPCC Working Group II report; the Climate, Land, Agriculture and Biodiversity (CLAB-AFRICA) report (2021) coordinated by the Future Africa Institute;[19] and the WMO-coordinated United in Science report.

For Africa, climate risks are expected to pose significant challenges to food security, biodiversity, poverty eradication, economic growth, and human health. Adaptation measures can reduce present climate risks, but their future effectiveness remains uncertain, pointing to the need for climate-resilient development across the continent.[20] As mentioned in the IPCC report, barriers to climate change adaptation in Africa include a lack of access to climate information, inadequate research opportunities, and a funding gap for adaptation. It is important to strengthen adaptation finance flows to Africa, develop legislative frameworks that facilitate effective design and implementation of adaptation responses, and emphasize good governance for climate-resilient development.[21]

While adaptation cannot prevent all losses and damages, there are a range of options that can be broadly applied across sectors, including disaster risk management, climate services, and risk spreading and sharing. Multi-hazard early-warning systems (MHEWS) are also critical for climate change adaptation and are an important element of disaster risk reduction. MHEWS integrate hazard information and risk analysis to provide early warnings for governments, communities and individuals, resulting in increased understanding of and preparedness for approaching events. When implemented effectively, MHEWS can minimize impacts, reduce losses and damages, and save lives. As of April 2022, however, less than half of all countries globally reported having national MHEWS. Coverage is particularly low in Africa.[22]

Ecosystem-based adaptation can have multiple benefits for society, reducing climate risk while providing social, economic and mitigation benefits. This is particularly the case for Africa, with a large proportion of the population being directly and highly dependent on ecosystem services.[23] Much of this potential, however, depends on how adaptation actions are designed and managed. For example, maintaining indigenous forest ecosystems sees both biodiversity gains and emission reductions, but wrongly targeting ancient grasslands and savannas for reforestation can harm biodiversity and reduce water security. This also points to the importance of cross-sectoral and transboundary planning.[24]

Equity-based and gender-sensitive adaptation measures reduce vulnerability for marginalized groups in Africa, across multiple sectors including food systems, livelihoods, water and health.[25] Integrating climate adaptation into social protection programs such as cash and in-kind transfers, public works programs, microinsurance and healthcare access, can help people in times of crisis and increase resilience to climate change.[26] African Indigenous knowledge and local knowledge systems are also important for strengthening local climate change adaptation.

This section offers an overview of the implications of climate risks for several key sectors in Africa: food systems; ecosystems; water; human settlements and infrastructure; health; and economics, education and heritage.

Food Systems

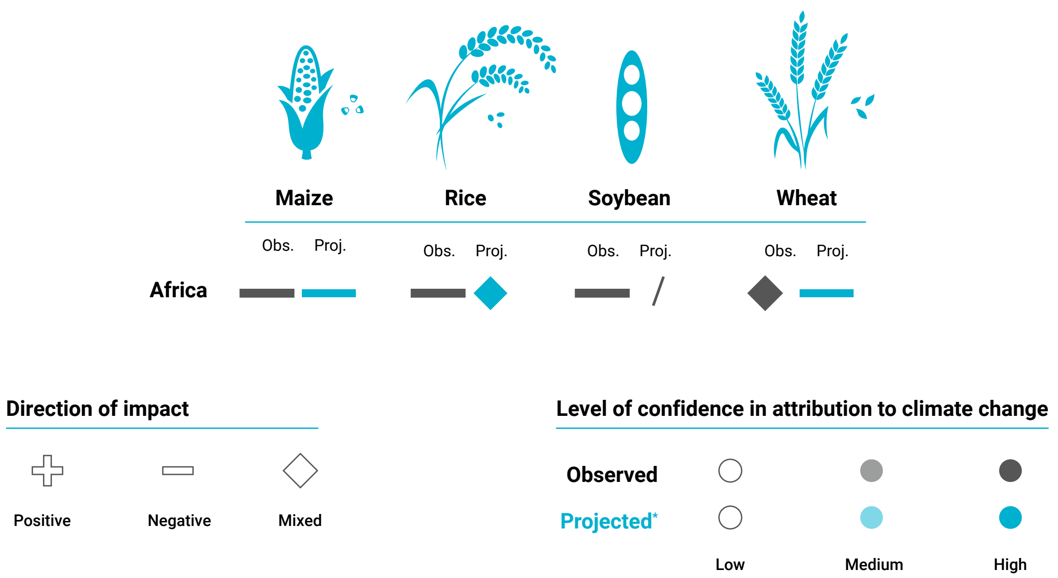
Growth in agricultural productivity in Africa has reduced by 34 percent since 1961 due to climate change, more than in any other region.[27] Global warming is projected to shorten growing seasons and increase water stress across the continent. Ethiopia, Sudan, and South Sudan were among the countries most affected by food crises in 2020, partly due to climate impacts such as drought, changes in pest distribution, and conflict in the region.[28] With 1.5°C of global warming, yields are projected to decline for olives in North Africa and sorghum in West Africa; a decline in suitable areas for coffee and tea is also expected in East Africa.[29] A 2°C temperature rise would result in yield reductions for staple crops across most of Africa, even with adaptation and even after accounting for any potential benefits from increased CO_2 concentrations (Figure 1). Elevated CO_2 concentrations might mitigate some climate-driven losses of staple crops; however, there is considerable uncertainty around crop response to CO_2.

For some cash crops, climate change is projected to have a positive impact on yields, such as for Bambara nuts and sugarcane in Southern Africa, chickpea in Ethiopia, and oil palm in Nigeria.[30] With global warming of 3°C, agricultural labor capacity could be reduced by 30–50 percent in Sub-Saharan Africa,[31] linked to a sharp increase in the number of extremely hot days (temperatures exceeding 40°C) across Africa. The "Present and Projected Climate Risks for Africa" chapter in STA21 provides extreme heat projections for different global warming levels.

Climate change also threatens livestock production across Africa. At 2°C of global warming, rangeland net primary productivity is expected to decline by 42 percent for West Africa by 2050.[32] Increasing warming will heighten the prevalence of vector-borne livestock diseases and the duration of severe heat stress.[33] More variable precipitation and increasing rainfall intensity are also linked to a risk of locust outbreaks in East Africa, which poses a major threat to crops and livestock in the region.[34]

The "Drylands" chapter in STA21 highlights the important opportunity that well-managed small-scale irrigation, particularly if supported by off-grid solar energy and with linkages to grower cooperatives and access to markets—in comparison to large-scale schemes—presents for more productive and resilient food systems and dryland communities in Africa.[35] Farming methods based on crop diversity can add varieties and hybrids, improve soil and water management, and promote sustainable irrigation. Integrating animal health, land use, and markets can help increase production and resilience of livestock pastoral systems. The chapter delves deeper into more adaptation options for food systems in Africa and presents an important vision for climate-adapted African drylands.

Figure 1. Observed and Projected Impacts from Climate Change to Crop Yield Productivity in Africa

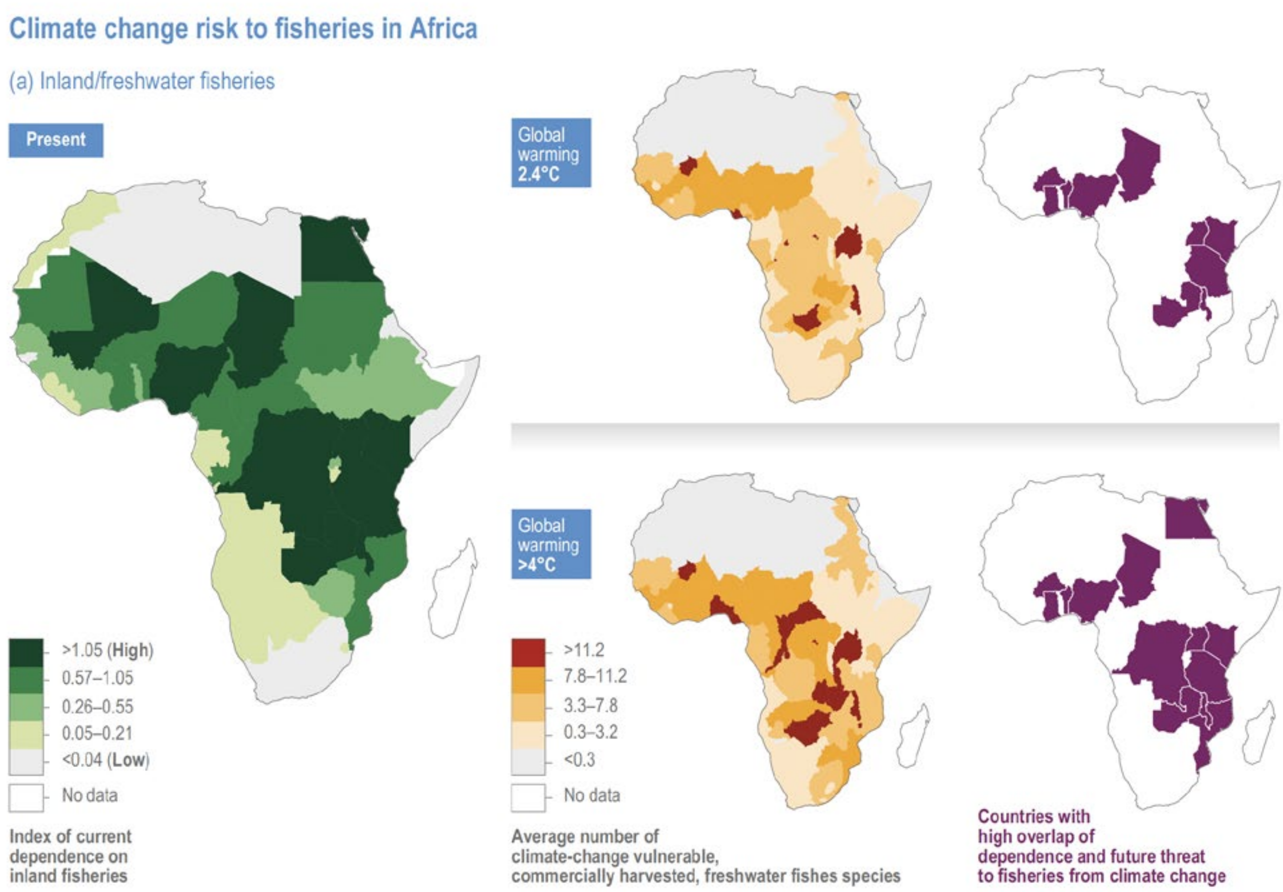


Source: Adapted from a section of IPCC (2022) Figure AI.17[36]

Notes: / not observed or insufficient evidence; * mid-century at RCP4.5 (about 2°C global warming level).

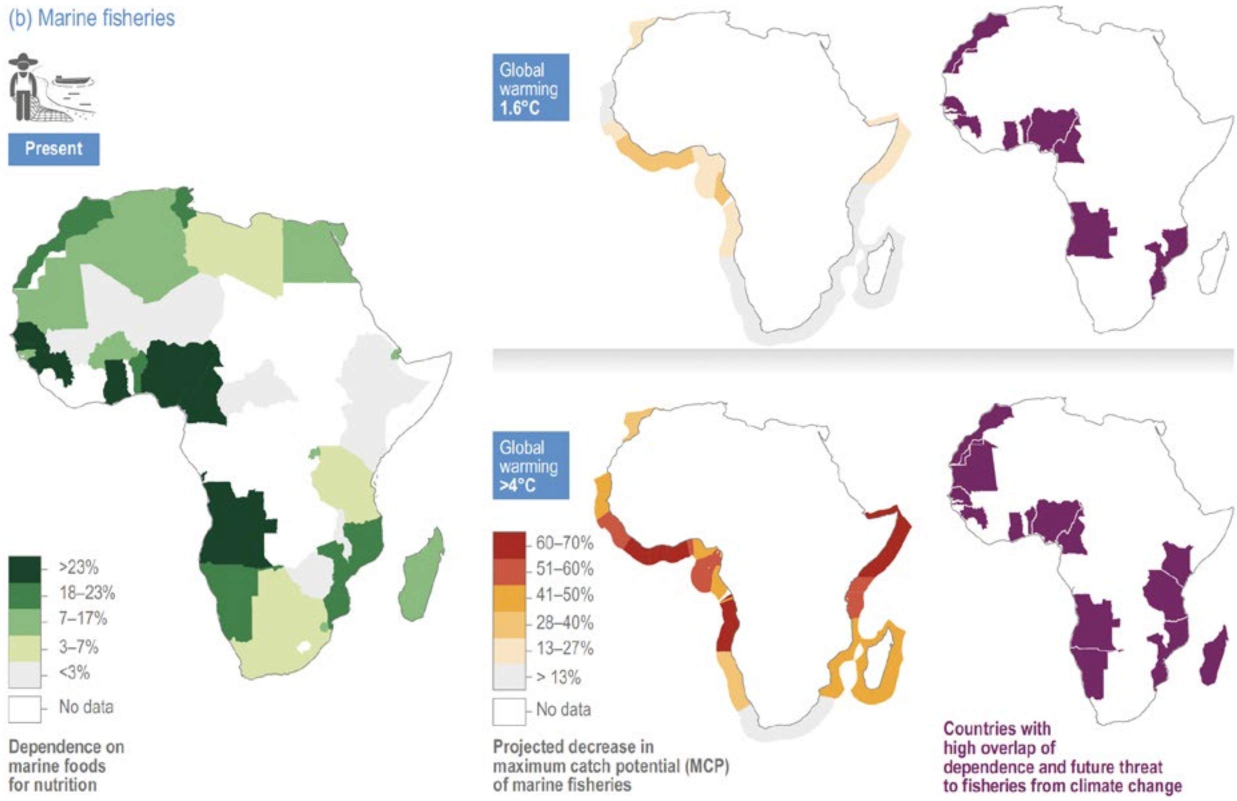
At 1.7°C of global warming, one study found that reduced fish harvests could render 1.2 million to 70 million people in Africa vulnerable to iron deficiencies, up to 188 million people to vitamin A deficiencies, and 285 million to vitamin B12 and omega-3 fatty acid deficiencies by mid-century.[37] By the end of the century (2071–2100), with 2.5°C of global warming, 55–68 percent of commercially harvested fish species in inland fisheries would be vulnerable to extinction (Figure 2a).[38] Also by mid-century, with 2°C of global warming, the catch potential for marine fisheries on the western coast of Africa and in the Horn of Africa could decline by 10 percent to more than 30 percent (Figure 2b).[39] Considering that in Africa, agriculture provides employment for approximately 60 percent of the population, and accounts for roughly 25 percent of GDP,[40] it is critical to keep enhancing the resilience of the sector in Africa by mainstreaming adaptation into policies, plans, strategies, and actions.

Figure 2a. Climate Change Risks to Inland/Freshwater Fisheries in Africa



Source: Reproduced from Trisos et al. (2022) Figure 9.26.[41]

Figure 2b. Climate Change Risks to Marine Fisheries in Africa



Source: Reproduced from Trisos et al. (2022) Figure 9.25.[42]

Ecosystems

With every 0.5°C increment above present-day global warming, biodiversity loss and species extinction are expected to escalate across Africa.[43] Above 1.5°C, half of assessed species are projected to lose over 30 percent of their population or suitable habitat area. At 2°C of global warming, 7–18 percent of African land-based species assessed would be at risk of extinction,[44] and 36 percent of freshwater fish species would be vulnerable to local extinction.[45] Also at 2°C, bleaching is projected to severely degrade over 90 percent of east African coral reefs.[46] Above 2°C, the risk of sudden and severe biodiversity losses becomes substantial in East Africa, West Africa, and Central Africa. Changing patterns of invasive species spread are also expected due to climate change.[47]

Some plant species are able to use water more efficiently under increased CO_2 conditions, possibly counteracting the effects of increasing aridity. There is some evidence of increased woody plant cover as a result of these interacting processes. The outcome is highly uncertain, but it could have significant effects on carbon sequestration and grazing systems.[48] The "Present and Projected Climate Risks in Africa" chapter in STA21 has a fuller account of expected changes in aridity across Africa.

Water

Water-dependent sectors across Africa are significantly, and negatively, impacted by extreme variability in rainfall and river discharge.[49] Extreme hydrological variability will rise progressively under all climate change scenarios (relative to the current baseline), depending on the region. However, there is significant uncertainty about future precipitation; a systematic literature review found that the number of people exposed to climate change-related water stress in Sub-Saharan Africa by 2050 was projected to rise by as much as 921 million, or drop by as much as 459 million.[50]

Projected changes entail heightened cross-cutting risks to water-dependent sectors and require planning under high uncertainty for the wide range of extremes expected (Figure 3).[51] Future climate change combined with increasing societal demands on limited water resources is anticipated to intensify water–energy–food competition and tradeoffs. For example, energy is needed for processing and distributing water. Greater rainfall variability, with periods of low rainfall and river flow, may impede hydropower generation with concurrent reductions in electricity production. Water and energy, in turn, are central to food production.

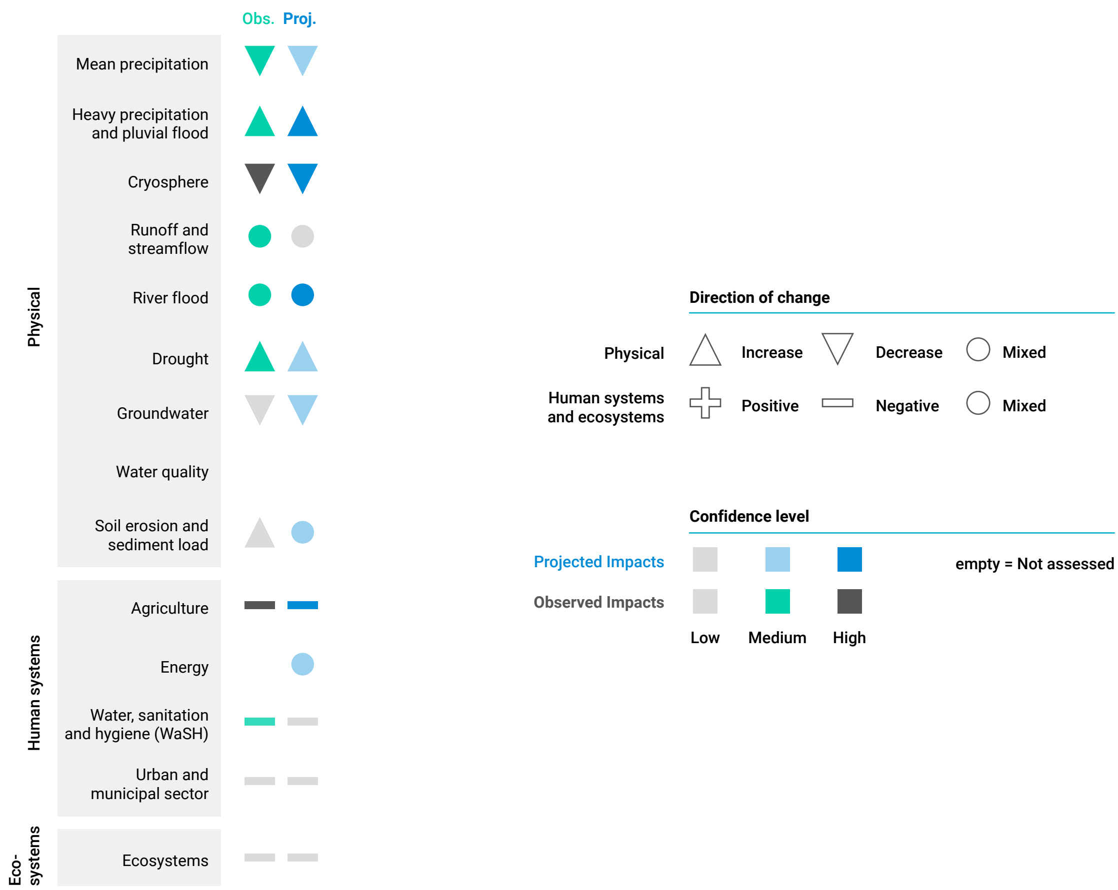
The inter-relationship between water, energy and land use calls for an integrated approach incorporating transdisciplinary teams. It is also important that a coordinated land and water governance approach addresses social inequities and gender imbalances in the socioeconomic value chain of these resources.

Important options for targeting agricultural water shortages include small-scale irrigation during dry spells and drip irrigation for trees and horticulture.[52]

Human Settlements and Infrastructure

By 2030, urbanization is projected to increase the extent of urban land exposed to arid conditions by around 700 percent (relative to 2000), and exposure to high-frequency flooding by 2,600 percent across West, Central, and East Africa.[54] At 1.7°C global warming and low population growth, exposure to extreme heat for urban populations is expected to increase from 2 billion person-days per year in 1985–2005 to 45 billion person-days by the 2060s, and at 2.8°C global warming and medium-high population growth, this is projected to increase to 95 billion person-days, with the greatest exposure projected in West Africa.

Figure 3. Regional Synthesis of Assessed Changes in Water and Consequent Impacts



Source: Excerpt from Figure AI.35 in IPCC (2022)[53]

One study estimated cumulative costs to 2100 to repair and maintain existing road networks damaged from climate change–related precipitation and temperature changes at US$183.6 billion (with adaptation) to US$248.3 billion (without adaptation).[55] Increased rainfall variability is also likely to affect electricity prices in countries with a high dependency on hydropower.[56]

By 2030, between 108 million and 116 million African people are projected to be exposed to sea-level rise (compared with 54 million in 2000), with this number increasing to 190–245 million by 2060.[57] This will be driven mainly by rapid population growth and urbanization in low-elevation coastal zones, and these trends will also increase the number of people exposed to other climate hazards, such as floods, droughts, and heatwaves.[58] A more in-depth overview of sea-level rise trends across Africa can be found in the "Present and Projected Climate Risks for Africa" chapter in STA21.

Impacts of sea-level rise will also be compounded by more pronounced storm surges, increasing the risks to coastal populations and infrastructure.[59] Under medium- and high-emissions scenarios, without adaptation, damages from sea-level rise and coastal extremes to 12 major African coastal cities could average US$65 billion and US$86.5 billion by 2050, respectively.[60]

Health

Further global warming will escalate mortality and morbidity, in turn placing additional strain on health systems. With global warming above 1.5°C, a sharp increase in the risk of heat-related deaths is projected, with at least 15 additional deaths per 100,000 residents annually across large areas of the continent.[61] This number increases to 50–180 additional deaths per 100,000 people annually in North Africa, West Africa, and East Africa at 2.5°C global warming, and to 200–600 per 100,000 people annually at 4.4°C. Above 2°C of global warming, seasonal transmission and distribution of vector-borne diseases are projected to increase, increasing exposure to tens of millions more people, mostly in West Africa, East Africa, and Southern Africa. Large numbers of additional cases of diarrheal disease are projected under 2°C, mainly in West Africa, Central Africa, and East Africa.

Children born in North Africa and West Africa in 2020, under a 1.5°C warming scenario, will be exposed to 4–6 times more heatwaves in their lifetimes compared to people born in 1960.[62] For Central Africa, children born in 2020 are expected to be exposed to 6–8 times more heatwaves. In East Africa and Southern Africa, increase in exposure is expected to be 3–4 times, except in Angola where it is expected to be 7–8 times. At 2.4°C global warming, numbers increase across the continent to between 4–10 times.[63]

The impact of climate change on water quality significantly affects health in Africa, with strong linkages between flooding, poor sanitation, and water contamination in locations where water sources are poorly built and sanitation is rudimentary or non-existent. This is because floods can destroy latrines and cause widespread contamination of the surface environment, soils, and water resources.[64]

Economic Growth, Education, and Heritage

Economic growth across Africa has already been reduced by climate change. Impacts manifest largely through losses in agriculture, as well as in tourism, infrastructure, and manufacturing. Across nearly all African countries, if global warming is held to 1.5°C rather than allowed to rise to 2°C, GDP per capita is projected to be at least 5 percent higher by 2050 and 10–20 percent higher by 2100.[65] Inequalities between African countries are projected to widen with increased warming. The informal sector and small to medium-sized enterprises can have high exposure to climate extremes. However, importantly, informal sector impacts are omitted from GDP-based impact projections.[66]

Climate change and variability can undermine educational attainment. Low rainfall, high temperatures, and flooding, especially during the growing season, may mean children are removed from school to help generate income. Undernutrition associated with weather-related food supply interruptions or poor harvests can hinder cognitive development in early life.[67] African cultural heritage is also at risk from climate hazards, including sea-level rise and coastal erosion, though the potential losses have not yet been quantified on a large scale.[68] Most African heritage sites are neither prepared for nor adapted to future climate change.[69]

Section 1
Economics and Finance

Photo: xxxx xxxxx

Overview

The **State and Trends in Adaptation 2021 (STA21)** report by the Global Center on Adaptation (GCA) provided a deep dive on the costs and macroeconomic risks of climate change impacts in Africa. It made a detailed case for the potential economic benefits of adaptation and modeled a range of cost-benefit ratios of adaptation interventions in Africa. It assessed adaptation finance flows to Africa, which are presently insufficient to meet the growing adaptation needs on the continent, and also identified opportunities to increase the volume and efficacy of that financing. STA21 also reviewed the role of the private sector, which generates two-thirds of the investment, 75 percent of the economic output, and 90 percent of the employment in Africa, through a diverse range of companies from large multinationals to many micro, small, and medium-sized enterprises (MSMEs). STA21 also supplied a range of insights on the role of the private sector in adaptation in Africa.

This new State and Trends in Adaptation 2022 presents a deep dive on the economics and finance of climate change impacts in Africa. It once again assesses the role of the private sector and considers the potential costs and benefits of adaptation interventions in Africa. It complements the analysis found in STA21 and combines in-depth analyses with case studies. It also presents a comprehensive set of recommendations for action by offering innovative adaptation and resilience ideas, solutions, and financing options.

The main **Adaptation Finance Flows in Africa** chapter provides an overview of existing adaptation finance flows in Africa. It analyzes African financial market readiness for climate adaptation finance and risk-finance mechanisms, and presents three country case studies to illustrate facets of the adaptation finance landscape in Africa (respectively covering country-level adaptation finance needs, domestic public finance for adaptation, and the issuance of sovereign bonds). It then proposes solutions to increase the volume and variety of capital available for adaptation finance and risk-transfer mechanisms in Africa and to enable pipelines for adaptation and dual-benefits projects in the region.

The **Financial Instruments in North Africa** chapter discusses a broad range of financial instruments for adaptation, drawing on examples from North Africa. It provides an overview of current climate finance flows to the region and articulated needs to identify financing gaps. It then lays out regulatory and legal instruments as well as institutional settings that can help create an environment for mobilizing adaptation finance and enhancing the efficiency of existing resources for climate action. It also presents examples of actual climate finance instruments that focus on the mobilization of domestic financial resources by mainstreaming climate into public budgets and fiscal instruments and by climate-proofing public investments, as well as through public support for mobilizing private adaptation finance. It also discusses more direct climate finance instruments such as green bonds, innovative debt swaps, and financing from multilateral development banks (MDBs) and climate funds, highlighting how they can be tailored to meet adaptation finance needs.

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The chapter on **Climate Risk Regulation in Africa** focuses on the impact of climate risks on African financial systems. Financial regulations and self-regulation practices of financial institutions are critical enablers of a resilient financial system and encourage more climate investment in the region. The chapter is based on a report produced in 2021 by McKinsey & Company in collaboration with AfDB, GCA, and UNEP FI. The report's goal was to assess the integration of climate-related risks in the prudential, financial, regulatory, and supervisory frameworks of several African countries, and identify potential levers to incentivize their internalization. It also features in-depth case studies on the Democratic Republic of the Congo, Egypt, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Rwanda, South Africa, Tunisia, and Zimbabwe, supported by interviews and discussion with regulators and stakeholders in the countries.

The chapter on **Resilient Recovery: Senegal and Côte d'Ivoire** presents an analysis of the economic and employment potential of green investments relative to traditional and high-carbon investments in Senegal and Côte d'Ivoire. For each country, an overview of the national economic context is provided, followed by the economic impacts of COVID-19 and country-specific policy responses. This is followed by the results of the modeling exercise and some policy recommendations.

The chapter on the **Impact of Climate Change on the Private Sector** focuses on the role of the private sector and why companies in Africa must prioritize adaptation to climate change so as to reduce risk, maintain productivity, and ensure the broader stability of the African economy. It shows how innovative measures in adaptation can not only make companies and their supply chains more resilient, they can also open up new markets in areas like construction and nature-based solutions and new avenues for employment. It also discusses how insurance organizations in Africa can act as a catalyst for the use of risk models and analytics to navigate best-suited climate adaptations. The financial services sector can also play a significant role by creating new products, monitoring climate risk, and incentivizing adaptation actions.

And last, the chapter on the **Technical Assistance Program (TAP)** is a survey of the lessons learned after one year of implementation of one of the core elements of the Africa Adaptation Acceleration Program (AAAP): a TAP that aims to reduce barriers to large-scale access to multilateral climate funds in Africa and foster country ownership of adaptation projects and funding. The chapter aims to measure the progress and achievements of the program, and identify areas for improvement to achieve more significant impact and sustainability.

Adaptation Finance Flows in Africa

KEY MESSAGES

- Africa faces a serious and urgent shortfall in funding for climate adaptation, even as the costs of delayed action rise.
- Cumulative analysis of the Nationally Determined Contributions (NDCs) of 51 African countries shows a need for an estimated US$579 billion in funding for adaptation through 2030. But this would require an annual outlay much larger than the US$11.4 billion in tracked adaptation finance to Africa on average annually in 2019 and 2020.
- Most of the funding for adaptation presently comes from the public sector. To tap a wide range of potential actors, it is necessary to build an enabling environment for adaptation investment and aggressively deploy innovative finance instruments at scale toward adaptation activities.


Photo: Sven Torfinn/Panos Pictures

- A number of case studies focused on adaptation and funding strategies in Rwanda, Ghana, Kenya and Egypt offer insights into best practices that, given the right context, can be modeled in other African countries.

> **"We are, at this moment, spending more than half of our public climate budget on adaptation and resilience—and the vast majority of the spending is now geared towards Africa, and rightly so."**
>
> **H.E. Mark Rutte**
> Prime Minister of the Netherlands

INTRODUCTION

Current adaptation finance flows in Africa are insufficient to meet the growing adaptation needs on the continent.[1] This chapter provides an overview of existing adaptation finance flows in Africa and identifies opportunities to increase the volume and efficacy of that finance. The core objectives of this chapter are to:

- Assess the state of adaptation finance and risk-finance mechanisms already available and in use in Africa.
- Analyze African financial market readiness for climate adaptation finance and risk-finance mechanisms.
- Present three country case studies to illustrate facets of the adaptation finance landscape in Africa, respectively covering country-level adaptation finance needs, domestic public finance to adaptation, and the issuance of sovereign bonds.
- Identify gaps where climate risk exists yet there is insufficient finance to address it, as well as the barriers to implementation.
- Propose solutions to increase the volume and variety of capital available for adaptation finance and risk-transfer mechanisms in Africa and to enable pipelines for adaptation and dual-benefits projects in the region.

FINANCIAL FLOWS ANALYSIS

The impacts of climate change in Africa are being exacerbated by rapid urbanization, geopolitical tensions, and the impact of global shocks such as the COVID-19 pandemic and the ongoing war in Ukraine. Rising prices of energy, food, and other commodities have worsened the climate-related food security and energy access risks to the population of Africa. Despite these challenges, there is a significant opportunity for climate investments in Africa to mainstream resilience and low-carbon development in the long term.

In September 2022, the analysis and advisory organization Climate Policy Initiative (CPI) released *The Landscape of Climate Finance in Africa*, a comprehensive exercise to map climate mitigation and adaptation investments in Africa. The analysis indicates that an annual average of US$29.5 billion in climate finance was committed to Africa in the years 2019 and 2020.[2] Approximately 39 percent of those commitments, amounting to US$11.4 billion, targeted adaptation activities.

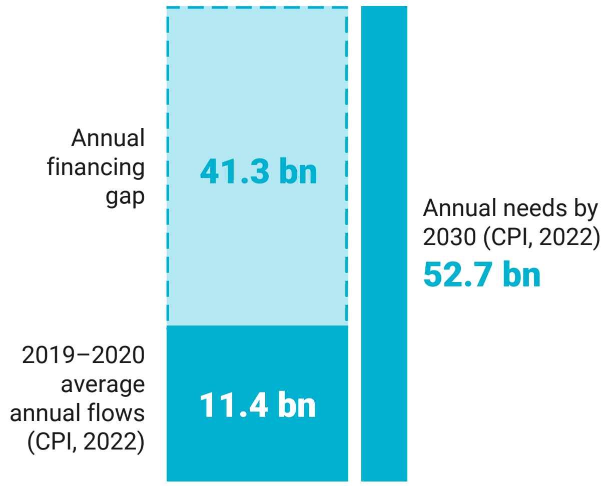
Importantly, the newly assessed commitments for 2019–2020 in the CPI report represent a 44 percent increase from the US$7.9 billion reported by CPI's 2021 *Global Landscape of Climate Finance* as adaptation finance in Africa for the same two years. CPI continually strives to enhance the tracking of climate finance by both updating data inputs as new information becomes available and by adding new data sources to address data gaps, which are especially pervasive in adaptation finance. The 2022 *Landscape of Climate Finance in Africa* study—the first of its kind—represents an especially concentrated effort to improve data availability and quality for Africa, leading to a relatively large difference between the commitments for 2019–2020 reported in 2021 as compared to those reported in 2022 for the same years.

The increase in the 2022 analysis is primarily attributable to 1) updated investment data for 2020 made available in April 2022 by the OECD Creditor Reporting System (CRS);[3] 2) new inclusion of adaptation activities from publicly available resources on African national government budget expenditures like climate budget tagging (CBT) and Climate Public Expenditure and Institutional Reviews (CPEIRs); 3) updated OECD statistics on the amounts mobilized from the private sector by official development finance interventions; and 4) screening of post-issuance reporting on climate bonds in African countries.[4]

Figure 1 shows the trends in adaptation financing flows and needs in Africa. It is informed by an analysis of the Nationally Determined Contributions, or NDCs, submitted by African countries that provide information on countries' climate finance needs. Of 53 African countries that submitted NDCs, 51 countries (collectively representing more than 93 percent of Africa's GDP) have also provided data on the costs of implementing their NDCs.

The analysis of that data indicates an estimated US$579.2 billion in adaptation finance needs for Africa over the period 2020–2030.[5,6] By contrast, as already noted, an annual average of US$11.4 billion was tracked in adaptation finance to Africa in 2019–2020. If this trend were to continue through 2030, adaptation finance would total US$125.4 billion

Figure 1. Adaptation Finance Commitments (US$bn) vs. Needs in Africa



through 2030, far short of the US$579.2 billion (or approximately US$52.7 billion annually) in estimated needs per costs of implementation stated in NDCs. Adaptation finance is thus scaling too slowly to close the investment gap, even as the costs of inaction rise.[7]

Adaptation finance was approximately 39 percent of total tracked climate finance to Africa in 2019–2020. Further, the share of adaptation finance as a percentage of total climate finance was higher in Africa than any other region for 2019–2020.[8] Due to the cross-sectoral nature of adaptation projects, a large share of tracked adaptation finance commitments to Africa in 2019–2020 went toward cross-sectoral activities (41 percent, US$4.7 billion), which included support for national-level policy and capacity building, disaster management activities, COVID-19 response, urban issues, and social security.[9] The agriculture, forestry, and other land use (AFOLU) sector saw the second-highest commitments, accounting for US$2.8 billion, followed by the water and wastewater sector with US$1.7 billion in annual commitments.

Across Africa, multilateral development finance institutions (DFIs) were the most significant source of adaptation finance flows (53 percent, US$6 billion), followed by governments (23 percent, US$2.6 billion) and bilateral DFIs (16 percent, US$1.8 billion). In line with the global trend of increasing prioritization of adaptation in DFIs climate portfolios, the 2019–2020 period was the first period where more finance commitments tracked from multilateral DFIs were directed to adaptation than to mitigation in Africa.[10]

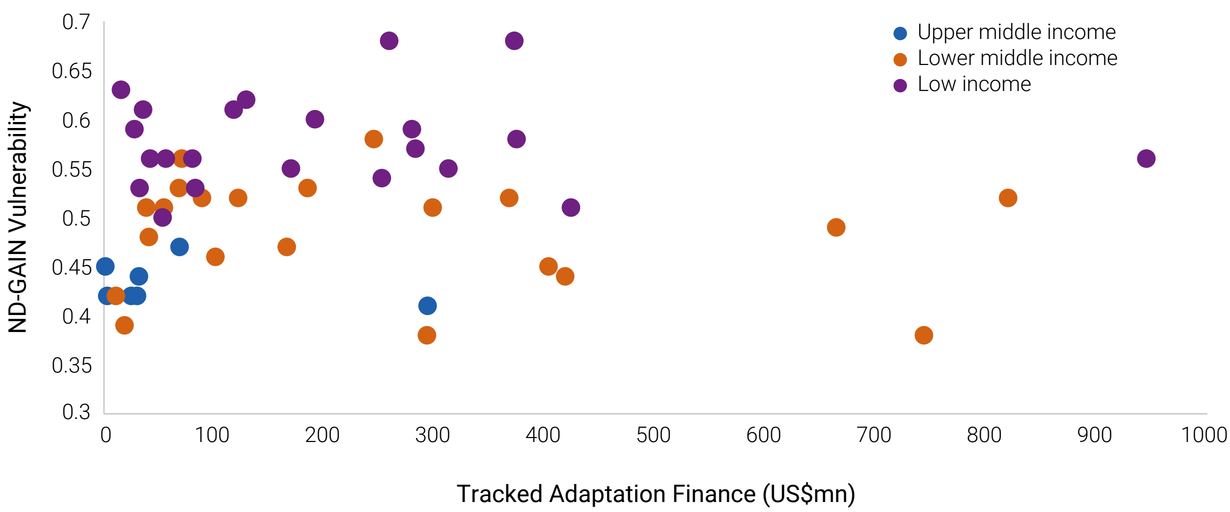

Simon Townsley/Panos Pictures

More than half (53 percent) of the adaptation finance commitments to Africa in 2019–2020 were loans. A high share of financing from multilateral DFIs was committed in the form of commercial-rate loans (41 percent) and concessional loans (32 percent), whereas bilateral DFIs primarily committed concessional loans (82 percent). By contrast, more than 90 percent of adaptation finance committed from governments was in the form of grants, with less than 6 percent in the form of loans. The share of grants and loans varies across regions and the income profile of countries. Low-income countries primarily attracted grant commitments for adaptation financing, whereas lower-middle-income countries largely saw commitments of loans at market rate (58 percent).

Photo: Fiston Wasanga/CIFOR/Flickr

As shown in Figure 2, there is limited to no correlation at the country level between tracked adaptation finance and climate vulnerability.

Figure 2. Tracked Adaptation Finance (US$million) vs. ND-GAIN Vulnerability by Country



Adaptation finance commitments to Africa remain substantially below the estimated needs detailed in NDCs.[11] Despite the global health and fiscal crisis caused by the pandemic, positive factors influencing adaptation finance flows to Africa appear to have outweighed negative factors, resulting in an overall increase in adaptation finance. Numbers for 2021 are not yet available and it is still premature to assess how 2022 events—notably the war in Ukraine and global supply chain and inflationary pressures—will impact investment for 2022 and beyond. A detailed summary of positive and negative factors can be found in Table 1.

Table 1. Factors Affecting Adaptation Finance Flows in Africa

Positive Factors	
DFI commitments to adaptation finance continue to grow	Pre-pandemic, nine MDBs announced a collective commitment to double their total levels of adaptation finance by 2025, to US$18 billion annually.[12] Toward that end, the World Bank announced a 35% target for climate finance as a proportion of total finance from 2021–2025, of which at least 50% will support adaptation. The African Development Bank (AfDB) has committed to a target of at least 40% for climate finance by 2025, to a doubling of climate finance to US$25 billion between 2020 and 2025, and to prioritizing adaptation finance. While simultaneously mobilizing massive resources toward the global COVID-19 response,[13] DFIs have increased adaptation investments in Africa by an estimated US$2.7 billion between 2019 and 2020.
Launch of innovative financing models	New innovative models for raising adaptation finance, such as the African Adaptation Acceleration Program (AAAP) jointly developed by the GCA and the AfDB, are beginning to be deployed. These instruments are designed to fill the financing gap facing adaptation projects, both by providing upfront capital and adjusting the risk-return profile of projects to meet the requirements of private investors. Between 2019 and 2020, tracked adaptation finance flows from grants and concessional debt in Africa increased by US$2.9 billion, with the potential to "crowd-in" commercial capital going forward.
International commitments at COP26	Additionally, COP26 outcomes included a call to action for developed countries to double their collective provision of adaptation finance from 2019 levels by 2025; strengthened adaptation finance pledges from multilateral organizations, governments, and private actors; and increased allocation of proceeds from market-based mechanisms toward adaptation.[14] The African Group of Negotiators on Climate Change is attempting to mobilize US$1.3 trillion in climate finance by 2030, with adaptation remaining a top priority.[15]
Negative Factors	
Capacity constraints	A number of capacity constraints within African countries limit access to adaptation finance. Many institutions, including National Designated Authorities (NDA), Direct Access Entities (DAEs), and other Accredited Entities (AEs), have constrained access to finance from climate funds given the significant technical and institutional capacity required to build project pipelines and generate proposals to climate funds including the Green Climate Fund (GCF).[16] Furthermore, there is a lack of reliable and accessible information about climate risks and impacts in many contexts. This lack of information combines with limited capacity to process available climate data and to translate findings into the necessary resilience measures.
Limited inclusion of resilience in stimulus packages	In the 2021 UNEP Adaptation Gap Report,[17] analysis of the fiscal stimulus packages of 66 countries—including all G20 and V20 countries—showed that less than one-third (18) of the responses were found to integrate physical climate-risk awareness and resilience components, including just three African countries: Niger, Ethiopia, and Kenya. As national budgets were strained during the pandemic, annual adaptation finance provided by domestic governments rose by only an estimated US$156 million between 2019 and 2020.
Minimal private sector investment	Although capital outflows stabilized relatively soon after hitting record lows in March 2020, total foreign direct investment (FDI) declined 16% in 2020 in Africa to US$40 billion, a decline to 2005 levels of investment.[18] While annual tracked private investment for adaptation in Africa rose between 2019 and 2020 by around US$114 million, private investment only comprised 2% of total adaptation finance during the period.
Africa debt crisis	The macroeconomic strain caused by COVID-19 will continue to affect 2021 finance flows, with governments and private investors particularly impacted. 56% of African countries with a credit rating suffered downgrades in 2020, further weakening the financing ability of domestic governments.[19] Despite this setback, FDI in Africa has rebounded in 2021, with positive growth in nearly all sub-regions.[20]
Aftermath of COVID-19 and war in Ukraine	Since early 2022, the ongoing war in Ukraine has caused sudden hikes in energy and food prices, with massive disruptions to the international trade and supply chain systems. The uncertainties around food security and energy access may significantly affect the adaptation outcomes of planned and future projects. Even though adaptation financing flows from bilateral governments, and to a lesser extent from DFIs, can be expected to face constraints as resources are directed toward humanitarian aid, there are significant opportunities for building long-term adaptive capacity and resilience through a holistic and coordinated approach.

SOURCES OF ADAPTATION FINANCE

To mobilize further adaptation investment and to increase the impact of investments in terms of building resilience, a wide variety of sources of finance need to be tapped. Public spending alone cannot meet the adaptation finance gap, so private sector investment must scale up alongside public investment to supplement limited public resources.[21] One initiative seeking to bring together key financial institutions within Africa to mobilize private flows toward climate objectives is the African Financial Alliance on Climate Change (AFAC).[22] AFAC brings together multilateral, national, and regional development banks, central banks, commercial banks, institutional investors, stock exchanges, insurance companies, and ministries of finance to increase alignment on initiatives to mobilize private capital to climate action. AFAC and other initiatives to galvanize partnerships to mobilize adaptation finance (including the Africa Adaptation Acceleration Program and the Africa Adaptation Initiative) are critical to leveraging the wide variety of finance sources that must play a role in increasing adaptation finance volumes and efficacy.

Figure 3 summarizes the financial actors that have a role to play in mobilizing finance for adaptation at scale in Africa. These actors offer financing along a spectrum of terms, ranging from highly concessional terms (lower return expectations and/or longer tenors) to commercial terms (market returns and tenors expected). Concessional capital is intended to fill a gap where the private sector (commercial capital) would not otherwise invest.

Photo: 2015CIAT/GeorginaSmith/Flickr

Figure 3. Current and Potential Sources of Adaptation Finance in Africa

Offer Finance on Commercial Terms

- **Commercial Banks:** Commercial banks can raise their own funds through bank deposits and are governed by international standards set by Basel II and Basel III regulations for capital adequacy. Commercial banks have networks that can be leveraged for climate adaptation finance, including relationships with farmers, cooperatives, and micro-, small, and medium-sized enterprises (MSMEs). Commercial banks can also build technical capacity to structure financial instruments in partnership with development banks and other concessional finance providers. A constraint for commercial banks in Africa seeking to increase investment in climate adaptation activities is that they have historically tended to focus on relatively large firms and retail clients. Thus, as of 2014, 57 percent of the African population remained unbanked.[23]
  - **Pan-African Banks (PABs):** PABs can invest in MSMEs and mainstream resilience into their lending portfolios. PABs have been successful in increasing African firms' access to finance and increasing competition and efficiency in the banking industry, and can have a positive impact on micro-prudential stability. The Invest in Africa Initiative's members include pan-African and domestic commercial banks; it has also developed an online learning academy for small and medium-sized enterprises (SMEs). These initiatives and engagements create an opportunity to raise awareness of climate-related risks and increase capacity to invest in adaptation.[24]
- **Private Equity and Venture Capital:** Africa's private equity industry was cultivated by DFIs that had a mandate to invest in private sector businesses in Africa to promote social and economic development. Gradually the industry expanded and there are now more than 400 private equity, venture capital, and asset management firms headquartered in Africa spread across regions and sectors. Private equity and venture capital are critical to scaling up adaptation finance in Africa because they can offer risk-tolerant finance to companies with limited access to bank loans or bonds.[25]
- **African Institutional Investors:** African institutional investors have approximately US$1.8 trillion in assets under management as of 2020. Institutional investors' core goals are capital gains and stabilization of returns over the long term. They have high capacity to mobilize funds through pensions and their prudential responsibilities require them to invest in assets that are listed and with high credit ratings.
  - **Sovereign Wealth Funds (SWFs):** SWFs invest in domestic markets and have the potential to finance adaptation-focused securities and government bonds. As detailed later in this chapter in a case study on Ghana, the Ghana Infrastructure Investment Fund (GIIF) SWF is currently seeking GCF accreditation. If able to tap into GCF funds, the GIIF could emerge as a key resilience infrastructure investment vehicle in Ghana.
  - **Pension Funds:** Pension funds are instrumental in mobilizing long-term savings and can thus support long-term adaptation investments. Pension fund assets under management in Africa have increased substantially in the last several decades and can provide key funding to private equity and venture capital markets in particular. For example, total assets under management in Nigeria's pension sector increased more than ninefold from 2006 to 2019

(to US$33 billion), illustrating the size of the potential opportunity for targeted adaptation investment.[26]

- **Insurers:** Insurers can play a role in providing sovereign cover for the impact of climate change (for example, the African Risk Capacity, which offers index-based weather risk insurance) and in helping households cope with risk of climate-related shocks. Insurance penetration is concentrated in a few major markets like South Africa, Egypt, Morocco, Nigeria, and Kenya. Many insurance companies must undertake qualitative and quantitative assessments of impact of physical and transition risks on their investment portfolios. Hence many insurers have advanced technical capacity to evaluate climate risks and to innovate via climate risk-transfer mechanisms.
- **Large Corporations:** Sustainability and resilience in food production and supply chains are increasingly a focus for large multinational corporations, especially those with global supply chains. Corporations have the potential to deploy finance (including potential issuance of climate resilience bonds) and technology at scale to undertake adaptation measures, though such measures will be largely focused on their own supply chains. Strategies reported by corporations to date in Africa to address climate risk include investing in physical climate risk analysis, supporting sustainable agroforestry in response to climate-related forestry risks, and investing in climate-smart capacity building for farmers in their supply chains.
- **Multilateral and Bilateral DFIs:** In every African Union region, the largest amount of adaptation finance tracked in 2019–2020 was from multilateral DFIs. DFIs play a critical role in mainstreaming adaptation in development finance by assessing climate risks and vulnerability, assisting country governments to build capacity for mainstreaming adaptation, and mobilizing private capital. DFIs are also uniquely placed to support adaptation investments in the private sector, which can create positive externalities for social and economic development. DFIs can bridge knowledge gaps through tools such as feasibility studies, business risk assessments, technical assistance, and market studies.
- **Sub-Regional Development Banks (SRDBs):** SRDBs have a mandate to contribute to regional integration and regional infrastructure development projects. Four African SRDBs (Eastern and Southern African Trade & Development Bank, East African Development Bank, West African Development Bank, and Economic Community of West African States (ECOWAS) Bank for Investment and Development) are operational in Africa in three separate Regional Economic Communities. ECOWAS, for example, is in the process of developing a regional climate strategy, and published an ECOWAS Guide to implementation of the Paris Agreement in September 2020 for its member states. SRDBs are relatively financially stable and shareholding countries generally report satisfaction with their performance, which makes them potentially suitable to mobilize more capital to finance adaptation in Africa.
- **National Development Banks (NDBs):** NDBs are state-owned or government-sponsored financial institutions with a primary mandate of providing long-term and concessional capital to high-risk sectors and industry, which are underserved by private commercial banks and contribute to the country's development agenda. NDBs are important intermediaries for international climate finance and more than 10 currently have direct access to GCF funding. NDBs' expertise

in domestic market opportunities, relationships with public and private sector entities, partnerships with large international MDBs, access to international capital markets to raise capital from a wide range of sources, co-lending ability in local currency for risk mitigation instruments like guarantees, and countercyclical nature of lending make them potentially important for financing resilient development in Africa.

- **Multilateral Climate Funds:** Multilateral Climate Funds established through international agreements or for a specific mandate provide financing for adaptation in Africa either through grants or market-linked instruments. They are catalytic in facilitating and accelerating financing in perceived high-risk adaptation projects by providing instruments like first-loss or junior equity, repayment guarantees, and grants to mobilize private investments.
- **National Climate Funds (NCFs):** These are national, country-driven, dedicated, catalytic financial institutions designed to address domestic market gaps, take ownership of climate finance, and crowd-in private investments in low-carbon and resilient projects. NCFs have the potential to provide integrated access to grants and finance to meet NDCs and also have strong potential to mobilize private sector investments. For example, as detailed later in a case study on Rwanda, the Rwanda Green Fund (FONERWA) serves as the main vehicle for climate finance in the country.
- **State-owned Enterprises (SOEs) and Financial Institutions:** SOEs are public entities that are partly or wholly owned by government to deliver services in a particular sector or sectors. SOEs have not financed many climate adaptation activities to date, but have substantial opportunity to lead in climate resilience given the size of their market share and public governance model.
- **African Governments:** Budgetary allocations are among the largest and most well-suited mechanisms for financing adaptation activities in Africa. African governments are already spending a considerable share of their budget on adaptation.[27] African governments are instrumental in deploying capital to non-commercial adaptation activities and current levels of expenditure meet around 10 percent of the total adaptation need.[28] As an illustration of the key role of African governments in deploying climate finance (as detailed later in a case study on Kenya), of the US$2.4 billion in climate finance committed in Kenya in 2018, 28 percent (US$670 million) came from public domestic sources, which include national ministries, subnational departments, and semi-autonomous government agencies.
- **Foreign Government Agencies:** Official development assistance (ODA) is a critical component of adaptation finance in Africa to de-risk adaptation activities and support more commercial finance. Bilateral agencies have a relatively high-risk appetite and strong climate mandates. Increasing global ambition should yield an increase in ODA for adaptation in Africa as countries seek to increasingly achieve a balance between adaptation and mitigation commitments in alignment with Article 9.4 of the Paris Agreement.
- **Philanthropies, Foundations, and Non-Profits:** Like ODA, funding from these organizations can de-risk adaptation activities, draw in private finance, and support technical capacity building. Philanthropic funding is nimbler and more flexible than ODA and can serve as catalytic capital for private sector investment.

Offer Finance on Highly Concessional Terms


Photo: guenterguni/iStock

CASE STUDY: Addressing the Domestic Investment in Adaptation Gap in Ghana and Rwanda

Context and Introduction

As part of their NDCs, Ghana and Rwanda have estimated their adaptation finance needs at US$12.8 billion[29] and US$5.3 billion,[30] respectively, from 2020 to 2030. Both countries have identified agriculture, human settlements, water, transport, and health as key sectoral priorities for adaptation investment. Ghana aims to cover almost one-third of adaptation finance needs through domestic sources, and Rwanda has announced its intent to cover almost 40 percent of its total mitigation and adaptation needs by leveraging domestic sources of finance.[31] Both countries have developed a range of policy frameworks and strategies to support the mobilization of domestic finance toward climate adaptation, including developing specific climate finance instruments, working to mainstream climate adaptation throughout the public sector, and engaging the private sector. These are now discussed in more detail.

Developing Tailored Climate Finance Instruments

In Ghana, the GIIF SWF is currently seeking GCF accreditation.[32] If able to tap into GCF funds the GIIF could emerge as a key resilience infrastructure investment vehicle. To this end, in 2021 Ghana launched the Green Climate Fund Readiness Program, which aims to support the Ghanaian Government in strengthening national capacities to plan for, deliver, and monitor climate finance, as well as build private sector capacity.[33] The country also has issued sovereign bonds with adaptation components.[34]

The Rwanda Green Fund (FONERWA) serves as the main vehicle for climate finance in the country. While originally capitalized by the UK, Rwandan, and German Governments, FONERWA's budget is now sourced from both public and private domestic and international sources. On the domestic side, funding sources include the state-allocated budget, grants and subsidies, and various fines and fees from environmental penalties.[35] FONERWA is incorporated into the Rwandan Ministry of Natural Resources but has its own administration, including a Managing and a Technical Committee. The Managing Committee cooperates with public and private sector stakeholders, while the Technical Committee aims to ensure all projects are in line with national adaptation priorities and to avoid duplication with other government or private sector–led projects.

Further, the Government of Rwanda in partnership with the AfDB is developing the Rwanda Catalytic Green Investment Facility (RCGIF), which will utilize blended financing structures for not-yet-bankable projects through direct loans and credits issued by the Development Bank of Rwanda, and a project preparation facility at FONERWA to increase the bankability of projects.[36]

Mainstreaming Climate Adaptation Throughout the Public Sector

Setting up a coherent and proactive policy environment is key to enhancing the effectiveness of climate finance and can in the long run strengthen countries' ability to tap into wider and more varied sources of finance.[37] In 2011, Rwanda launched its Green Growth and Climate Resilience National Strategy,[38] which aimed to mainstream climate change and low-carbon development into all areas of the economy and policymaking, with special emphasis on climate resilience.[39] Further, Joint Sector Reviews were set up to foster cross-sectoral dialogues across relevant ministries, non-governmental actors, and the public.

Ghana has identified limited in-country capacity and a siloed approach toward climate finance proposals across Government ministries as key challenges to meeting its climate adaptation finance needs as outlined in the NDC.[40] The government has announced plans to work on creating an enabling environment to attract private sector funds and to enhance domestic revenue mobilization through improvements in compliance, widening the tax net, digitization, and tax policies.

Indeed, adequate tax incentives and expanding the countries' tax base are key to mobilizing public funds. A joint study by Action Aid, the Government of Ghana, and the Integrated Social Development Centre estimates that because of misaligned tax incentives,[41] Ghana may be missing out on close to US$1.2 billion annually in general tax revenues that could be directed toward climate finance, among others. The Ghanaian Ministry of Finance has identified improvements in compliance, widening the tax base and reassessing tax policies as key next steps to fulfill the country's NDC.[42] Supporting initiatives to establish new specialized Funds to finance resilient infrastructure, deepening of bond markets, establishing Strategic Development SWFs, and using existing sovereign-backed pension funds for development projects are further recommended steps for the mobilization of domestic financial resources.

Lessons Learned

Private sector adaptation finance mobilization remains a challenge in both countries. To date, most entities engaging in climate finance have focused their efforts on mitigation.[43] Lack of government incentives for private sector involvement and limited awareness of public initiatives in this space are often cited as key barriers to private sector finance for adaptation. Moreover, SMEs in these countries often lack access to credit and funding, which limits their ability to invest in resilience measures.

In Rwanda, supported by several grants, FONERWA has developed capacity-building trainings specific to private sector actors and routinely holds private sector stakeholder engagement workshops.[44] The Fund, which also received grant funding to build capacity to identify climate interventions within the private sector, actively seeks out private sector project co-finance and reserves 20 percent of funds for private sector projects. More generally, in both cases, public-private partnerships, the use of compliance, and voluntary carbon market mechanisms have been put forward as potential options to attract private sector funds.[45]

Photo: brittak/iStock

CASE STUDY: Tracking Domestic Public Finance for Adaptation in Kenya

Context and Introduction

Kenya is among the most water-scarce countries in the world and nearly half the population lacks access to basic water services.[46] Recurring droughts, flooding, and sea level rise will compound the issue resulting in severe crop, livestock, infrastructure, and freshwater losses in turn leading to widespread famine and displacement. Kenya's economy is heavily reliant on climate-sensitive sectors like fishing, agriculture, and forestry, which make up more than a third of its GDP and are already fragile from the 2020 locust invasion[47] and COVID-19 pandemic.[48]

To respond to the significant climate risk facing the country, Kenya passed the Climate Change Act of 2016 and the National Climate Change Action Plan (NCCAP) to provide a framework for coordinating adaptation and mitigation efforts.[49] A landmark analysis from 2018 found that Kenya invested roughly US$2.4 billion in public and private capital from both domestic and international sources toward climate projects.[50]

Kenya estimates that it will need US$65 billion through 2030 to achieve its NDC goals. The national government plans to provide 13 percent of the funding, and the rest would be provided by international development partners.[51] An analysis of the sources, instruments, destinations, and accuracy of Kenya's domestic public climate finance flows captures the breadth of the national and international efforts needed going forward to meet Kenya's NDC.

Public Domestic Climate Finance in Kenya

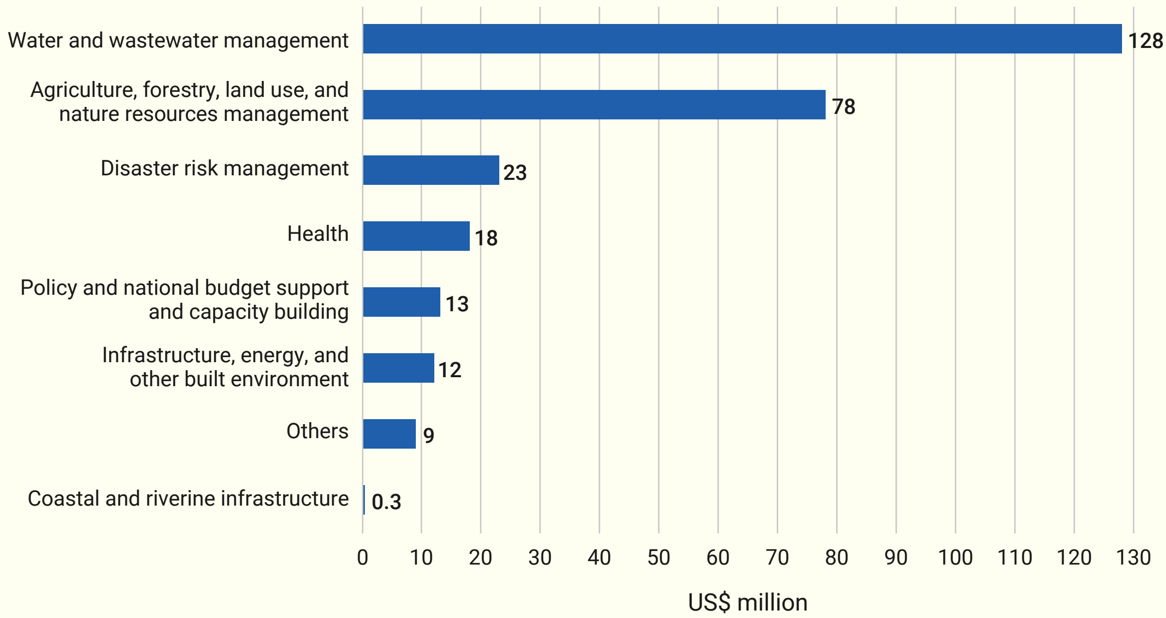
Of the US$2.4 billion in climate finance committed in Kenya in 2018, 28 percent (US$670 million) came from public domestic sources, which include national ministries, subnational departments, and semi-autonomous government agencies.[52] Roughly half the US$670 million was committed through the Government's central budget and the other half through semi-autonomous government agencies in the form of equity.

Only 12 percent of all climate finance funds committed in 2018 across domestic, international, public, and private sources were directed toward adaptation, most of which was spent in water and wastewater management. Figure 4 breaks down the sub-sectoral investments across these adaptation efforts. However, 30 percent of the climate finance channeled through the Kenyan Government's central budget was allocated to adaptation projects, indicating a higher sensitivity to adaptation needs compared with most investors.

The sectoral breakdown of domestic equity financed projects was more difficult to ascertain due to a lack of visibility of expenditure data from semi-autonomous government agencies, which are the primary recipients of domestic and international finance flows.[53] They are responsible for budget implementation, making them the de facto implementers of climate projects in Kenya.[54] This lack of visibility makes it challenging to get an accurate overall picture of climate finance in Kenya.

> **"Africa is facing three major challenges which are called the three Cs: COVID, climate and conflict. The solution to the three Cs is the same, three Fs: finance, finance and finance."**
>
> **Dr. Akinwumi Adesina**
> President, African Development Bank

Figure 4. Climate Finance In Kenya By Adaptation Sub-Sector (US$million)



Recommendations and Lessons Learned

Improving climate finance visibility is vital in enabling governments and international investors to operationalize their capacity to act on the data and close investment gaps. For example, after the release of the 2021 Landscape of Climate Finance in Kenya report the central Government issued a new training handbook and Government-wide circular for tracking and reporting climate finance spending. Broadly speaking, this transparency and accuracy in climate finance flows is vital in Kenya and across Africa to help the national ministries, DFIs, and international investors to know which sectors to prioritize for future investments in order to close the gaps and build resilience where needed.

There is a need for African nations to modernize their public financial management systems to enable more granular levels of climate finance expenditure tracking. Kenya needs expenditures from all ministries, departments, and semi-autonomous government entities to be reported through the central Government's public financial management system, known as the Integrated Financial Management Information System (IFMIS). A new analytical segment of the IFMIS called Segment 8 has been introduced but not yet rolled out, which would allow for distinct levels of tagging climate-related expenditures for adaptation, mitigation, and cross-cutting activities.[55] African nations should begin developing similar functionality in their finance ministries, without which climate expenditures will continue to be manually tagged in ad hoc ways with conflicting information and double counting impairing the accuracy of the data.

Adaptation frameworks need to be institutionalized into ministries and departments that oversee tagging and tracking of climate finance expenditures. Due to definitional issues, much of Kenya's adaptation finance could not be properly tracked. However, Kenya had already developed a Tracking Adaptation and Measuring Development (TAMD) framework in its National Adaptation Plan, which contained a series of top-down county-level institutional adaptive capacity indicators and bottom-up vulnerability indicators that spanned the national and sectoral levels.[56] There is a need for these existing taxonomies and frameworks, both in Kenya and other African countries, to be substantively used and to filter down to the line ministries that are tasked with tagging climate finance. This will help align climate projects implemented by entities at different levels of government as that data is fed into a public financial management system, thus streamlining data reconciliation and improving the quality of the qualitative information that is reviewed and tagged for adaptation.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CASE STUDY: Egypt's Green Sovereign Bond

Context and Introduction

Egypt's Nile Delta faces significant climate risks.[57] Sea level rise and flash floods will likely lead to inundation and erosion of a sizeable portion of the northern delta, and extreme heatwaves and dust storms will severely strain water resources and the agriculture sector, which employs a third of the country's labor force. In response to these threats, Egypt has launched Vision 2030, a holistic sustainable development strategy that includes specific aims to prepare the country for climate change. As part of this effort, Egypt's Ministry of Finance debuted the first sovereign green bond for the Middle East and North Africa region in September 2020.[58]

Green bonds are a debt instrument that allows the issuer to raise finance as through a typical bond but where the proceeds are earmarked for projects with environmental benefits. Green bonds have been used in other contexts, such as the world's first sovereign blue bond issued by the Seychelles in 2018 to support sustainable marine and fisheries projects.[59] Ghana has also recently implemented a green bond program called the Green Exchange, which aims to raise US$5 billion.[60]

Egypt's green bond was met with significant investor interest. The initial US$500 million sale was oversubscribed by more than seven times with US$3.7 billion of purchase orders. This prompted the Egyptian Ministry of Finance to increase the sale to US$750 million and lower the investor return to 5.25 percent—the lowest yield for a five-year bond in the country's history.

Relevance of Green Bonds to Adaptation in Africa

Fifty-four percent of the green bond proceeds, or roughly US$400 million, have been spent on 14 water and wastewater projects including desalination and sludge treatment facilities. The remaining 46 percent, about US$350 million, has been spent on clean transportation to build a monorail system from Cairo to the new capital known as the New Administrative Capital. Egypt has passed an independent review certifying that the program meets the International Capital Markets Association's Green Bond Principles.

Though the aims of Egypt's green bond issuance are not solely adaptation focused, the bond aligns relatively closely with the Climate Bonds Initiative's (CBI) climate resilience principles advanced in 2018. The principles broadly seek to determine whether the proceeds from a green bond sale are invested in a way that either enhances the climate resilience of an asset over its lifespan or increases the climate resilience of a broader sector/system.

CBI has outlined six illustrative examples of investments that would enhance the resilience of an asset, including relocating at-risk infrastructure and implementing drought-resistant seeds. CBI also noted six sectors that would enhance the resilience of a broader system including—with most relevance for Egypt's green bond—water, which encompasses investments in wastewater treatment, desalination, and strengthened water distribution.[61] Table 2 notes the elements of close alignment between Egypt's green bond issuance and CBI's climate resilience principles. This evaluation is intended to help explain Egypt's bond through the lens of climate resilience but is not intended to be definitive given the limited public information available to make a comprehensive expert assessment.

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Table 2. Alignment between Egypt's Sovereign Green Bond and CBI's Climate Resilience Principles

Resilience Bond Principle	Egypt Green Bond Alignment
Assets and activities receiving investment must have clearly defined boundaries and identify interdependencies for assessing climate risks and resilience impacts	Egypt has defined seven categories of assets and activities eligible to be financed: energy efficiency, renewable energy, sustainable transport, green buildings, waste and water efficiency, energy management systems, and non-greenhouse-gas (GHG) reduction energy management systems. During the screening process, a team utilizes the International Finance Corporation's (IFC) Climate Assessment for Financial Institutions tool,[62] which notes that an adaptation project should reduce risk, exposure, and sensitivity to climate change and also increase climate resilience.[63] As part of the green bond issuance process executed by the Commercial International Bank (CIB), the green bond issuer, the findings are also vetted by a Green Bond Task Force.[64]
Expected climate resilience benefits assessment must be undertaken for system-focused assets and activities receiving investment	Egypt has determined resilience benefits for its water treatment projects across cubic meters/day of treated water, megawatt hours of electricity generated, and number of people benefiting from the projects.[65] It has outlined a formal set of impact indicators that inform six green bond project types: energy efficiency, renewable energy, green buildings, sustainable transportation, water and wastewater, and waste projects. Indicators for its primary resilience project type, water and wastewater, include annual absolute (gross) water use before and after the project in m^3 per year, reduction in water use (in percentages), and annual absolute (gross) amount of wastewater treated, reused, or avoided before and after the project in m^3 per year or as percentages.[66]
Mitigation tradeoffs must be assessed	Egypt has calculated the GHG emission reduction benefits for its projects[67] and reports on any emissions generated,[68] thus allowing for mitigation tradeoff analyses.
There must be ongoing monitoring and evaluation	Egypt will conduct an annual report evaluating the use of its green bond proceeds[69] while also establishing a national committee for monitoring progress on the UN Sustainable Development Goals.[70]

Recommendations and Lessons Learned

Though Egypt's green bond is not solely climate adaptation focused, it has significant potential to deliver climate resilience benefits. Other countries can benefit from the lessons learned from Egypt's implementation to move forward with similar initiatives. African DFIs and ministries of finance can, for example, look to leverage and potentially replicate Egypt's Regional Center for Sustainable Finance (RCSF) to build institutional capacity. Following the launch of the green bond program, Egypt established the RCSF with the aim of removing market barriers in the Middle East and North Africa region to integrate sustainable finance practices, instruments, and management models. African nations should take advantage of RCSF's training and educational institutes for capacity building on sustainable finance literacy, debt management operations, cross-ministry coordination, and technical support for setting up their own green finance programs.

Egypt's green bond issuance also benefited from the establishment of a robust legal and green financing framework in collaboration with international finance institutions including the World Bank and the IFC. Egypt brought together three crucial ingredients that enabled the right economic and political conditions for its green bond program, setting a template for other African nations to model. First, early involvement from key ministries who established a guiding green bond framework, thus imparting confidence in the sustained political support for the program.[71] Second, utilizing the CIB, the nation's largest private bank, to issue the green bond sale. This ensured that the deposits were held in a separate account in a safe and liquid part of the domestic financial system, which made it easy to provide proof of documentation and tracing of project and category level allocations during audits. Lastly, partnering with the World Bank and IFC to act as technical advisors on the project created global credibility on the execution of the sale and use of proceeds and served to guide assessments of impact indicators.[72] Awareness of these ingredients for success will be valuable for replication and scale.

Finally, concessional funding from DFIs, foreign governments, and foundations could help increase climate information collection to bolster the adaptation relevance of green bond-financed projects moving forward.[73] This information could unlock further investor interest and set up a future pipeline of resilience-focused projects. In Egypt and beyond, this work could allow countries to expand the resilience pipeline and promote further liquidity in the green bond market and prove investor demand.[74]

BARRIERS

There are cross-sectoral barriers as well as sector-specific barriers hindering investment in adaptation activities. Table 3 summarizes key barriers to investment across seven key sectors assessed in this analysis alongside cross-cutting barriers that affect investment potential across sectors.

Table 3. Barriers to Mobilizing Adaptation Finance by Sector and Cross-Cutting

Sector	Barriers
Cross-cutting	**Constrained macroeconomic environment:** The macroeconomic strain caused by geopolitical and health conditions, including the COVID-19 crisis and ongoing war in Ukraine, will continue to affect adaptation finance flows. Credit rating downgrades may weaken the financing ability of domestic governments and international governments and DFIs may face constraints as resources are directed toward humanitarian aid. **Inadequate risk-adjusted returns:** Returns do not compensate investors in developing countries for the additional risk associated with unfavorable regulations and policies, such as foreign investment restrictions. **Complexity of due diligence for projects:** Many private sector actors, including institutional investors, have largely avoided financing infrastructure projects across sectors in the region due to cost recovery challenges and the complexity of the technical due diligence. **Limited capacity to collect and analyze relevant climate data:** The lack of reliable and accessible information about climate risks and impacts, combined with limited capacity to process available climate data in infrastructure modeling and translate findings into the necessary resilience measures, makes it difficult to adapt proactively.
Water	**Lack of municipal/subnational implementation capacity:** Water projects often involve municipal or other subnational implementers with limited implementation capacity (to pursue finance, structure an adaptation project, or access climate analytics).
Agriculture	**Policy and regulatory barriers:** Lack of regulatory incentives for climate-smart agriculture in terms of priority lending and mal-incentives in regulatory environments with subsidies for non-adaptive crops. **Limitations in aggregation:** Difficulty in aggregating or securitizing many small-scale projects due to local contexts and disparate level of development.
Transport	**Variability of climatic conditions within a single project:** Transport projects are often cross-jurisdictional in nature and therefore face a complex range of climate risks. **Public sector orientation of the sector:** Even more than for other infrastructure projects, some elements of the transport sector including roads, railways, and ports are often publicly owned and operated and private sector investment involvement may not be feasible.
Energy	**Need for regional coordination:** As countries are tackling domestic energy security challenges separately, this is creating build-up of overcapacity in some countries and deficiencies in others. **Risk attitudes of decision-makers:** Given the long lifespan of energy infrastructure, ranging from 50 to 100 years for hydropower assets, it is critical to base expansions and new infrastructure investments on future climate projections. However, uncertainties around climate projections and the magnitude of associated revenue losses contribute to the lower risk capacity of decision-makers.
Urban infrastructure	**Lack of subnational fiscal autonomy:** Subnational borrowing capacities for infrastructure and other capital needs are severely constrained, making long-term planning for climate resilience challenging and creating delays in responding and recovering promptly from disasters.
Coastal ecosystems	**Challenging economics:** Adaptation in coastal ecosystems is often overlapping with flood risk management and land-use planning, which have significant public goods characteristics, making it difficult to build an economic case.[75]
Land use and forestry	**Multi-stakeholder solutions can create complexity for channeling funding:** Developing and implementing solutions in land use and forestry involves numerous actors and flows across sectors and jurisdictions. Coordination across these sectors and jurisdictions can make the design and implementation of funding solutions complex.


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RECOMMENDATIONS

Mainstream Adaptation and Resilience into Investment Decision-making

Many investors in Africa are already engaged in investment that has significant relevance to adaptation goals, but their investments are not yet climate-resilient. For example, a multinational corporation investing in Africa along an agricultural supply chain or an infrastructure investor building a water treatment facility will be operating in a sector with substantial climate risk, but may not be screening for climate risk nor mitigating that risk. To enable financial institutions to mainstream resilience into the investments they are making, the following steps are critical:

- **Increase access to robust climate information:** There is a critical lack of climate data in many parts of Africa, which limits adaptation projects and leads to uncertainty about the optimal approach to building resilience. The poorest countries have the most significant lack of climate data: either they are post-conflict or fragile states, or simply do not have the funding and technical resources to develop climate data such as groundwater baseline data, 24–48-hour precipitation data, and forward-looking climate projections. More targeted concessional finance and grants from DFIs, donor governments, and foundations are needed to support policymakers and other implementers in collecting and providing access to sufficient data, as well as to support collaboration and training on open-source models that can utilize the data. Across the board, there should be an emphasis on increasing access to high-resolution climate data at low cost so that implementers may undertake climate risk assessments as a basis for future adaptation planning.

- **Build capacity of African financial institutions and government entities to evaluate and act on climate risks:** A concerted effort should be made to increase membership of pan-African banks, locally based pension funds, and national development banks in international financial initiatives such as the UN Principles for Responsible Investment and Banking, and the International Development Finance Club—and to provide these institutions with the resources to participate actively. Capacity building is also crucial to strengthen African financial institutions' capacity to access finance from Climate Funds through pre- and post-accreditation support.

- **Require disclosure of climate risks, via national legislation and/or via DFI on-lending:** Domestic financial regulators in Africa should consider requiring financial institutions to disclose climate-related risks in line with the Task Force for Climate-Related Financial Disclosures (TCFD) recommendations. Moody's has found that the 49 banks it rates across Africa have more than US$200 billion in lending across sectors with high potential climate risk, so disclosure of climate risks is critical.[76]

Build an Enabling Environment for Adaptation Investment

The enabling environment in a country is critical to the viability of adaptation investment. Key factors that influence the strength of the enabling environment for investment in adaptation and resilience are reflected in Table 4 where a country with a strong enabling environment has the majority of these factors in place:

To build the enabling environment of countries that do not meet the key factors in the enabling environment captured in Table 4, key actions needed include:

- **Articulate investment-ready National Adaptation Plans (NAPs) and mainstream climate resilience in government procurement:** Having a nationally articulated strategy for adaptation is critical for establishing long-term expectations, identifying priority actions across sectors, and indicating areas for private sector participation. Only six countries in Africa have submitted NAPs to date, while 34 other countries have received funding or have submitted proposals to access funding from the GCF and the Least Developed Countries Fund (LDCF) for NAP development. Policymakers should ensure that adaptation planning is incorporated and mainstreamed into all relevant policy and procurements plans. An increased focus on climate adaptation mainstreaming within procurement plans in particular is critical to ensure that international infrastructure investment must screen for and build in resilience.
- **Build capacity to develop science-based policy and projects:** For much international public climate finance, there is a need to establish attribution between a climate impact and the corresponding action/measure that aims to mitigate that impact. This attribution is challenging, requires substantial quantitative and science capacity, and is often a critical factor for mobilizing adaptation finance.

  There is a substantial need to increase capacity to translate science into policy, and to translate policy into investment needs, for instance by utilizing climate resilience indicators to prioritize budget allocations. Resilience outcomes are also difficult to track against a moving baseline—for example, other development projects may have also contributed to improved social outcomes in a given region.
- **Improve macroeconomic environments and adopt a multifaceted approach to address debt burdens faced by African countries:** African finance ministers have called for external assistance of US$100 billion annually over the next three years to close a financing gap of US$345 billion to achieve a sustainable recovery.[77] The participation of private creditors will be critical to relieve existing debt burdens, requiring innovative financing models that set clear incentives. Additional actions that should be considered to address debt challenges in African countries include: 1) advancing efforts to link credit ratings with reductions in climate risk to incentivize resilience and lower the cost of debt; 2) continuing implementation of the Debt Service Suspension Initiative (DSSI) program and seeking as many avenues as possible for alleviating debt strain on African countries as a key strategy to increase domestic adaptation finance; and 3) exploring development of sovereign bonds with an adaptation component (e.g. Ghana's 2030 bond with an International Development Association guarantee of 40 percent) and scaling up sovereign debt-for-adaptation swaps to countries where conditions are viable.[78]

Deploy Innovative Finance Instruments

There is a wide array of available investment instruments, risk-finance mechanisms, and broader finance-relevant solutions that financial actors are already mobilizing in support of climate

Table 4. Key Factors in the Enabling Environment

Policy environment	Market environment	Institutional/stakeholder environment
• National adaptation plans/strategy in place • Regulations enforcing adaptation measures (i.e. building codes) • Availability and capacity to analyze climate data	• Access to international markets • Developed insurance market • PE/VC availability • Subnational borrowing capacity	• Availability of accredited entities for accessing climate finance • Engagement of NDBs, regional development banks, and other regional institutions

resilience across Africa. The universe of financial instruments captured in this analysis is represented in Figure 5. The level of "concessionality" required for certain instruments will vary by market or policy environment. Financial instruments can be used to finance activities that build physical resilience to climate change impacts (reducing physical risk) and are also useful in responding to risks where physical climate impacts cannot or have not been eliminated (through risk-transfer and risk-reduction instruments).

It is critical to carefully select a financial instrument or structure that meets the conditions and activities targeted. Selection of appropriate financial instruments must be informed by the sectoral focus of the adaptation activity, underlying country-level policy and market conditions, and the stakeholders and actors engaged. Instruments will only function successfully when they target an appropriate context. Key factors that must be considered when designing an instrument include currency stability, strength of the project pipeline, strength of debt capital markets, presence of a strong policy environment, existence of a sovereign credit rating, existence of a corporate bond market, robustness of climate information, and engagement/existence of a domestic private sector.

Figure 5. Financial Instrument Types

PURPOSE

Risk Reduction	Risk Retention and Risk Transfer

Grants: Funding (non-repayable or reimbursable) typically used for technical assistance, early-stage project development, and capacity building

- Development grants
- Technical assistance funding
- Project preparation facilities

Project Finance: Typically involves direct debt or equity investments into a single project; can be fully commercial, or forms of concessional finance could include loan guarantees, first-loss debt, and off-taker guarantees

- Direct infrastructure debt and equity investments
- Public–private partnership (PPP) financing

Financing Facilities: Involve debt or equity funding for a pool of projects, companies, or individuals (as opposed to single projects); can offer varying levels of concessionality including subordinate debt or equity, longer debt tenors or fund horizons, or supplemental grant capital

- Private equity funds
- Debt facilities

Results-Based Finance: Involves debt or grant capital for a project or portfolio of projects that is contingent on the achievement of a certain climate adaptation outcome

- Impact notes and climate bonds
- Conservation trusts

Debt-for-Climate (DFC) Swaps: DFC swaps are a type of debt swap in which the debtor nation, instead of continuing to make external debt payments in a foreign currency, makes payments in local currency to finance climate projects domestically on agreed terms

- DFC adaptation swaps

Liquidity Instruments: Grant or debt facilities designed to provide immediate access to capital; typically established to help governments, businesses, or individuals cover their immediate needs in the wake of a major event

- Shock-responsive cash transfers
- Liquidity support
- Budget reallocations

Insurance: The most common form of risk transfer and captures catastrophe bonds, parametric insurance, index insurance, and risk pooling

- Parametric insurance and index insurance
- Risk pooling
- Catastrophe bonds

Three examples of financial instruments implemented to finance adaptation in Africa that match well with the conditions of the implementing context are:

- **The Food Securities Fund**. The Food Securities Fund seeks to provide working capital loans to agricultural aggregators (cooperatives, processors, traders) operating in developing and emerging markets. The fund has been developed by Clarmondial with input from leading institutional investors, agribusinesses, and conservation organizations and aims to provide an additional source of timely and affordable credit to support the transition to sustainable agriculture, notably on climate mitigation, sustainable land management, rural livelihoods, and gender. The fund targets local SMEs operating in established value-chain relationships and will be most successful in markets where there are relevant agri-SMEs and where access to working capital is scarce. The fund will also appeal to investors primarily in areas where institutional investors have an interest in SDG-aligned fixed income and private credit investments and which are primarily targeting European and US institutional investors (banks, pension funds, insurance companies).
- **DFC Swap – Seychelles.** In 2017, the Seychelles became the first country to successfully undertake a DFC swap aimed at specifically protecting the world's oceans. The Nature Conservancy (TNC) acquired Seychelles' foreign external debt at a discounted price and raised additional donor funding worth US$5 million from private actors. The Government of Seychelles will repay the loans to a specially created Seychelles Conservation and Climate Adaptation Trust by TNC. Key conditions met within the market and policy enabling environment that led to the success of the swap

include: the country has a high level of public external debt held bilaterally by other sovereigns, is in a position to service their debt but has a limited fiscal capacity to mobilize domestic public climate finance, and had high-level political and whole-of-Government support.

- **Komaza Smallholder Forestry Vehicle (SFV).** A forestry business based in Kenya whose mission is to move small-scale farmers out of poverty. SFV is an instrument that packages tree production partnership contracts with thousands of smallholder farmers and sells them to investors, providing farmers and forestry companies with access to low-cost, long-term finance while enabling institutional investors to access sustainable forestry investments. The instrument has broad applicability in terms of a market and policy enabling environment because it is based on funding to and contracts with individual farmers.

CONCLUSION

African countries are among the most at risk of increasing frequency and severity of climate-related shocks and stressors. There is a pressing need to invest in climate change adaptation to support individuals, SMEs, municipalities, corporations, financial actors, and governments in building resilience to climate impacts. To date, climate adaptation finance which are scaling far too slowly to build climate resilience, even as the costs of climate impacts rise.

- To mobilize the levels of investment needed and to increase the resilience impact of these investments, a wider variety of sources of finance must be tapped. A three-pronged strategy is needed to tap the wide range of potential actors: 1) mainstream adaptation and resilience in investment decision-making; 2) build an enabling environment for adaptation investment; and 3) aggressively deploy innovative finance instruments at scale toward adaptation activities. Action taken now across the full range of potential adaptation finance sources will be critical to determining the course of Africa's capacity to respond to present and oncoming climate impacts and to building a more climate-resilient and livable future.

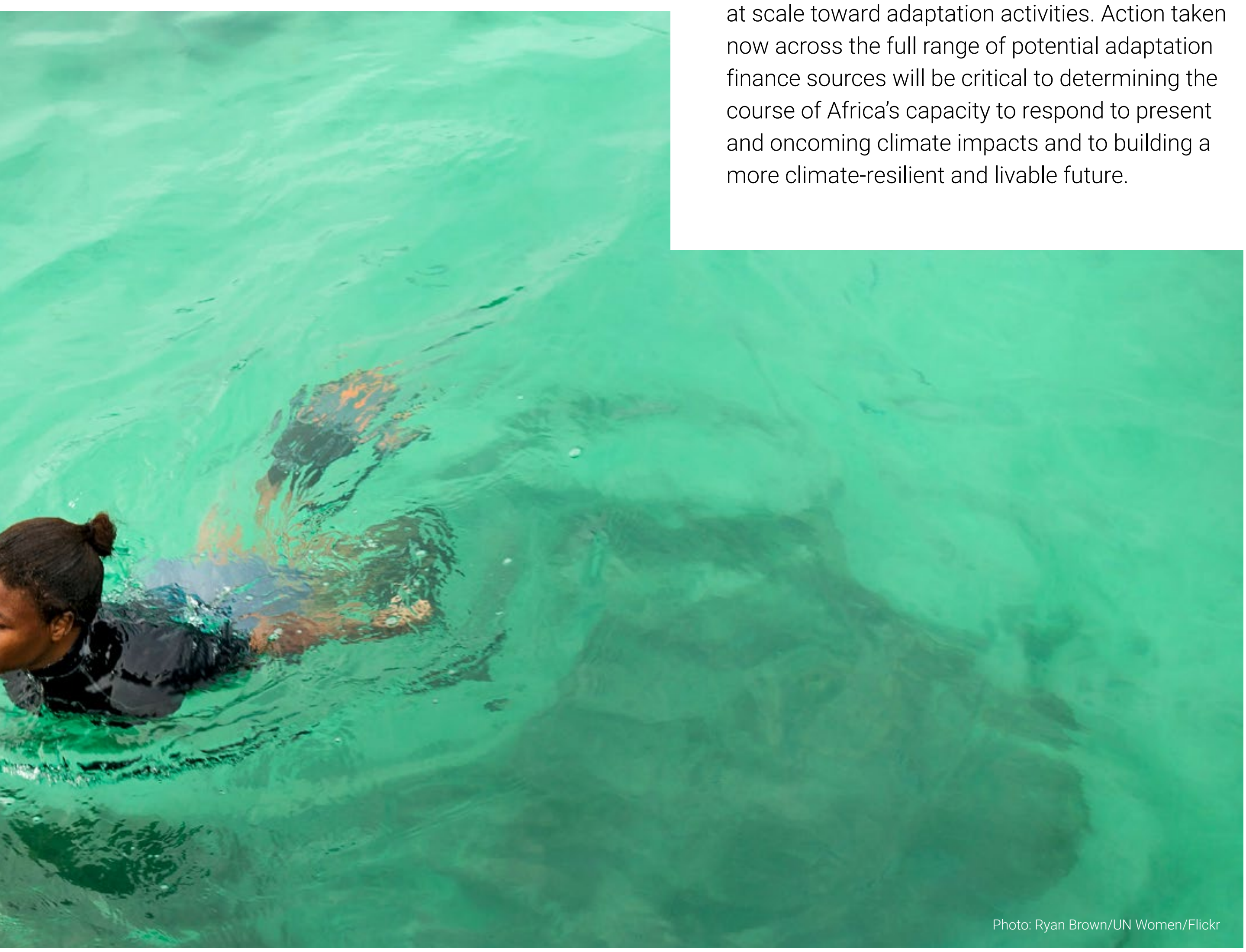


Photo: Ryan Brown/UN Women/Flickr

Fiscal Policies for Adaptation: IMF Perspective

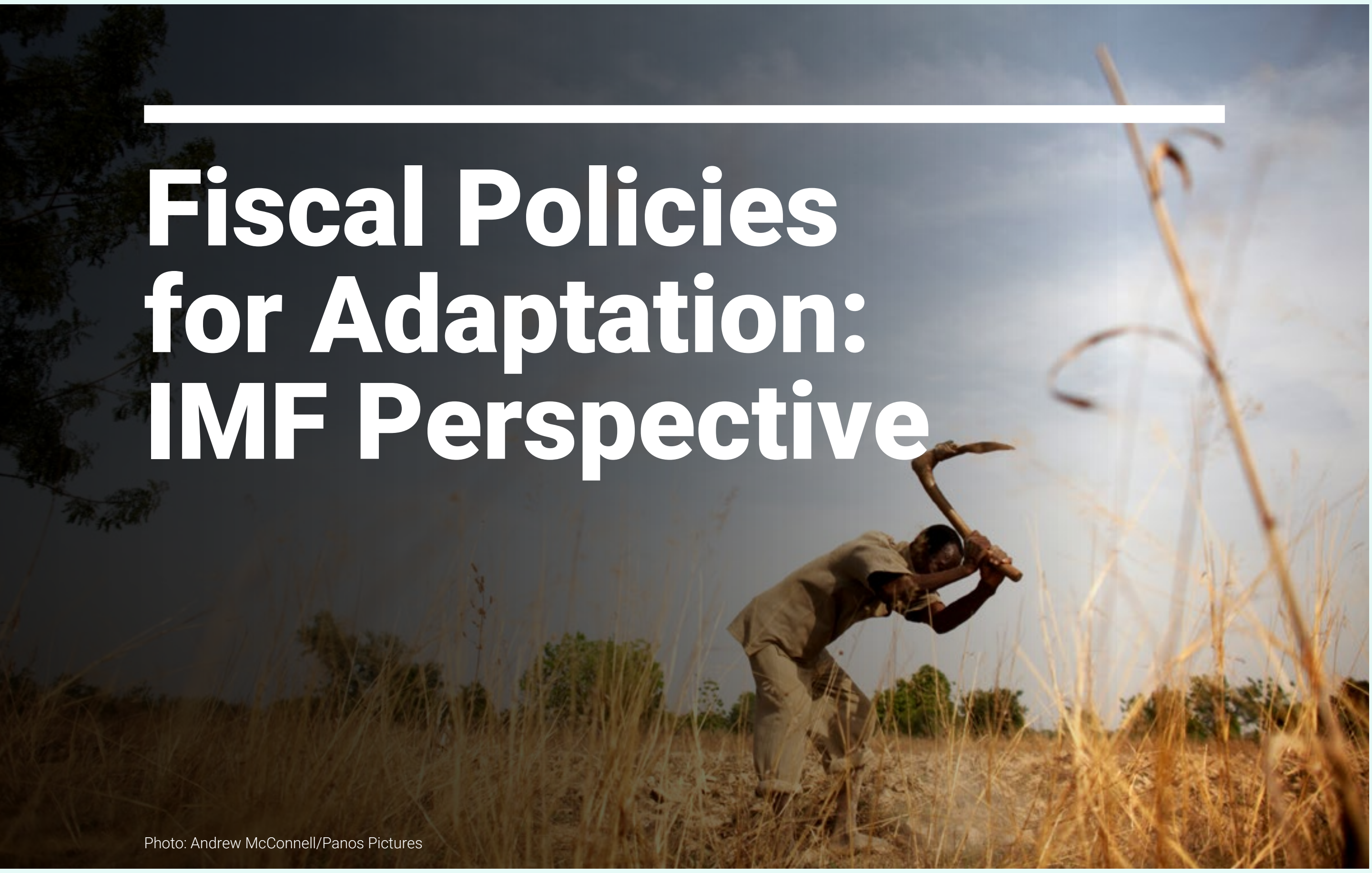


Photo: Andrew McConnell/Panos Pictures

Climate change is emerging as a critical threat to long-term economic growth and stability. The fiscal impacts of climate shocks are very important for many economies with weak resilience. The International Monetary Fund's (IMF) policy guidance on adaptation focuses on financial and institutional resilience building to natural disasters and infrastructure investments to cope with rising sea levels and other warming-related phenomena.

The IMF Staff Climate Notes are a series of reports that discuss the fiscal policies for climate change adaptation.[1] This insert presents a summary of the key messages from recent Climate Notes, focusing on the processes and implications of integrating climate change adaptation into macro-fiscal policies. The IMF Staff Climate Notes make a case for adaptation to be part of a holistic, sustainable, and equitable development strategy. Effective decision-making can maximize the impact of scarce resources and ensure climate-resilient societies. This is particularly important for countries in Sub-Saharan Africa that are at risk of entering poverty traps due to a vicious cycle of low economic development, increasing climate vulnerability, and low adaptive capacity.

ECONOMIC PRINCIPLES FOR INTEGRATING ADAPTATION INTO FISCAL POLICY

Climate change impacts and adaptation to it will affect economies across the world. However, these impacts will be heavier for lower-income and small, vulnerable nations with a higher proportion of economic activity in climate-sensitive sectors. The complexity, cost, and limits of adaptation increase with the speed and severity of climate change.

An important message of the IMF Staff Climate Notes is that despite its many benefits, adaptation to climate change cannot replace mitigation. Both are necessary to reduce damages from climate change. Adaptation can only partly compensate for delayed mitigation efforts, and without sharp greenhouse gas reductions, the stabilization of global temperatures will not be possible, making adaptation impossible or too expensive for some countries, as discussed in the climate risk sections of the 2021 and 2022 editions of the State and Trends in Adaptation report.

The IMF Staff Climate Notes recommend that, just as for other development programs, the principles of welfare economics can be used by decision-makers to make informed choices on adaptation policies and programs for climate change. Governments should prioritize adaptation policies with positive externalities by removing market imperfections and policies that hinder adaptation actions by the private sector. Since adaptation benefits tend to be local and private, individuals and firms are already strongly incentivized to adapt. Therefore, progress on adaptation is not affected by coordination problems as much as progress on mitigation is.

The IMF work indicates that climate adaptation can lead to productive and stable economies in Africa in the long term. Systematic investment in risk reduction results in significant development co-benefits. For example, adaptation actions have resulted in the decline in deaths from climate-related disasters over the last hundred years (especially from droughts) and contributed to the modest upward trend (in some studies, no trend) in economic losses due to climate disasters at the global level.[2] However, climate change can exacerbate inequalities between and within countries and will disproportionately affect the poorer sections in countries of all income levels.

Some countries are on the verge of entering a poverty trap through a vicious cycle of low economic growth and increasing climate vulnerability. Sub-Saharan Africa is at particular risk from extreme weather with limited adaptation capacity. Capacity development, large investments, and external aid are indispensable to prevent such vicious cycles.

According to recent IMF calculations for Sub-Saharan Africa, each large-scale drought reduces medium-term growth by one percentage point, with low-income households most severely affected as their coping mechanisms are limited. IMF research reflects that key adaptation policies integrated into near- and medium-term budgets can impactfully reduce vulnerability to climate shocks and support sustainable and inclusive growth. For instance, in Ghana, the use of improved seed varieties and irrigation has bolstered cocoa's drought resistance and increased productivity. Similarly, the development of rust-resistant wheat varieties has increased yields by up to 40 percent in some cases in Ethiopia.

Photo: Nyani Quarmyne/Panos Pictures

Cost–benefit analysis (CBA) methods, which are often used to evaluate development programs, can also be applied to adaptation programs. The IMF recommends considering adaptation and other development priorities together, including synergies and tradeoffs among different development goals. By consistently investing in projects with the highest returns, governments can maximize the impacts of their spending. Estimating net benefits for adaptation programs and monetizing the benefits far in the future is fraught with uncertainty. But CBA is routinely applied to many investments with long lifetimes, and the same guidance developed for other sectors can be used for adaptation projects. Again, a major difficulty of such projects is the reluctance of policymakers to invest in ventures with a much longer time horizon than the usual electoral cycle. Even here, using CBA can allow African policymakers to emphasize the benefits over the entire lifetime of the project, including the possibilities for adaptation to growing risks linked to climate change.

Governments could decide to use adaptation policies for redistribution motives within and between countries. If so, they would benefit from weighing the costs and benefits of redistributive adaptation programs against those of other available redistribution instruments. The IMF recommends giving preference to a combination of efficient adaptation policies with dedicated redistributive programs if they have larger aggregate net benefits for the entire population and the most vulnerable. To ensure consistency across multiple programs, including all development investments, governments can standardize how they assess tradeoffs across investment programs, different groups in society, and different goals.

MACRO-FISCAL IMPLICATIONS OF ADAPTATION TO CLIMATE CHANGE

Climate-related disasters worsen fiscal balance ex post, creating explicit and implicit liabilities that trigger additional borrowing. Assessing disaster risks would help countries calculate the size of required fiscal buffers. Examining both explicit and implicit liabilities can inform financial planning and post-disaster response.

Climate change costs are calculated as the sum of the cost of adaptation and the costs of residual risks. Experience shows that these costs can be greatly reduced by timely adaptation. Estimating and incorporating projected climate damages into macro-fiscal policies can aid government planning for climate change. This exercise is particularly important for vulnerable developing economies and Small Island Developing States. Despite the challenges in the exercise there is a growing consensus that the returns on climate adaptation are large. Macroeconomic simulations spanning the 21st century to calculate global average returns for the optimal level of adaptation show high average returns.

Global estimates of public funding needs for adaptation in 2030 are 0.25 percent of world GDP per year on average.[3] However, this is not representative of the challenges faced by many countries. The IMF analysis points to annual adaptation costs exceeding 1 percent of GDP for some developing countries, and above 10 percent of GDP for some island states. For some lower-income vulnerable countries, bottom-up self-assessment of their needs can be as much as 100 to 250 times higher than global averages. The 46 countries that included adaptation cost estimates in their Nationally Determined Contributions (NDCs) estimate a collective cost of almost 1.5 percent of their GDP annually from 2015 on average. These estimates vary widely due to different definitions of adaptation needs and future development levels and varying assumptions of adaptation goals, climate change, and adaptation technology. Better estimates with local information and data collection are needed to ensure the necessary resources for adaptation are mobilized for Africa.

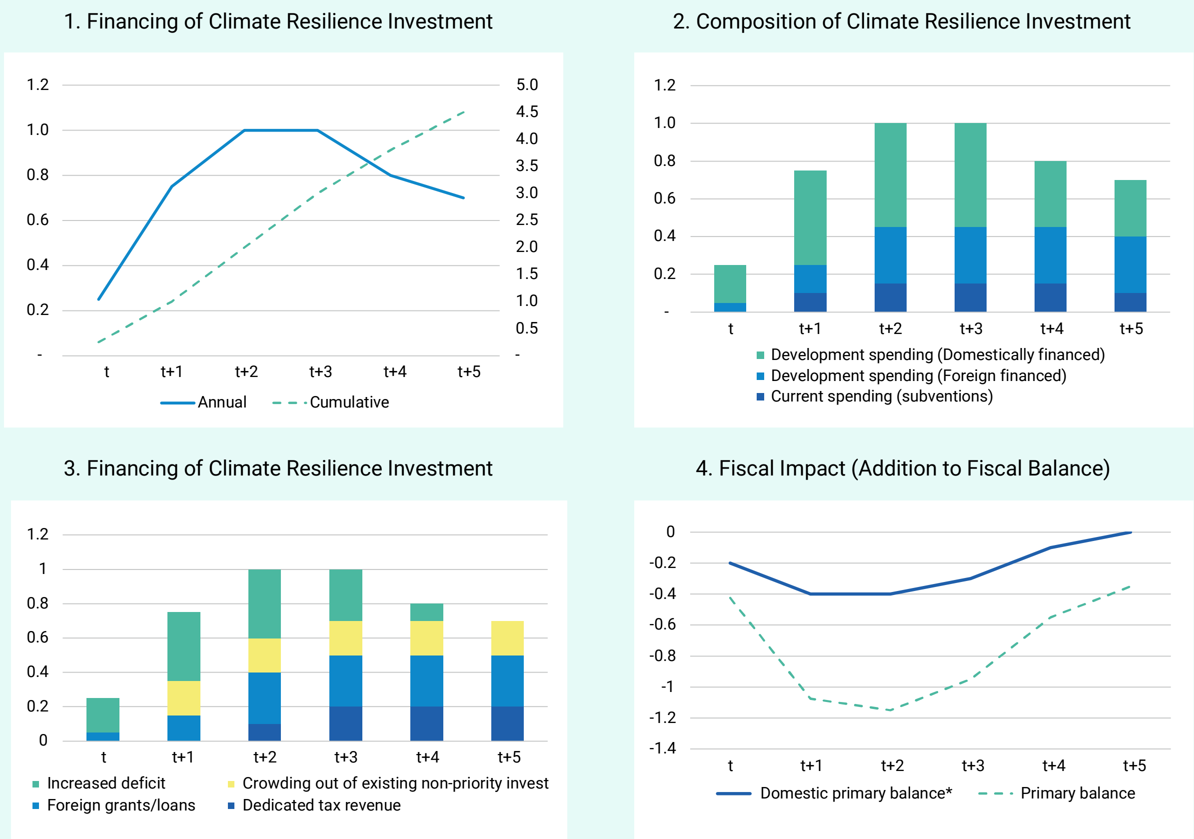
According to IMF calculations, strengthening new and existing public assets from current storm and flood risks alone could cost 0.4 and 0.6 percent of GDP per year, respectively, from 2021 to 2025, with large disparities across countries.[4] Emerging markets face the largest costs, followed by low-income countries. The costs of improving private-sector asset resilience could be twice as high, though more evenly distributed across income groups.[5]

Market distortions arising from policy failures can be addressed by governments as part of a comprehensive plan to improve economic efficiency while considering the distributional implications of these measures. Market reforms targeting market failures and credit constraints, particularly for low-income consumers and small firms who are impacted severely by climate shocks, can have considerable positive benefits. Subsidies such as investments in agricultural research or energy technology can help deliver a socially optimal amount of climate change adaptation with positive externalities. In terms of international aid, the costs and benefits of adaptation investments must be weighed by international donors against those of other uses of such aid, if the investments are not additional to existing development assistance or if they do not have significant development benefits.[6] This will ensure that adaptation projects effectively contribute to development goals of the society.

Box 1. Malawi: Investment Scenario with Fiscal Impacts

Results from several post-disaster studies show that improving resilience to climate shocks can potentially lead to a virtuous cycle of self-reinforcing adaptation and development. Malawi is one of the countries that is most vulnerable to climate change impacts in Sub-Saharan Africa. The increasing frequency and intensity of climate-related disasters has created the need for adjusting baseline macroeconomic projections for the country. Therefore, since 2019, the IMF has integrated the macro-fiscal implications of climate change into its analysis for Malawi. Climate shocks were integrated into the baseline macroeconomic projections for the country, and its debt sustainability analysis included alternative tail-risk scenarios, with the magnitude of climate shocks assumed in the baseline being amplified. This exercise helped assess the required fiscal space and the efficacy of existing and planned buffers, revealing large gaps in the country's fiscal financing needs.

Figure 1. Malawi: Investment Scenario with Financial Impacts



Source: IMF. 2022. Macro-Fiscal Implications of Adaptation to Climate Change. Staff Note.
Current primary balance is defined as the sum of planned climate-dedicated taxation, crowding out of investment, and current spending on climate subventions less domestically financed development spending.

"The IMF today is a systemically significant institution in the fight against climate change. We integrate climate in our policy analysis and policy recommendations, in our financial sector assessments. We integrate it in our public investment management assessments. And we now have an instrument to finance, to put money where our mouth is – the Resilience and Sustainability Trust. It is now at US$40 billion strong."

Kristalina Georgieva
Managing Director, International Monetary Fund

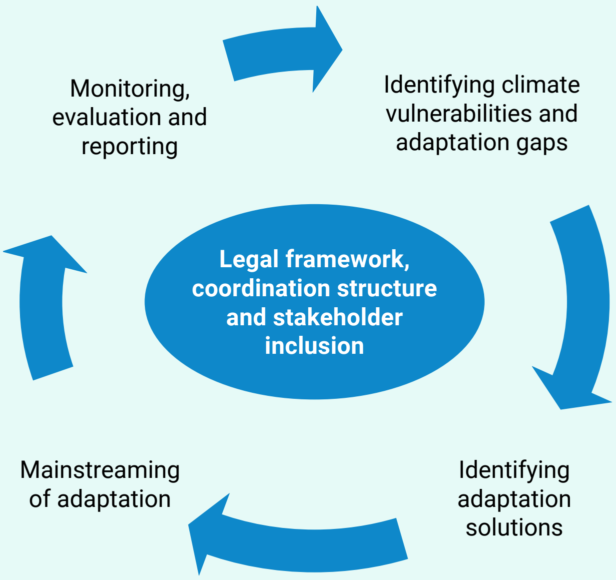
For longer horizons, macro-frameworks should reflect all climate change effects, in addition to disaster episodes. Climate change will likely also affect long-term debt sustainability, particularly for vulnerable countries. In long-term scenarios that assume little or no climate change mitigation, the literature predicts that vulnerable countries will have significantly lower GDP per capita levels by 2050 compared to scenarios without climate change. Therefore, long-term sustainability is best assessed using long-term scenarios that account for the cumulative effects of climate change and are informed by coherent adaptation policy narratives.

THE IMF'S THREE-PILLAR APPROACH TO CLIMATE ADAPTATION

Identification of climate vulnerabilities and adaptation gaps aids in stock-taking of climate change impacts, planning, and development of roadmaps for National Action Plan (NAP) processes and their implementation. Adaptation needs to be mainstreamed into public financial management (PFM) through national planning, incorporating climate risk management, adding estimated adaptation needs to the budget and financing plans, and enhancing the implementation capacity. Progress monitoring, re-evaluation, and regular updating of adaptation plans are also necessary.

Photo: Nikada/iStock

Figure 2. Adaptation Plan Structure



Source: Reproduced from Figure 2 in IMF (2022).[7]

The IMF's three-pillar approach to guide the identification of adaptation options can also be considered for Africa.[8] The three pillars include prevention, alleviation, and macro-fiscal resilience:

- **The prevention pillar** focuses on public goods and incentives to facilitate adaptation and reduce climate risks and their impacts. Provision of information on risks, accurate pricing of risks, and provision of infrastructure and new technologies can incentivize agents for efficient resource allocation.
- **The alleviation pillar** focuses on improving the efficiency of policies to alleviate residual risks. This includes disaster contingency plans to ensure post-disaster support and reconstruction, financial inclusion, and reliable social safety nets to cope with residual climate risks.
- **The macro-fiscal resilience pillar** creates financial strategies for macro-fiscal resilience to residual climate risks and ensures sustainable and timely financing of adaptation policies. Inclusion of climate costs into macro-frameworks helps develop effective financial strategies that mobilize necessary resources for adaptation policies. It also serves as insurance against large risks and secures timely access to liquidity post climate disasters.

The IMF recommends a combination of structural protection and financial protection as an optimal resilience-building strategy. The identification, quantification, inclusion, and disclosure of fiscal risks from climate change would help guide policymakers and the public in planning and implementing adaptation policies and their management.

In addition, it is important to finance priority interventions across sectors, income, and population groups based on a society's preferences on goals and distributional outcomes in a way that maximizes social welfare.

To keep the cost of adaptation to a more affordable level, the IMF recommends monitoring the country's infrastructure asset conditions and their vulnerability to climate shocks. This will ensure efficient selection, execution, and maintenance of adaptation investments. The relocation and rebuilding of some assets currently located in areas facing overwhelming climate risks may be needed in certain situations.

Domestic revenue mobilization, reprioritized investment plans, and donor community support are required to finance adaptation costs, among other sources. Climate adaptation investment is a cost-effective alternative for international donors compared to disaster relief, as it can minimize climate change risks before they materialize, resulting in a net reduction of total spending.

As climate change is dynamic, adaptation should not be considered a one-time adjustment for African countries. Rather, new investments should be designed with the flexibility needed to respond to new climate conditions, despite the uncertainty of the specific magnitude of future shocks. Governments can start accumulating knowledge and experience in dealing with present challenges and can consult climate scientists for climate change projections to interpret and adapt available knowledge to the local situation.

Financial Instruments in North Africa

KEY MESSAGES

- Despite the pressing adaptation needs expressed by several countries in the North Africa region in their Nationally Determined Contributions (NDCs), current adaptation finance represents less than 30 percent of total climate finance received.
- While overall climate financing flows fall short of needs, funding adaptation actions seems particularly difficult. It is apparent that adaptation action is often hindered by the "tragedy of the horizons," as most policy and financing stakeholders operate under a short- or medium-term planning horizon that is not aligned with the long-term payback periods of most adaptation projects.
- Green bonds are an important domestic public financial tool to raise resources to finance new climate projects or refinance existing ones. They can also serve as a signal of domestic climate awareness and commitment, which can support the growth of private sector climate finance.
- Countries in the North Africa region are also facing a contraction in their fiscal space because of rising levels of public debt due to global factors. Debt for climate or nature swaps are another innovative financial tool that can help secure funding for adaptation projects and thus accelerate climate action while not increasing the country's debt service burden further.

Photo: Sean Sprague/Panos Pictures

- A country's legal and regulatory framework can create an enabling environment for mobilizing adaptation finance and climate-proofing public and private sector investments. Dedicated climate laws, national strategies, and directives from financial authorities can help set the scene for adaptation finance and define the overall level of ambition by showcasing high-level endorsement.
- Standardized methodologies are vital for assessing country-specific climate vulnerabilities and risks and in turn identifying adaptation needs. In addition, a clear taxonomy and well-defined evaluation methodology are important to create a collective understanding of what qualifies as adaptation action.

"The climate finance architecture is insufficient, inefficient and unfair. It's insufficient because even if we deliver all on the $100 billion, this is going to be close to the 3% of what is required for climate action."

Mahmoud Mohieldin
UN Climate Change High-Level Champion, COP27

INTRODUCTION

Despite the pressing climate change adaptation needs identified by many countries across the globe, securing funding to finance adaptation projects has proven challenging. While overall climate financing flows fall short of needs, funding adaptation (as opposed to climate mitigation) actions seems particularly difficult, as adaptation projects tend to accrue benefits over a longer time horizon and face more difficulty in ensuring cost recovery and profitability.

This chapter discusses a broad range of financial instruments for adaptation, providing examples from North Africa.[1] The chapter starts with a brief overview of current climate finance flows to the region and articulated needs to identify financing gaps. It then lays out regulatory and legal instruments as well as institutional settings that can help create an environment for mobilizing adaptation finance and enhancing the efficiency of existing resources for climate action. The chapter then presents examples of actual climate finance instruments. First, it focuses on the mobilization of domestic financial resources, achieved by mainstreaming climate into public budgets and fiscal instruments and by climate-proofing public investments, as well as through public support for mobilizing private adaptation finance. Second, it discusses more direct climate finance instruments such as green bonds, innovative debt swaps, and financing from multilateral development banks (MDBs) and climate funds, highlighting how they can be tailored to meet adaptation finance needs.

Photo: Brookgardener/Shutterstock

CLIMATE FINANCE IN NORTH AFRICA: CURRENT FLOWS AND NEEDS

Climate finance should respond to regional and national needs and be based on the articulated priorities and development objectives of countries. As such, while the North Africa sub-region faces similar climate change challenges, climate finance needs at the national level depend, among other things, on climate change exposure, sensitivity, and adaptive capacity as well as the country's socioeconomic conditions, financial situation, and development objectives. A one-size-fits-all solution is likely to fail. Assessing these needs is therefore a prerequisite for mobilizing and securing adequate climate finance for reducing vulnerability and enhancing resilience.

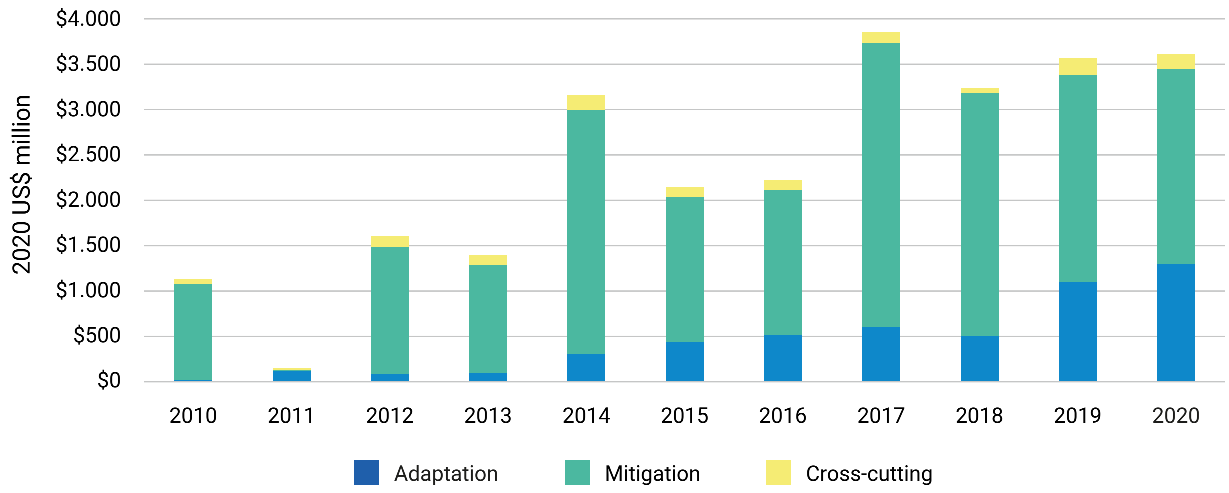
At the policy and prioritization level, many countries in North Africa have identified their climate financing needs in their communications to the United Nations Framework Convention on Climate Change (UNFCCC). These documents include Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), Biennial Update Reports (BURs), as well as national and sectoral development strategies and plans. The needs-based climate finance assessment for Arab States reviewed these documents and found that climate change adaptation priorities in the region focus on agriculture for improved food security, integrated management of water resources and desalination, and coastal zone management.[2] However, the costs of adaptation interventions are not straightforward to quantify. This is due to uncertainties relating to future climate trajectories and differences across costing methods.[3] Interdependencies between adaptation options at the national and local levels further contribute to the complexity.

A review of the updated NDCs for five North African countries (Egypt, Mauritania, Morocco, Sudan, and Tunisia) indicates that climate financing needs total US$393 billion for the implementation of the NDCs over the next decade.[4] Of this amount, almost three quarters (US$288 billion) are requested for climate mitigation actions, and US$105 billion for adaptation.

Mobilizing the climate finance that responds to the country needs and avoids potential sustainable development tradeoffs remains challenging for many states in North Africa. Nevertheless, promising signals exist. A slight increase in climate financial flows to the region has been witnessed since 2018 (Figure 1). Climate finance also continued to be disbursed to the region even after the onset of the COVID-19 pandemic in 2020. However, total public climate finance between 2010 and 2020 totaled only US$26.1 billion,[5] which represents less than 7 percent of the amount of financing required for NDC implementation over the coming 10 years.

> **"We must do a lot more for Africa. There are a hundred public development banks in Africa. Let's mobilize them there too. Let's bring the resources so that they play their role in each of the countries, in each of the regions, with their private sector and with the financial system much more strongly."**
>
> **Rémy Rioux**
> CEO, Agence française de développement

Figure 1. Climate Finance Flows to North Africa by Purpose (2010–2020)



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cross-cutting	$55.12	$0.19	$125.60	$111.30	$157.30	$104.60	$104.30	$110.40	$44.79	$184.80	$167.50
Mitigation	$1,071	$29.19	$1,389	$1,188	$2,693	$1,588	$1,600	$3,127	$2,675	$2,290	$2,131
Adaptation	$17.60	$125.70	$96.85	$108.10	$308.50	$447.80	$523.80	$612.90	$515.90	$1,103	$1,310

Source: ESCWA calculations based on OECD DAC data (recipient perspective)[6]

Access to adaptation financing is particularly difficult. Of the US$26.1 billion the region received in total public climate finance over the past decade, on average only 20 percent was directed at pure adaptation projects (Figure 1); and 4 percent supported cross-cutting climate mitigation and adaptation projects. Mitigation projects received the largest share of public climate finance. The share of adaptation finance in total public climate finance flows has been growing slightly since 2017 but remained at just 31 percent in 2019 and 36 percent in 2020. Comparing across African sub-regions, the imbalance between adaptation and mitigation finance seems particularly high in North Africa, while the allocations are closer to parity between mitigation and adaptation finance for West Africa (54 percent for mitigation), Central Africa (52 percent for mitigation) and East Africa (52 percent for mitigation) for the period 2014–2018.[7]

In addition, climate finance flows to North Africa were almost exclusively in the form of debt-based instruments (88 percent), despite the large debt burden many countries in the region are currently facing (Figure 2). There are also large regional disparities in received climate finance. In the sub-region, Egypt and Morocco have been most successful in attracting public international climate finance, while the least developed countries Mauritania and Sudan received only 3 percent of total flows to the sub-region (Figure 3). On a broader scale, Egypt, Morocco, and South Africa received almost one-third of all mitigation finance disbursed in Africa, with the Noor Midelt Solar Power Project in Morocco among the largest projects on the continent.[8]

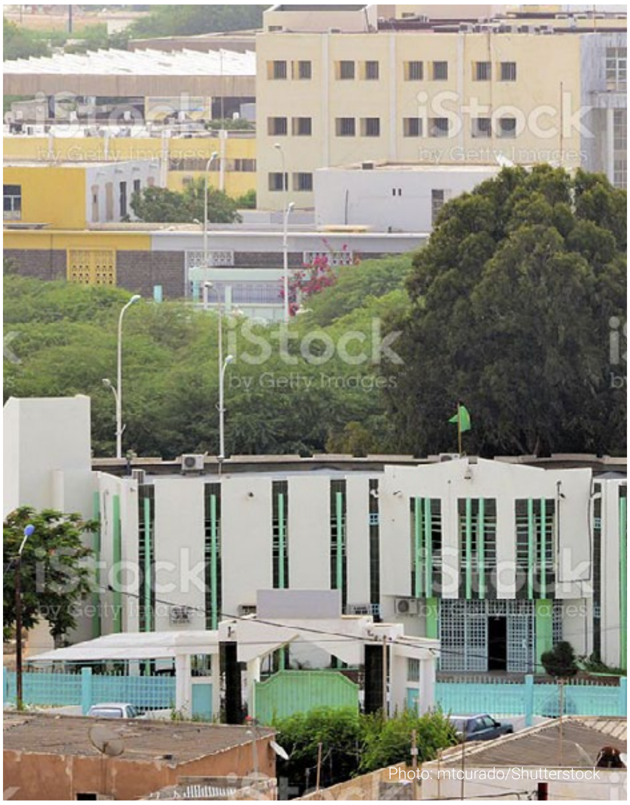
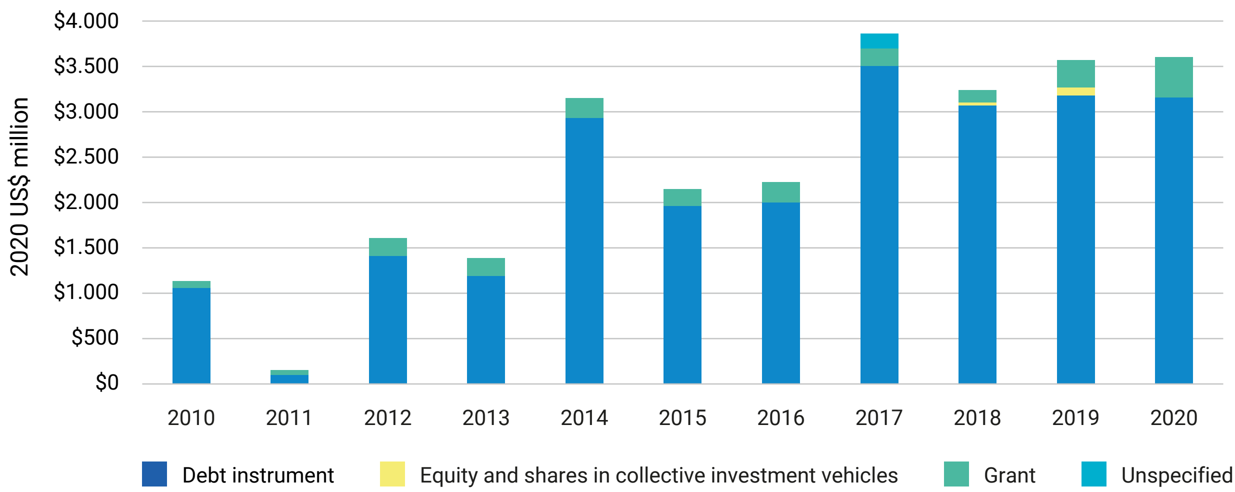


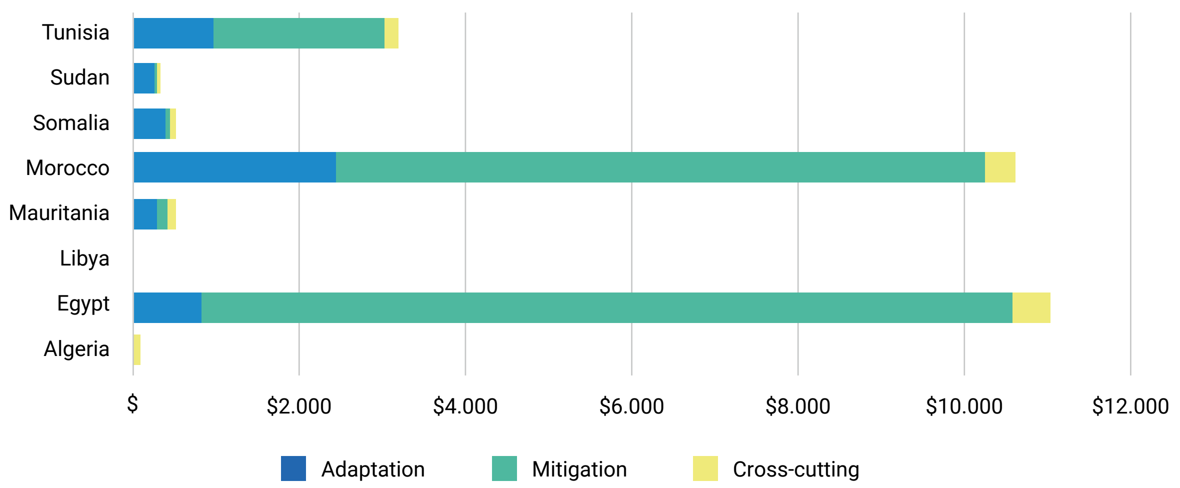
Figure 2. Climate Finance Flows to North Africa by Type of Financial instrument (2010–2020)



Source: ESCWA calculations based on OECD DAC data (recipient perspective)[9]

Demonstrating a clear climate rationale for adaptation projects to attract dedicated climate finance poses another challenge for countries. As such, the share of adaptation finance is much higher (55 percent in 2020) in projects for which climate is only a significant objective compared to projects for which climate is the principal objective.[10] According to the Rio marker framework, projects with a significant climate objective are those that would have been undertaken even without a climate component, while projects with a principal climate objective would not.

Figure 3. Climate Finance Flows to North Africa by Country and Purpose (2010–2020)



Source: ESCWA calculations based on OECD DAC data (recipient perspective)[11]

FINANCIAL INSTRUMENTS FOR ADAPTATION: CREATING AN ENABLING ENVIRONMENT

Countries can mobilize climate finance from a broad range of sources and in many different forms. There are public and private as well as national and international financing instruments. Furthermore, in addition to mobilizing external funds, existing national resources can be freed for financing climate action by mainstreaming climate into public budget and expenditure processes as well as fiscal mechanisms. Unlike mitigation projects, adaptation projects tend to accrue benefits over a longer time horizon and face more difficulty in ensuring cost recovery and profitability. This renders them less attractive for private sector investment.[12]

At the same time, countries in the region face a contraction in their fiscal space. Public debt has been rising in an unprecedented way over the past decade. Debt burdens have been aggravated further by the COVID-19 pandemic and the Russian invasion of Ukraine, particularly through price increases for energy and wheat, of which many North African countries are net importers. For middle-income countries in the Arab region,[13] the total public debt more than doubled between 2008 and 2020, reaching US$658 billion in 2020, which implies a debt-to-GDP ratio of 91 percent.[14] This severely limits the resources available for investing in climate action. In addition, debt vulnerability considerations might limit a country's external borrowing ability. More innovative financial instruments are needed to ensure that the cost burden for adaptation is not placed exclusively on the public purse.

Regulatory and Legal Instruments to Create an Enabling Environment for Adaptation Finance

A country's legal and regulatory framework can create an enabling environment for mobilizing adaptation finance and climate-proofing public and private sector investments. Dedicated climate laws, national strategies, and directives from financial authorities help set the scene for adaptation finance and define the overall level of ambition by showcasing high-level endorsement. For example, Egypt recently published its National Climate Change Strategy 2050. This 2022 policy document provides one consolidated climate reference agenda that defines goals related to green growth and climate resilience, climate governance and climate finance, and climate mainstreaming into all levels of planning and decision-making.[15]

Specific guidelines are also needed to prioritize areas of action. In a large consultative process ahead of COP22 involving many stakeholders, including regulators and banking sector representatives, Morocco developed its Roadmap for Aligning the Moroccan Financial Sector with Sustainable Development.[16] While this Roadmap is not exclusively

Photo: monticello/Shutterstock

dedicated to climate adaptation, many of its guidelines can be used to support financing for adaptation as well. The Roadmap includes specific provisions for the banking sector, the insurance sector, and the capital market, and calls for risk governance as well as the supply of specific climate-related financial tools and products.

Sector-specific regulations and action plans can also help translate national-level goals into concrete actions. The Plan Maroc Vert,[17] an ambitious strategy to make the Moroccan agricultural sector a lever of socioeconomic development, seeks to enhance climate resilience and adaptation of the agricultural sector by promoting drip irrigation and crop rotation to reduce vulnerability to climate change. The Plan also seeks to develop new laws and regulations, structural reforms, and specific support for private sector investments.

Institutional structures can also help to create an enabling environment for mobilizing adaptation finance. Institutionalized communication channels and cooperation incentives between all ministries and at all levels of policymaking help to create and identify synergies and avoid spending at cross-purpose. Several North African States have passed decrees to establish national management units to coordinate, streamline, and monitor national climate-related activities.[18] In Egypt for example, the National Committee on Climate Change monitors climate change budget allocations to ministries involved in climate change action and is responsible for raising climate awareness among decision-makers. Algeria established a National Climate Committee under its Ministry of Environment that facilitates coordination across ministries.

Further, an enabling environment for mobilizing adaptation finance should engage all levels of government and involve local stakeholders. Drawing upon local knowledge helps to develop tailored solutions responsive to stakeholder needs. As such, a bottom-up approach can help strengthen local authorities and actively engage communities in the planning and implementation of projects as well as in knowledge and capacity-building processes. For example, two regions in Morocco have already responded to the national government's call to develop Territorial Plans against Global Warming with the support of a recent Green Climate Fund (GCF) project. These plans contain an adaptation component which includes a vulnerability analysis, outlines the governance and operational planning for adaptation in the region, and identifies a list of strategic priorities and a portfolio of adaptation actions by sector. The development of these regional plans has enabled more detailed climate risk analyses to inform planning, a stronger focus on the needs and priorities on the ground, a stronger engagement with the regional and local authorities, and a more direct involvement of vulnerable communities. This detailed knowledge on vulnerabilities and adaptation needs and prospects can help strengthen the climate rationale of projects that can then be postulated by the Kingdom and enhance access to international climate finance.

Fostering a Common Understanding of Adaptation Needs: Climate-Related Financial Risk Disclosures and a Climate Taxonomy

A better understanding of climate risks and vulnerabilities for individuals, firms, and the public sector is paramount in defining adaptation needs and thus for mobilizing and accessing adaptation finance. Climate-related financial risk disclosures regarding adaptation and disaster risk can do just this. The Task Force on Climate-Related Financial Disclosures (TCFD) provides specific guidelines on how to disclose such risks, in particular by examining the assets and operations exposed to climate risks due to both direct climate hazards as well as changing taxonomies which could lead to stranded assets. Several banks, asset managers, and companies in Egypt, Morocco, and Tunisia, including the Moroccan Central Bank (Bank Al-Maghrib), support these guidelines.[19]

In addition, as part of the Roadmap for Aligning the Moroccan Financial Sector with Sustainable Development, the Central Bank of Morocco issued a regulation in 2021 requiring credit institutions to identify, manage and monitor climate-related and environmental risks in line with international practices, setting out specific guidelines on the disclosure of these financial risks, and calling for new commitments on sustainable finance.[20] The European Bank for Reconstruction and Development (EBRD) and the Moroccan Banking Association have established a cooperation framework to support the implementation of these climate risk management regulations. Similarly, the Moroccan Capital Market Association is currently updating its 2019 Circular 03/19 on Environmental, Social and Governance (ESG) disclosure, which, with the assistance of the International Finance Corporation (IFC), will build on existing requirements for issuers to disclose climate risks using international standards such as from the Carbon Disclosure Standards Board and the TCFD. Egypt has similar disclosure rules for ESG practices, requiring companies to report on the climate and environmental impact of their activities as well as on the risks that climate change poses for their operations. Such a better understanding of climate-related risks, in combination with a clear taxonomy defining what counts as a climate adaptation project, can motivate adaptation investments by the private sector to enhance their climate resilience.

FINANCIAL INSTRUMENTS FOR ADAPTATION: MOBILIZING PUBLIC BUDGETS AND PRIVATE INVESTMENTS

National Public Sector Adaptation Finance: Greening Public Budgets and Climate-Proofing Development Plans

The public sector can play an important role in financing climate change adaptation. Mainstreaming climate considerations into public budgets and incorporating adaptation finance into all stages of the budgeting process can provide a direct channel of funding for dedicated climate adaptation projects and facilitate the climate-proofing of planned or ongoing public investments, such as in infrastructure or housing.[21] Transparency and a strengthened fiscal discipline can improve the efficiency of climate expenditure management as well as the intersectoral allocation of climate funds to maximize the value of existing budgetary resources. A climate-sensitive budgeting process with budget tracking tools can enhance overall operational performance.

Climate Public Expenditure and Institutional Reviews can help to inform the national response to climate change by "examining the linkages between the national climate change policy, the institutional structures through which policy is channeled, and the resource allocation processes whereby public funding is made available for the implementation of relevant projects, programmes and policies."[22] Such a review was initiated in 2013 in Morocco. It found that 64 percent of all climate-related spending in the country over the period 2005–2010 (or 9 percent of the country's overall investment expenditures) supported adaptation projects.[23] In the future, Morocco seeks to dedicate at least 15 percent of its overall investment budgets to climate change adaptation, with the most significant proportion dedicated to infrastructure. Despite these impressive numbers, the review also highlighted barriers, particularly the limited institutional coordination and the lack of standardized data collection, methodologies, and taxonomies, as well as monitoring and evaluation. As a follow-up, Morocco is working on establishing a system to monitor public spending on climate change with the support of the Low Emission Capacity Building Project.[24] Adaptation indicators to measure vulnerability, adaptive capacity, adaptation measures undertaken, as well as wellbeing were also integrated into the Regional Information System on Environment and Sustainable Development, an existing decentralized information system to track development progress.[25]

Establishing a reliable system for tagging and tracking climate-related public expenditures is important to earmark funds and assess whether public budgets have been used to their designated end in a results-based framework. Thus far, climate-related budget tagging and budget tracking are still rare in the North Africa sub-region, which can in part be attributed to the lack of data and monitoring capacity, including a clear taxonomy and performance indicators, manifest in several countries in the region. Lessons can however be learned from budget tracking and tagging in other sectors. For example, the social expenditure monitor led by the United Nations Economic and Social Commission for Western Asia (ESCWA) features a pilot study on Tunisia.[26] This tool provides disaggregated data on public social expenditures to identify the neediest sectors for a resource reallocation and to help governments improve the link between expenditure choices and macroeconomic objectives. Environmental protection is addressed as one of the seven dimensions of social spending. Overall, the monitor showed that public expenditure on environmental protection was scarce, with financing for environmental protection coming primarily from external sources, particularly grants and loans from international institutions or bilateral donors.

Another public budget instrument is the provision of dedicated national funds to allow both for ad hoc financing in the aftermath of a disaster as well as for investing in strategic adaptation measures. Morocco has established two such funds, the National Environment Fund and the National Fund Against Natural Disasters. These funds receive funding from various sources, including external donations and allocations from the national budget. While the natural disaster fund originally focused on post-disaster response, Morocco, with the support of the World Bank's Integrated Disaster Risk Management Program, is transforming it into a national resilience fund. This resilience fund currently co-finances more than 150 strategic investments to reduce climate-related risks, ranging from flood protection infrastructure to early warning systems, hazard mapping, and capacity building.[27]

Further, the public sector can indirectly support climate action by greening public procurement. Egypt, for example, recently adopted sustainability standards that are used as criteria to evaluate and ensure that public investment projects included in the national investment plan are consistent with environmental sustainability standards. So far, only the reduction of greenhouse gas (GHG) emissions is included in these standards, even though no specific emission reduction target has been set. But these could easily be extended to also cover standards for enhancing climate resilience and adaptation. The level of green national investment was 15 percent for the fiscal year 2020/21, which the government seeks to increase to 50–60 percent by the fiscal year 2024/25.[28]

Public Support for Private Adaptation Finance

The private sector has great potential for financing climate action. So far, however, private climate finance is almost exclusively geared toward climate change mitigation. To incentivize and support the private sector to also finance climate change adaptation, the public sector can take several steps. In addition to requiring climate-related financial risk disclosures from companies, which can help to motivate direct investments in adaptation and enhanced resilience, public national banks or development banks could for example provide credit guarantee schemes or blended finance solutions to de-risk private sector adaptation investments. In Morocco, for example, investment and loan guarantees as well as environmental and energy audits are provided under the Tatwir Croissance Verte program, which is part of the national financial inclusion strategy.[29] While most of the program's components are focused on financing climate change mitigation, such as by providing support for the development of carbon-free processes and products or the reduction of industrial pollution, this program could in principle also be used for supporting climate adaptation projects, particularly for climate-proofing and enhancing the climate resilience of existing investments.

In addition, a clear legal and regulatory framework can make blended finance and public-private partnerships (PPPs) more attractive. For example, the recently published cross-cutting Law for Improving Business for Climate Finance in Tunisia[30] supports structural reforms to encourage private sector investment. It focuses on providing enhanced access to finance for small and medium-sized enterprises (SMEs), enabling PPPs and concessions, and eliminating bureaucratic bottlenecks. Morocco, as part of its national adaptation planning process, aims to incentivize private sector adaptation investments by setting up business incubators for adaptation, encouraging innovation through an adaptation innovation competition, and developing catastrophe risk insurance programs.[31] A national climate adaptation investment forum involving financial institutions, investment funds, and private sector companies is also planned to facilitate financial engagements through assessing barriers and opportunities for private investments in climate change adaptation activities.

Further, in complementarity with adaptation efforts, disaster insurance can help alleviate the immediate impacts of climate-related disasters and build back better. In 2019, Morocco made insurance against natural and human-made disasters compulsory for all its citizens through the promulgation of Law No. 110-14, which was accompanied by a social solidarity premium to ensure coverage for those who are unable to pay.[32] The program was accompanied by an information and awareness-raising campaign on catastrophic risk by the Supervisory Authority of Insurance and Social Welfare. This initiative is supported by the World Bank Disaster Risk Management Development Policy Loan, and a National Flood Risk Management Information System also has been established. This experience could inform disaster risk management efforts in other countries in the North Africa sub-region. Sudan, for example, has experienced nearly annual flood events since 2013 that destroyed agricultural lands and devastated vulnerable communities.

Overall, successfully mobilizing public budgets for adaptation requires capacity building and awareness-raising.[33] In Egypt for example, several capacity-building initiatives are under way to improve the country's financial readiness. As part of the development of its Fourth National Communication on Climate Change, the Ministry of Environment has organized climate change intensive courses for officials in ministries of finance and planning to support the mainstreaming of climate considerations in budget and investment planning processes.[34]

FINANCIAL INSTRUMENTS FOR ADAPTATION: REVENUES

Green Bonds

Recent years have witnessed an increasing interest in green bonds.[35] They are an important domestic public financial tool to raise resources to finance new climate projects or refinance existing ones. They can also serve as signals of domestic climate awareness and commitment, which can support the growth of private sector climate finance. Their issuance is however a time- and resource-intensive process. Such bonds require a clear taxonomy to define what qualifies as a green project that can be supported by the proceeds, a clear key performance indicators (KPI) framework, and a transparent verification and reporting system that includes an external oversight authority. A pipeline of eligible projects to be financed should already be part of the bond offerings description. Further, on the institutional level, green bond issuances require the formation of a multisectoral committee. This should be chaired by the Debt Management Office of the Ministry of Finance and co-chaired by the Ministry of Environment to ensure that the allocation of expenditures is aligned with the country's climate objectives and strategies, such as outlined in its NDC or NAP.[36]

Egypt and Morocco are both active on the green bond market. However, bond proceeds have primarily financed climate mitigation projects. Morocco issued its first green bond in 2016 for a total of US$447 million. Additional bonds were issued in 2018 and 2020, financing renewable energy, energy efficiency, and sustainable housing projects. Egypt issued its first sovereign green bond in September 2020 with a five-year term worth US$750 million. As of November 2021, 75 percent of the net proceeds of the issuance (US$564.46 million) have been used to finance eligible projects. Of these, 46 percent are being used for the Cairo Monorail as a clean transportation project. The remaining 54 percent are supporting 14 sustainable water, water desalination, and wastewater management projects.[37]

To promote the development of green bonds, the Moroccan Capital Market Authority (AMMC), in partnership with the IFC, published its first guidelines in 2016 setting the regulatory framework and rules for issuing green bonds. The guidelines help issuers and investors to identify, evaluate, and select eligible projects. They also provide guidance on the regulatory requirements for the issuance, use, and management of green bonds' proceeds, for independent external reviews, and for reporting and disclosure. In Egypt, the Capital Market Law No. 95 of 1992, as well as its executive regulations and relevant directives issued by the Financial Regulatory Authority's (FRA) board of directors, serves to regulate the green bonds market. The legal framework authorizing the issuance of green bonds, detailing rules based on the Green Bond Principles to enhance transparency and consistency of green bond approval, was published by the FRA in 2018.[38]

To increase the potential of green bonds to support adaptation finance, bonds can be used in tandem with conventional financing instruments to support projects that require long-term planning and investment horizons. Long-term bonds also give time to the public sector to raise the revenues to

cover the interest and payment coupon. Science-based assessments to help prioritize adaptation needs and to provide the climate rationale for the preparation of bankable adaptation projects can help to attract funding through green bonds or dedicated climate bonds.[39]

Debt Swaps

The historically high and still rising debt service burden many countries in the region are facing puts at risk their ability to meet climate-related expenditure commitments and allocate additional resources for climate action. In addition, a high debt burden coupled with uncertain economic development prospects might lead to rising sovereign credit risk and thus higher borrowing costs, exacerbating liquidity constraints and further narrowing the fiscal space. Bonds are more debt-generating and thus less accessible or not the first best financing option in such a critical situation.


Photo: Socha/iStock

Debt for climate or nature swaps on the other hand present an innovative financial tool that can help secure funding for adaptation projects and thus accelerate climate action while not increasing the country's debt service burden further. A debt swap converts national debt servicing payments on external debt into domestic investments, which can in turn be directed toward projects or programs that support national sustainable development or climate goals. Such an arrangement provides multiple benefits. For the creditor, it reduces the risk of moral hazard and fungibility of investments and ensures the debtor's expenditure commitment to climate action through public budgets. For the debtor, it not only provides debt relief and fiscal benefits as well as support for national adaptation and mitigation targets, but also promotes economic transformation, diversification, and private sector opportunities. Egypt is currently implementing a debt swap program with Germany over three phases with a total value of €240 million. While most of the funds are directed at education, energy, infrastructure and employment generation projects, the swap covers some activities that support clean water and sanitation.[40] Egypt has also signed a debt swap with Italy that focuses on food security and nutrition, agriculture, environment and education.[41] Opportunities thus exist for using this modality to support adaptation projects as well.

In light of these opportunities and growing concern regarding the high debt burden being faced by countries in the region, ESCWA launched the Climate/SDGs Debt Swap-Donor Nexus Initiative in 2020.[42] This initiative provides an alternative to debt restructuring by facilitating a debt swap between bilateral creditors and middle-income countries that are facing increasing fiscal pressure, but which are not at risk of defaulting on their payments. This ensures that, unlike conventional debt swaps, the initiative has a neutral or positive impact on the country's credit rating. In addition, focusing on bilateral creditors with significant loans outstanding with the debtor country does not require any third-party transaction and thus reduces transaction costs and coordination time as well as improves budgetary commitments for climate action.

The initiative works to achieve economies of scale in terms of transaction costs by providing a multi-year framework for a pipeline of projects that can support the achievement of national goals under the 2030 Agenda for Sustainable Development or national climate commitments. A KPI framework targeted at the project and policy levels assists in the selection and monitoring of projects. These KPIs should be carefully selected, based on vulnerability and needs assessment as well as national climate and development strategies, action plans and priorities, and allow for regular monitoring by choosing indicators that are frequently and easily available and be attributable to national policy action. Benchmarking projects against such clear and measurable criteria can ensure projects are selected that accelerate climate action, target vulnerable populations and locations, and improve debt sustainability by scaling up long-term finance.[43]

Furthermore, beyond the direct benefits of the implementation of climate-related projects, debt swaps can achieve a transformational impact at the country level. Linking debt swaps to KPIs at the policy level can support the acceleration of policy reforms and other policy action at the macro level to create an enabling environment, which in turn will enhance the sustainability of outcomes.[44] In addition, a clear implementation and monitoring framework and the larger scale of these multi-year swaps help to build confidence among bilateral creditors and crowds in additional support from donors that can scale up the resources provided through the swap.


Photo: nemar74/iStock

ESCWA's debt swap initiative is currently being piloted in Jordan. As clear country ownership and a reliable institutional framework are paramount to ensure sufficient support and sustainability of the initiative, Jordan has established an interagency taskforce. Members from the ministries of planning, finance, energy, environment, and water and irrigation coordinate to operationalize the debt swap. The taskforce has identified a set of actionable projects that support climate adaptation and mitigation, including those focused on water supply and wastewater management, sustainable forest management, as well as on renewable energy and energy efficiency measures. North African countries have expressed their interest in this debt swap initiative, which provides opportunities for securing funding for climate adaptation projects while not increasing their national debt burden.

Climate Funds and Multilateral Development Banks

MDBs and climate funds provide climate finance through different channels, some of which specifically focus on adaptation. These funding instruments support readiness projects to help prepare countries for securing climate finance. They also finance climate adaptation and mitigation projects through grants. Concessional international finance can be used catalytically for crowding in new finance, including from the private sector, which tends to charge commercial rates.

MDBs have become the dominant source of climate finance, providing almost two-thirds of total public climate finance flows to the Arab region between 2013 and 2019.[45] However, most of these flows have been non-concessional debt instruments with a very small share of grants offered. MDBs have also diversified their offerings into green financial instruments, in support of commitments made to align their operations with the Paris Agreement and the 2030 Agenda. For instance, the Islamic Development Bank (IsDB) issued in 2019 a €1 billion green sukuk, a financing instrument compliant with the rules of Islamic banking. Tunisia is among the IsDB Member Countries to have received proceeds from the offering. Overall, most of the proceeds were allocated to climate mitigation projects to support clean transportation (68 percent of total proceeds) and renewable energy and energy efficiency (27 percent of total proceeds). A small fraction has however also been used to support climate adaptation through sustainable water and wastewater management projects.[46]

Climate funds can also play an important role in providing alternative forms of financing, but their overall contributions remained at 1 to 2 percent of total public climate finance. In the Middle East and North Africa (MENA) region, the five funds serving the Paris Agreement (the Global Environmental Facility, the GCF, the Adaptation Fund, the Least Developed Countries Fund, and the Special Climate Change Fund) were the most active multilateral climate funds between 2003 and 2018. However, their average commitment per project has been relatively low. The Climate Investment Funds' Clean Technology Fund also provides financing to the region, but it primarily serves mitigation objectives.[47] In Morocco, the EBRD, the GCF, and the Green Economy Financing Facility provide funding and technical assistance through various funding lines, addressing SMEs in particular.[48] The focus of these funding lines is on climate change mitigation, such as smart green investments for saving energy and resources, and financing the green transition, but some support has also been made available for technologies that increase climate resilience. In addition to pure financial support, the programs offer knowledge and awareness-raising campaigns on climate change mitigation and adaptation and project development support. For example, the Green Economy Financing Facility seeks to enhance access to finance from local financial institutions through capacity-building activities.

However, many countries in North Africa continue to face challenges in accessing resources from international climate funds. While Egypt, Morocco, and Tunisia have been able to secure funding of US$294 million, US$220 million and US$141 million in total from the GCF until now, other countries have received much smaller amounts (Mauritania only received $46 million) or no project support at all (Algeria and Libya only received readiness funding).[49] The accreditation of suitable local entities as well as the time-consuming and complex project development and approval process have been identified as main barriers, particularly for low-income countries.[50] The GCF is currently providing readiness support to help address these challenges. Developing national capacity in this area could further improve the access to funds.[51]

Making Financial Instruments Work for Adaptation

Until now, the described climate finance instruments support primarily mitigation projects. There are several reasons for this. Understanding and addressing them can help make the financial instruments work for adaptation. In particular, developing bankable adaptation projects is challenging. In addition, the way in which the climate finance instruments are designed and currently used does not align well with the nature of adaptation projects.

As such, a limited understanding of climate risks and vulnerabilities as well as general uncertainties relating to the frequency, severity and spread of future climate extremes—and thus the costs involved in alternative climate scenarios in which no adaptation is undertaken—renders it difficult to provide exact estimates on the benefits of adaptation. This reduces the incentives for actors to invest in adaptation. Conducting vulnerability assessments and providing local climate projections (as done through the ESCWA-led Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR) project, for example[52]) can help formulate a clear climate rationale and identify where climate finance, particularly from the private sector, is needed the most. Making this information publicly available and supporting knowledge sharing among different stakeholders further helps to reduce transaction and information costs and involve businesses and the private sector in identifying vulnerabilities as well as project ideas.

Further, clearly attributing results and impacts to project activities is challenging for adaptation actions. Many adaptation interventions, such as enhancing the resilience of infrastructure or providing common resources without clearly enforceable property rights (such as biodiversity), have traits of a public good and their benefits are expected to accrue over a longer time horizon.[53] This renders their rate of return difficult to assess and quantify, which might deter investments. In addition, adaptation lacks a commonly accepted metric for comparing and valuing its benefits, similar to the system of carbon credits received for investing in climate change mitigation. Establishing such a commodification of adaptation is difficult as adaptation interventions are much more context-specific compared to mitigation actions. A sound KPI framework that builds on frequently available and easily accessible data can help to make impacts—and thus the benefits of adaptation projects—measurable and tangible. This in turn can attract investments. Coupling such a KPI framework with a proper monitoring and evaluation system is needed to ensure transparency on the distribution of funds and consider interlinkages between financial flows from different sources as well as between climate and development co-benefits.

In addition to these challenges relating to the nature of adaptation interventions, the current design of many financing instruments also present barriers to adaptation financing. Quantifiable investment incentives, in particular the rate of return, are especially important for tradable instruments such as green bonds to attract the interest of investors. However, adaptation projects are primarily designed to avoid future losses from anticipated climate risks rather than to generate a stable revenue stream. At the same time, the long-term payback period of adaptation interventions as well as the uncertainties and lack of information on resilience-enhancing technologies and future climate trajectories increase the perceived risk involved in financing adaptation. This raises the rate of return that would be required for an investment to be attractive even further. Further, climate action in general, and adaptation action in particular, is often hindered by the tragedy of the horizons,[54] as most policy and financing stakeholders operate under a short- or medium-term planning horizon that is ill-aligned with the long-term payback periods of most adaptation projects. To make financing instruments work for adaptation, it is thus paramount to consider these longer payback periods in their design.

While it is more difficult to achieve predictable positive returns on investments over a reasonable time horizon for adaptation projects compared to mitigation projects, it is not impossible. Activities focusing on technology development, such as those aimed at enhancing agricultural productivity through crop resilience, the provision of financial services that promote and finance adaptation, as well as supporting businesses in evaluating and incorporating climate risk into their operations, are likely to yield positive returns.[55] Similarly, projects with mitigation and adaptation co-benefits also have the potential to yield quantifiable investment benefits. Even if the rate of return on these projects is still too low for private investors, institutional investors with a clear climate mandate might be interested in financing them. To attract such investments, a framework to reliably measure targets, implementation, and outcomes is paramount.

Further, institutional and legal barriers can deter support for adaptation actions. Regulatory policies are needed to create demand for adaptation projects. Improvements in the overall investment climate can also help attract adaptation financing. As such, policy reforms to enhance institutional arrangements and legal frameworks can reduce policy and institutional risk. For example, uncertainties on tenure security and property rights might hinder reforestation or water-sector adaptation investments. In addition, public actors can help de-risk adaptation interventions to make them more attractive, for example by providing investment security through showing high-level commitment, legal reforms and long-term policy planning, as well as public investment guarantees, insurance schemes or co-financing of investments.

To scale up adaptation financing from MDBs and climate funds, as well as through debt swaps, capacity building and an enabling environment are needed. A review of the updated NDCs of North African States shows that there is an imbalance in the costed needs for climate adaptation and mitigation. Only Morocco specifies equal financing needs for both. The others either do not provide a cost estimate for climate adaptation at all, or specify much smaller needs for adaptation finance (between one-third and one-fifth) than for climate change mitigation. This indicates a lack of capacity in properly developing and costing climate adaptation projects. Similarly, finance mobilization effectiveness[56] tends to be prioritized in the selection of project proposals to seek funding for, even though the success of climate finance also depends on whether climate goals are met, whether public cost is minimized, and whether the distributive impacts are equitable and leave no one behind. This might lead to biased choices. MDB and climate fund support for capacity building could alleviate constraints in accessing and absorbing adaptation finance.

In addition, donors are often seen to have stronger incentives to invest in climate change mitigation compared to adaptation actions. The benefits of adaptation interventions are more concentrated geographically, and mitigation actions are perceived as more effective in addressing global risks.[57] Recipient countries could concentrate on large-scale projects or a pipeline of projects to reduce transaction costs and thus increase funding and investment incentives. Furthermore, MDBs, climate funds, and bilateral donors should focus on designing and providing more long-term financing options to align the time horizons of their financing products with the timeline of most adaptation interventions.

RECOMMENDATIONS

Climate finance is receiving increasingly more attention in international climate negotiations. While the importance of additional financial flows for achieving climate change adaptation and mitigation goals is undebated, current financial flows still fall far short of the identified financing needs, both in terms of their quantity as well as their quality. In particular, despite the pressing adaptation needs expressed by several countries in the region in their NDCs, current adaptation finance represents less than 30 percent of total climate finance received.

Innovative financial approaches and instruments can help access additional funds and maximize the value of existing ones. As such, financial instruments for adaptation range from greening public budgets and climate-proofing public expenditures, the mobilization of private sector financing through an enabling institutional environment, and from regulatory provisions as well as credit guarantee schemes to traditional revenue-oriented financing instruments such as green bonds, innovative debt swap programs, or multilateral development bank and climate fund financing.

In order to enhance access to adaptation finance and maximize the value of existing resources, current barriers and challenges need to be overcome. In particular, standardized methodologies are vital for assessing country-specific climate vulnerabilities and risks and in turn identifying adaptation needs. In addition, a clear taxonomy and well-defined evaluation methodology are important to create a collective understanding of what qualifies as adaptation action. Fostering cooperation and communication between ministries and decision-makers at all levels of policymaking can create an enabling institutional framework and support the prioritization of adaptation at the planning and funding stage. This can help generate synergies and avoid distortions.

A clear policy, legal, and regulatory framework that takes international standards and good practices into account while at the same time responding to local needs and circumstances is needed to establish an enabling investment environment for project identification and active private sector engagement. Similarly, a comprehensive monitoring and evaluation system and ambitious budget tagging and tracking will allow supervision of whether funds have been used for their purpose, help to respond to reporting requirements by funders, enhance transparency, and build trust.

Overall, a holistic approach to climate change adaptation that mainstreams climate considerations into all stages of national development planning can help maximize the value of existing financial instruments for adaptation. Continuous knowledge sharing among all stakeholders, including fostered South–South cooperation, as well as comprehensive capacity-building efforts can facilitate the translation of qualitative needs assessments into actually costed adaptation projects.

Climate Risk Regulation in Africa

KEY MESSAGES

- African financial authorities and the private sector have a growing awareness of climate-related risks, which can be divided into physical risks and transition risks. Climate risks pose a significant threat to financial stability by reducing the collateral value of economic agents and jeopardizing the soundness of financial institutions.
- Climate-related risks have been added to the research agendas of various central banks and supervisory organizations as governments acknowledge the threat that climate change could pose to their economies and financial systems, including financial losses caused by climate-related disasters and implications on financial valuations of a necessary transition away from high-emitting sectors of the economy.
- Financial regulations and self-regulation practices of financial institutions are critical enablers of a resilient financial system and encourage more climate investment in the region. The increased quantification, pricing, and management of physical climate risks by financial institutions can help foster social resilience, not only by assuring the financial system's resilience to climate change, but also by providing price signals that influence economic behavior.

Photo: MOIZ HUSEIN/iStock

- As long-term measures to address climate-related financial risk, all 54 African countries have signed the Paris Agreement and submitted ambitious INDCs, while the majority have ratified NDCs. However, many of their commitments require financial, technical, and capacity-building support.
- There are three significant challenges that African governments are currently facing in their efforts to integrate climate risk into their financial systems: a lack of data; a lack of internal capability to define regulations and guidelines; and a lack of international standards or common methodologies, such as stress tests.

"We are ready to take on more risk. Typically, we finance only 50 percent of projects. Now, we have decided to finance up to 75 percent of projects that are primarily motivated by adaptation and up to 100 percent in the most vulnerable parts of the world, including small and developing states and the least developed countries."

Werner Hoyer
President, European Investment Bank

INTRODUCTION

In different reports on financial risk, the World Bank, the International Monetary Fund (IMF), the European Central Bank, the U.S. Federal Reserve and the Global Center on Adaptation (GCA), among others, convey that climate change will be a source of systemic risk, with potentially severe consequences for both financial institutions and financial markets. The effects of climate change on financial stability depend on the distribution of financial exposure and the evolution of prospective financial system losses.

As the International Finance Corporation (IFC) has warned, the unexpected volatility of conditions caused by unaddressed climate impacts can affect projected results and weaken the financial systems.[1] For general debt instruments such as loans, for example, debt repayment capacity can be impacted by changes in underlying cash-flow values—projected earnings and expenses—caused by climate change, resulting in a deterioration of financial positions.

An analysis by Moody's Analytics found that 49 banks across 14 African countries had extended US$218 billion of credit to environmentally sensitive sectors—about 29 percent of their total loans.[2] As a result, African banks are vulnerable to climate change shocks increasing in frequency and severity, as they are projected to do. Unless lenders take action to manage these risks, Moody's expects that environmental factors will lead to a deterioration of the credit quality and profitability of these banks in the long term. Financial regulations and self-regulation practices of financial institutions are critical enablers of a resilient financial system and encourage more climate investment in the region.

Photo: James Harrison/iStock

This chapter focuses on the impact of climate risks on African financial systems. It is based on a study in 2021 by McKinsey & Company in collaboration with African Development Bank (AfDB), GCA, and United Nations Environment Programme Finance Initiative (UNEP FI).[3] The report's goal was to assess the integration of climate-related risks in the prudential, financial, regulatory, and supervisory frameworks of several African countries and identify potential levers to incentivize their internalization. It also included in-depth case studies on the Democratic Republic of the Congo (DRC), Egypt, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Rwanda, South Africa, Tunisia, and Zimbabwe, supported by interviews and discussion with regulators and stakeholders in these countries.

The first section focuses on the exposure to climate-related risks of Africa's financial sector, pointing out that some African nations are among the most vulnerable in the world to climate risks. It then goes on to show that there is a growing momentum globally among financial authorities, including in Africa, to develop a broad-based regulatory framework to address such risks, and details the transmission channels through which climate risks threaten the stability of the financial system. The second, most substantial section presents the research and findings of the 2021 report. The chapter concludes with a set of recommendations for improving the capacity of African financial institutions, whether in the public or private sector, to manage such risks.

AFRICA'S FINANCIAL SECTOR: EXPOSURE TO CLIMATE CHANGE

Climate change poses a significant threat to financial stability. Climate hazards are already a highly relevant concern in Africa today and are expected to intensify, with their effects contributing to food insecurity, population displacement, and stress on water resources. A 2021 World Bank analysis warned that extreme weather events can strand assets, reducing the collateral value of economic agents and jeopardizing the soundness of financial institutions.[4] African authorities and the private sector have a growing awareness of these physical risks of climate change. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) found that climate change is already reducing economic growth across Africa, increasing income inequality between African countries and those in temperate climates.[5]

African countries are dealing with climate-related issues that threaten livelihoods, public health, infrastructure investments, economies, water and food systems, and agriculture. According to the Global Climate Risk Index 2021, five African nations were among the 10 most affected by extreme weather in 2019: Mozambique (No. 1), Zimbabwe (No. 2), Malawi (No. 5), South Sudan (No. 8), and Niger (No. 9).[6] African countries thus have a significant incentive to join the global effort to adapt to climate change and climate variability because they are among the most vulnerable to climate hazards. Water stress, food insecurity, and disruptions across the continent will worsen as the climate warms, worsened by more severe weather events.

GLOBAL MOMENTUM FOR ADDRESSING CLIMATE CHANGE RISKS IN THE FINANCIAL SECTOR

The "Breaking the Tragedy of the Horizon" speech by former Bank of England Governor Mark Carney on September 29, 2015, brought climate risk-related issues to the attention of financial authorities worldwide.[7] By tying climate risks to financial stability, it changed how regulators saw global warming's threat to financial stability and prompted additional action by numerous financial market stakeholders.

As a result, the G20 Financial Stability Board (FSB) launched the Task Force on Climate-Related Financial Disclosures (TCFD) in December 2015, seeking to identify the information needed by investors, lenders, and insurance underwriters to assess and price climate-related risks and opportunities effectively.[8] TCFD principles are substantially comparable with most environmental, social, and governance (ESG) standards in terms of risk management framework (identification, quantification, modeling, strategy, and disclosure), notably on risk identification and assessment.

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) brings together supervisors to create a forum for discussion and knowledge exchange on green finance and climate change systemic issues. In contrast, the TCFD is a private sector initiative for market participants.

Box 1. NGFS Commitments to Climate-Related Risks

Commitment 1: Integrating climate-related risk into financial stability monitoring and micro-supervision

Commitment 2: Integrating sustainability factors into own-portfolio management

Commitment 3: Bridging the data gaps

Commitment 4: Building awareness and intellectual capacity and encouraging technical assistance and knowledge

Commitment 5: Achieving robust and internationally consistent climate and environment-related disclosure

Commitment 6: Supporting the development of a taxonomy of economic activities

There are other similar initiatives that are being formed around the world, including the Sustainable Banking and Finance Network (SBFN), the Partnership for Carbon Accounting Financials (PCAF), the Principles for Responsible Investment (PRI), and various initiatives under the United Nations Environment Programme Finance Initiative (UNEP FI), such as the Principles for Responsible Banking (PRB), Collective Commitment to Climate Action (CCCA), and the Net-Zero Alliances.

The African Financial Alliance on Climate Change (AFAC) brings together leaders in the African financial industry: central banks, insurance companies, sovereign wealth and pension funds, stock exchanges, and commercial and development banks. AFAC aims to increase financial sector participation in climate action to raise the share of investments supporting low-carbon and climate-resilient development in Africa.

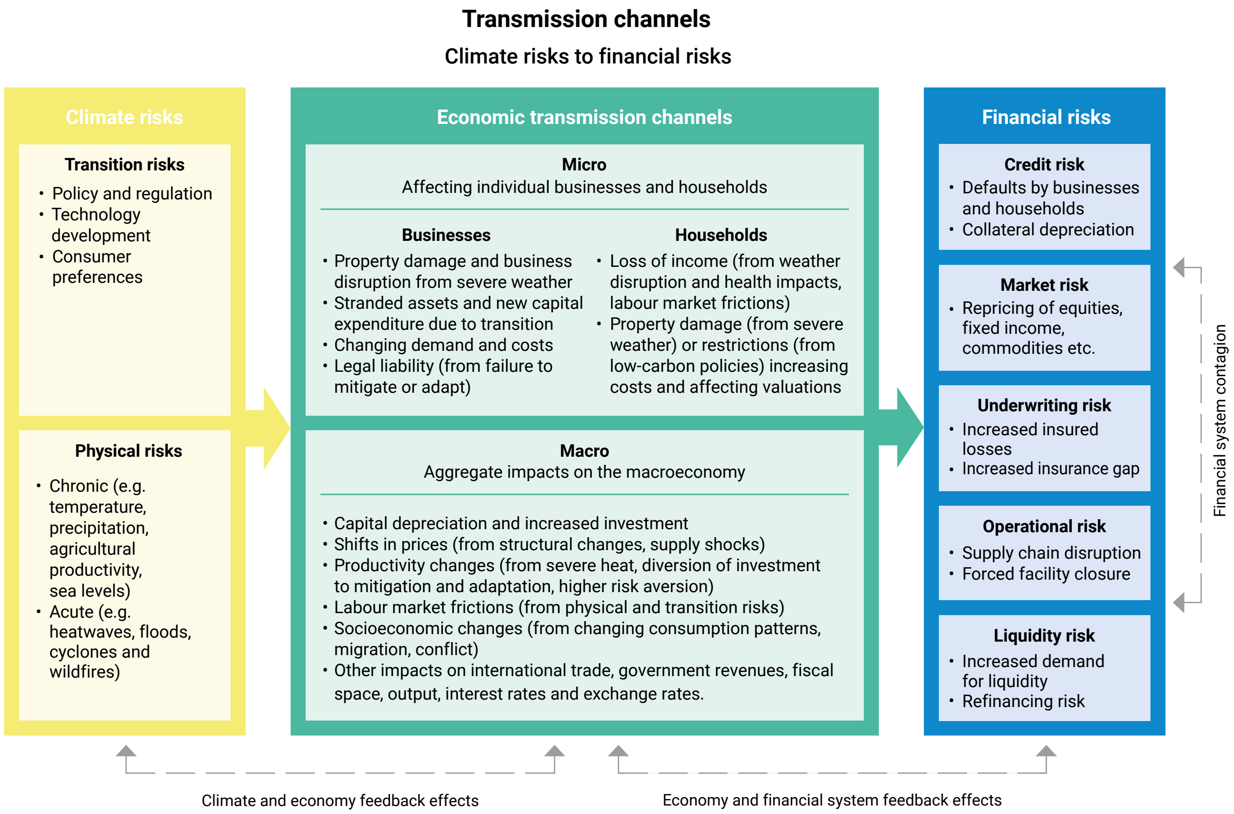
CLIMATE-RELATED RISKS AND FINANCIAL STABILITY

Climate-related financial risks are a group of potential risks that may arise as a result of climate change, and which may have an impact on the safety and soundness of individual financial institutions as well as a broader financial stability implication for the banking system.[9] Climate-related risks have been added to the research agendas of various central banks and supervisory organizations as governments acknowledge the threat that climate change could pose to their economies and financial systems, including financial losses caused by climate-related disasters and the implications on financial valuations of a necessary transition away from high-emitting sectors.[10] Moreover, some countries have already established well-defined frameworks for defining and regulating climate-related risks.

Climate risks are of two main kinds: physical risks and transition risks.[11] Physical risks include the potential economic costs and financial losses stemming from the increased severity and frequency of extreme climate change-related events and longer-term shifts in the climate. Transition risks are associated with the process of transitioning to a low-carbon economy. Financial institutions from all sectors are required to adopt a consistent definition of climate-related financial risks that encompasses both physical and transition aspects.

As the financial implications of climate change become obvious, financial services and supervisors are focusing on acceptable responses. The increased quantification, pricing, and management of physical climate risks by financial institutions can help to foster social resilience, not only by assuring the financial system's resilience to climate change, but also by providing price signals that influence economic behavior. Financial institutions could also promote the formation of markets for climate resilience funding, generating opportunities for financing adaptation and resilience.

Figure 1. Transmission Channels from Climate Risks to Financial Risks



Source: Reproduced from NGFS Climate Scenarios for Central Banks and Supervisors report (2021)[12]

According to the Africa NDC Hub, all 54 African countries have signed the Paris Agreement and submitted ambitious Intended Nationally Determined Contributions (INDCs), and the majority have ratified Nationally Determined Contributions (NDCs).[13] Signatories have committed to enhancing climate action by reducing their greenhouse gas (GHG) emissions and building resilience. However, many of their commitments require financial, technical, and capacity-building support.

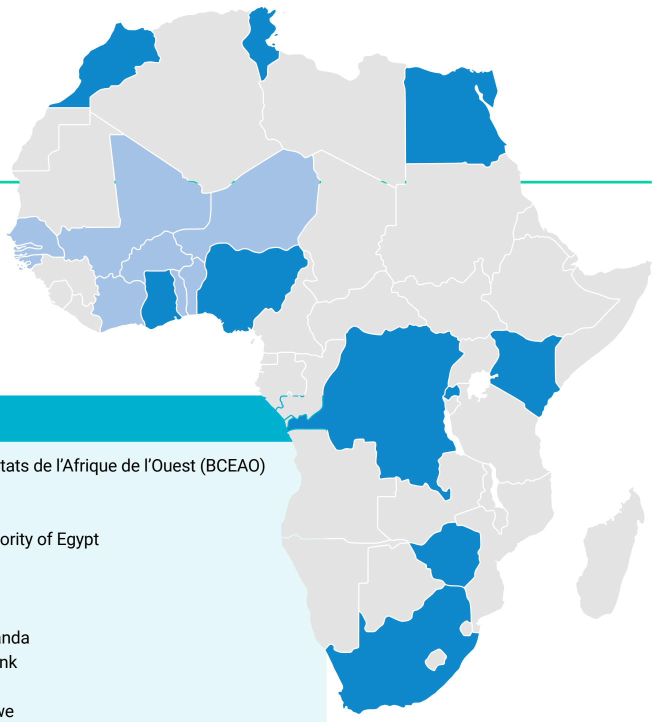
CLIMATE RISK INTEGRATION IN AFRICAN FINANCE REGULATORY FRAMEWORKS

Regulators can speed up the adoption of climate risk-related practices in the business sector. The recent report on climate risk regulation in Africa's financial sector by McKinsey & Company in collaboration with AfDB, GCA, and UNEP FI sought to establish which African countries' financial sectors already have climate-related legal and supervisory requirements and whether authorities want to make additional advancements in this area.[14] The assessment also considered industry-level private sector initiatives, such as national or regional working groups promoting self-regulation, supporting capacity building, or developing information-sharing forums.

The analysis was conducted through a series of semi-structured interviews, and a questionnaire was created for each of the countries studied. These questionnaires were distributed to the authorities of the financial systems of each country, as well as to regulated financial institutions in those countries. The study included 19 countries with different levels of financial system sensitivity to climate-related hazards. Overall, 25 organizations were surveyed, including 11 financial regulators and 14 private entities. Figure 2 provides an overview of the project.

Figure 2. Overview of Participating Institutions in the Climate Risk in Africa Analysis

26 interviews with authorities and private players covering 19 countries were organized between September and October 2021



Organisation category	Region or country	Organisation name
Central bank/Authority (11)	Mali DRC Egypt Egypt Ghana Mauritius Morocco Rwanda South Africa Tunisia Zimbabwe	La Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO) Central Bank of Congo Central Bank of Egypt Financial Regulatory Authority of Egypt Bank of Ghana Bank of Mauritius Al Maghrib Bank Banque Nationale de Rwanda South African Reserve Bank National Bank of Tunisia Reserve Bank of Zimbabwe
Industry initiative/Group (2)	Zimbabwe Kenya	Bankers Association of Zimbabwe Kenya Bankers Association
Private sector players (13)	Egypt Kenya Mauritius Nigeria Nigeria Rwanda Rwanda South Africa South Africa South Africa South Africa Zimbabwe	Commercial International Bank of Egypt ICEA LION Group KCB Group Mauritius Commercial Bank Wema Bank Africa Re Bank of Kigali Equity Bank FirstRand Group Investec Group Land Bank Standard Bank Central Africa Building Society (CABS)

Note: UMOA member countries in dark blue; non-UMOA member countries in light blue

Source: Reproduced with permission from AfDB et al. (2021)[3]

Table 1 summarizes the state of climate risk regulation in 12 countries examined in greater depth. A more thematic analysis of the data follows.

Table 1. **Climate Risk-Related Initiatives: Country Analysis for 12 Countries**

Country	Financial stability architecture	Climate risk-related initiatives	
		Regulation on climate-related risks	**Self-regulatory bodies and private sector initiatives**
DRC	Regulated by the Central Bank	No regulation on climate-related risks	Private sector does not currently have an industry initiative working on climate-related risks
Egypt	The Egyptian financial sector is overseen by the Central Bank of Egypt (CBE) and the Financial Regulatory Authority (FRA)	CBE issued its Guiding Principles on Sustainable Finance for the banking sector; FRA laid out the sustainability disclosure requirements	FRA launched the Regional Center for Sustainable Finance (RCSF)
Ghana	Ghana's financial system is regulated and supervised by four distinct authorities	Bank of Ghana (BoG) issued voluntary guiding Sustainable Banking Principles to underpin banks' Environmental and Social Risk Management (ESRM)	To the knowledge of BoG, no private player is currently building capacity on climate-related risk
Kenya	Kenya's financial sector (excluding insurance) is supervised and regulated by the Central Bank of Kenya (CBK)	Kenya's parliament enacted the Climate Change Act (2016), providing a regulatory framework in response to climate change and a mechanism for effective institutional arrangements for climate action, including climate finance	Kenya Bankers Association (KBA) has commenced the development of Sustainable Finance Guiding Principles to create a globally competitive industry
Mali	The Malian financial sector is regulated by the Central Bank of Western African States (BCEAO)	The Malian financial regulatory framework does not explicitly mention climate-related risks	According to interview responses and desk research, there is currently little private sector initiative on climate-related risks in Mali
Mauritius	The financial sector in Mauritius is regulated and supervised by the Central Bank of Mauritius (BoM) in collaboration with the Financial Services Commission (FSC)	BoM has established the Climate Change Center (CCC) and various taskforces	No voluntary private sector initiatives have been reported
Morocco	The Moroccan banking system is solely regulated by the Central Bank of Morocco, also called Bank Al-Maghrib (BKAM)	BKAM and the Moroccan Capital Market Authority (AMMC) have become members of the SBFN	The Professional Banking Group of Morocco (GPBM) has published a Banks and Climate Charter
Nigeria	The Nigerian financial sector is overseen by the Central Bank of Nigeria (CBN)	CBN, via the Bankers' Committee, has approved the adoption of the Nigeria Sustainable Banking Principles (NSBP)	In collaboration with the CBN, the private sector of the banking industry has established a group called the Sustainability Champions
Rwanda	The National Bank of Rwanda (BNR) is the sole regulator and supervisor of the Rwandan financial sector	BNR has no regulation on climate risks as yet; however, this is under development	The Rwanda Bankers Association has a mandate to ensure proper risk management frameworks in general and in banking operations
South Africa	The South African financial services sector is overseen by the South African Reserve Bank (SARB), a member of NGFS, to ensure its stability and functioning	South Africa currently has no active regulation relating to climate risk, but the Prudential Authority (PA) is working on a set of regulations expected to be enforced	The financial industry is taking voluntary steps towards integrating climate risk in decision-making

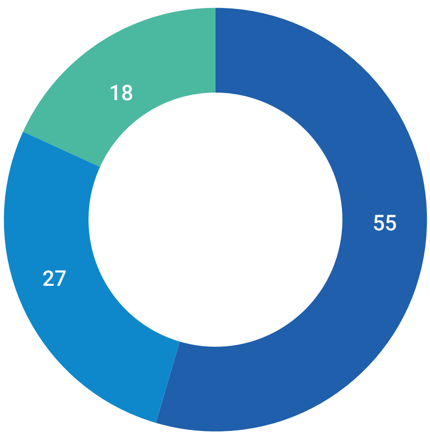
Country	Financial stability architecture	Climate risk-related initiatives	
Tunisia	The Central Bank of Tunisia regulates the country's banks with the main objective of maintaining price stability	In line with the country's efforts in terms of green growth, the Central Bank of Tunisia has integrated NGFS principles	The Tunisia Green Economy Financing Facility (GEFF)
Zimbabwe	Zimbabwe's financial sector is made up of four regulatory authorities supervised by the Ministry of Finance: The Reserve Bank of Zimbabwe (RBZ), the Deposit Protection Corporation, the Securities Commission, and the Insurance and Pensions Commission	Expert interviews indicate that climate risk-related initiatives in Zimbabwe are still developing	There is no legislative directive on climate-related risk initiatives

Source: Authors' summary of the findings of AfDB et al. (2021).[3]

Key Insights from the Analysis

Climate risk is a top priority for financial authorities. Nine of the 11 officials interviewed (82 percent) ranked it as a high or very high priority on their agenda. This sense of urgency can be seen in the broad participation of authorities in climate and sustainability risk-related initiatives such as the NGFS and SBFN. Several interviewees emphasized that climate-related risks cannot be considered in isolation and that overall economic and societal circumstances (for example, economic concentration in carbon-intensive sectors) must be considered.

Figure 3. Priority Perception of Climate Risk Among Financial Authorities



Very high priority

High priority

Medium priority

82% of the authorities interviewed considered climate risk a high or very high priority

"With monetary policy, climate risk has become our top concern"

Central Bank – Head of Sustainability Department

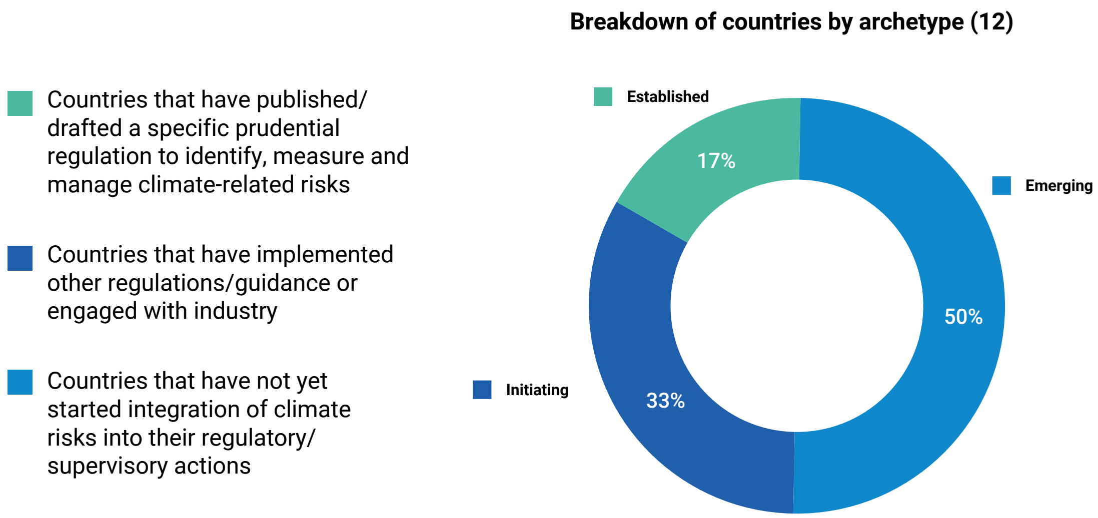
Source: Reproduced from Figure 5 in AfDB et al. (2021)[3]

Climate risk data and methodologies are inadequate. There are three significant challenges that African governments are currently facing in their efforts to integrate climate risk into their financial systems. The most relevant ones for authorities were a lack of data and a lack of internal capability to define regulations and guidelines, both of which were mentioned by 82 percent of those interviewed. This was followed by 73 percent of interviewed authorities mentioning a lack of international standards or common methodologies, such as stress tests. Data has many dimensions, including access, availability, coverage, and granularity. Many respondents, particularly those from the private sector, expressed a lack of access to reliable databases for assessing and measuring climate risk.

There is a lack of regulations and measures. Very few authorities and supervisors in the financial sector have established regulations or supervisory expectations. The report concludes that most regulators and supervisors in the financial industry have not addressed climate-related risks or more significant sustainability-related concerns through binding rules and supervisory guidelines. Although authorities can evaluate these risks as part of their existing duties, there are ongoing attempts to build effective and comprehensive frameworks to detect, analyze, manage, and communicate climate-related risks that are connected to developments in the private sector.

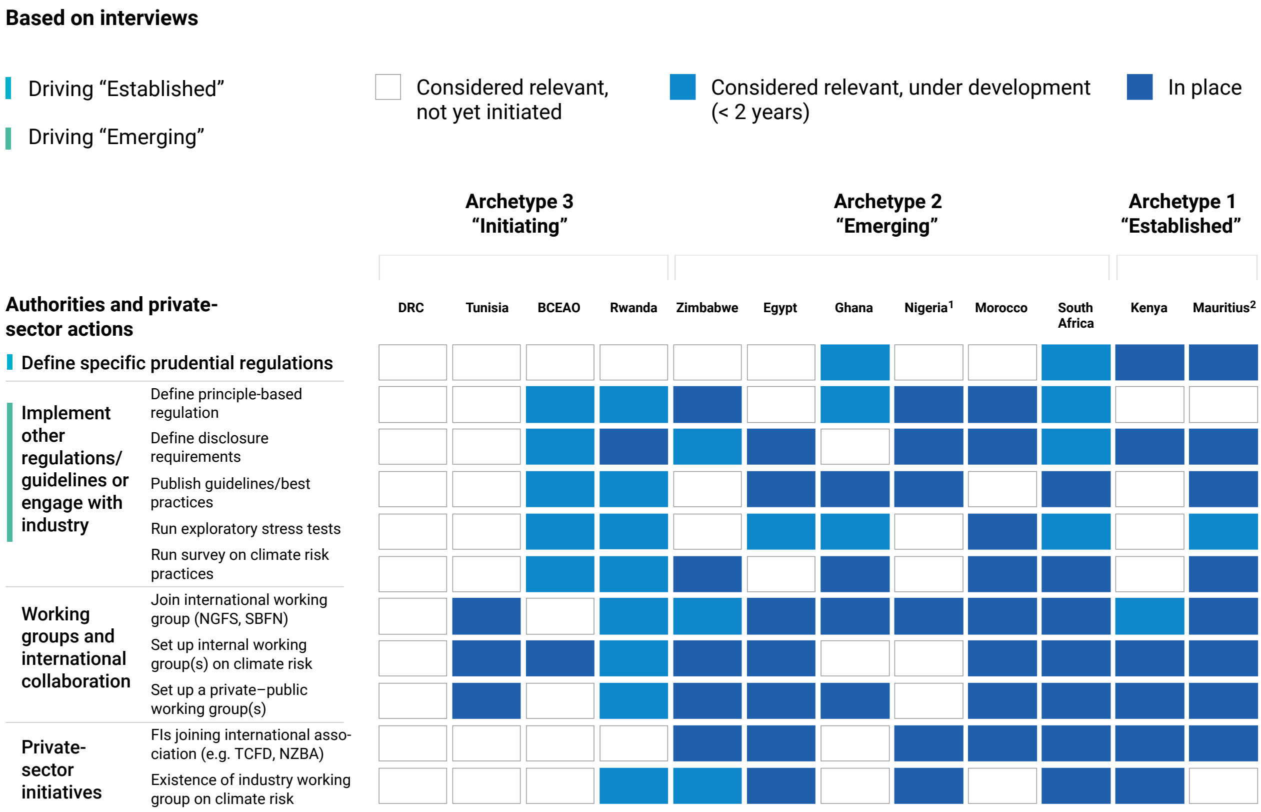
In terms of regulatory status, countries were classified into three regulatory and supervisory categories, or archetypes. Figure 4 summarizes the results. Figure 5 provides an overview of climate risk-related regulations and initiatives in the 12 countries.

Figure 4. Classification of 12 African Countries by Regulatory Action on Climate Risk



Source: Authors' summary of the findings of AfDB et al. (2021)[3]

Figure 5. Overview of Climate Risk-Related Regulations and Initiatives Across African Regions



Notes: Archetypes were defined in terms of regulatory advancement. (1) Implementation Guidance to the Nigerian Sustainable Banking Principles are not binding per se, but can generally be considered detailed. (2) Mauritius has drafted its prudential regulations and should be finished by the end of the year 2021. Source: Amended from Figure 6 in AfDB et al. (2021)[3]

Non-binding measures are considered very relevant. Non-binding measures are preferred by authorities but are not widely implemented at the moment. For example, six of the top nine initiatives declared highly relevant or in place (by more than 50 percent of authorities interviewed) among the 14 measures to strengthen the financial industry's integration of climate risk are non-binding.

Encouragement through informal promotion is emphasized. Conducting awareness-raising campaigns and events (for example, through surveys, conferences, and dialogue) is the most relevant non-regulatory action, with a full 100 percent of authorities rating it as "very relevant," but it is only implemented in two of the featured jurisdictions. Sharing best practices (for example, through guides and roundtables) is deemed necessary by 82 percent of the interviewed authorities and has been implemented by two featured jurisdictions. Publishing assessments of the aggregate climate risk exposure of the financial sector is deemed relevant by 64 percent of the authorities questioned and has been implemented by two featured jurisdictions. Finally, although 64 percent of all authorities interviewed believe that defining a taxonomy for economic activities is essential, no featured jurisdiction has done so.


Photo: Davor Lovincic/iStock

POLICY RECOMMENDATIONS

Based on the challenges of addressing climate risks identified in the analysis, the following recommendations for action emerge:

Address the lack of capacity and capabilities of authorities

Public authorities and financial regulators should be encouraged to develop their own capabilities while also contributing to the capacity development of private sector players, for example by highlighting best practices, offering training programs, forming working groups, and so on. Several interviewees mentioned the importance of collaborating with external organizations and initiatives to implement this approach.

Set standard disclosure instructions/set mandatory reporting and disclosures

Consider mandating minimum disclosure standards for the financial and non-financial sectors in accordance with TCFD recommendations, covering governance, strategy, risk management, metrics, and targets. Consider specific regulations and supervisory guidelines and metrics to ensure that financial institutions adequately consider climate risk and facilitate interactions with counterparties, investors, and clients.

Promote access to data and information/develop stress test models and scenarios analysis

Make physical and transition risk-related data and information more accessible, for example by incorporating reliable sources into a central repository. Develop stress test models and scenario analyses for supervisory purposes as well as institutional reference points.

Promote non-bidding measures

Non-regulatory actions are often the most effective ways to raise awareness about climate change. For instance, conducting awareness-raising events and surveys is often the most effective way to gather information about the financial sector's exposure to climate risk. Sharing best practices, for example via guides and roundtables, publishing assessments of the financial sector's aggregate climate risk exposure, and defining a taxonomy for economic activities are other tools and resources that can help financial stakeholders make informed decisions when assessing their exposure to climate risk.

Resilient Recovery

Senegal and Côte d'Ivoire

Photo: Simon Townsley/Panos Pictures

KEY MESSAGES

- Senegal and Côte d'Ivoire face steep challenges, including from climate change, in making a transition to the next stage of economic prosperity. As these countries plan for the future, investment in green sectors could deliver a sustainable and environmentally friendly post-pandemic recovery.
- Investment in adaptation measures could have the highest social-economic returns by generating more jobs and economic value in the long term relative to traditional investments. Strategically targeted investments in adaptation can help expand opportunities for the labor force, which is currently tied up in informal work. These realizable results, in turn, further increase resilience to climate impacts.
- Modeling shows that in Senegal, investment in adaptation initiatives could create over 200 percent more jobs within five years (600 percent within 20 years) and around 700 percent greater economic value in 20 years) relative to the stimulus financial package used as a counterfactual. A similar package in Côte d'Ivoire would generate up

to 180 percent more jobs within five years (400 percent within 20 years) and 265 percent more economic value in 20 years.

- Governments in both countries, which have a key role to play in setting long-term priorities for the economy and creating an enabling environment for the private sector, should develop a holistic approach to integrating public and private adaptation initiatives. They should integrate adaptation into fiscal policy and introduce innovative green financing.

> “Africa, a continent vulnerable to climate change, is lagging behind in the adaptation process. Africa benefits very little from green financing and investments despite the existence of dedicated mechanisms. Yet even if they pollute the least, they remain the most vulnerable to the effects of global warming. African countries remain fully committed to climate action, ecosystem resilience and the conservation of biodiversity and the natural habitat that offers so much to humanity.”

H.E. Macky Sall
President of Senegal and Chair of the African Union

INTRODUCTION

Recent international crises, including the COVID-19 pandemic and war in Ukraine, have heavily affected the economic and social development of many countries globally. Africa is on the frontline of these crises. This chapter focuses on two country case studies: Senegal and Côte d'Ivoire. Both economies exhibit a recovery path from COVID-19, with real GDP growth in 2021 of 6.1 percent[1] and 7 percent,[2] respectively. However, the economic fallouts of the outbreak, the appearance of new variants, and the low rates of vaccines still threaten their recovery. Further, the tensions between Russia and Ukraine have led to a steep increase in food and energy prices, a deterioration of terms of trade, and a shortage of fertilizers, threatening the macroeconomic outlook and food security.

The impacts of these international shocks in Africa, especially on food security, economic recovery, and existing environmental and climate change vulnerabilities, only reemphasizes the need to engage in smart green economic growth. The concept of green growth encompasses the idea of sustained economic growth through 1) resource-use efficiency; 2) climate change response through adaptation and mitigation; 3) the creation of decent green jobs; and 4) human wellbeing and social inclusiveness.

Crucial for an effective green recovery plan is mainstreaming climate change adaptation into it. Adaptation measures must be implemented in every sector—agriculture, transportation, energy, trade, water resources, and urban development. It is important to invest in nature-based solutions (NbS), such as restoring mangroves to protect coastal communities or creating urban parks that absorb stormwater and moderate heat waves in cities. Given the vast human and natural resources of Senegal and Côte d'Ivoire, there is immense potential to move forward rapidly in labor-intensive modern industries such as ecotourism services, climate-smart agriculture, renewable energy, green building, and infrastructure.

Such adaptation measures will have several co-benefits. As highlighted in the State and Trends in Adaptation Report 2021,[3] adaptation measures can be enormously cost-effective and have the potential to start a positively reinforcing cycle of benefits. Adaptation measures could help lift people out of poverty, reduce hunger and undernourishment, fight diseases, create jobs, reduce inequality, mitigate the risk of conflicts, and give voice to the most vulnerable. Specifically, in Côte d'Ivoire, adaptation measures could increase the productivity and resilience of smallholder cocoa farmers. There is strong potential to pair adaptive investments in Côte d'Ivoire with several support initiatives in different sectors, including agriculture, fisheries, and forestry, to promote sustainable and efficient practices. Strategically targeted investments in adaptation can help expand opportunities for the labor force, which is currently tied up in informal work characterized by irregular and volatile incomes. These realizable results, in turn, further increase resilience to climate impacts.

This chapter presents an analysis of the economic and employment potential of green investments relative to traditional and high-carbon investments in Senegal and Côte d'Ivoire.[4] For each country, an overview of the national economic context is provided, followed by the economic impacts of COVID-19 and country-specific policy responses, and then the results of the modeling exercise. Finally, some policy recommendations are provided.

This chapter expands the number of countries reviewed in the State and Trends in Adaptation Report 2021, using the same methodology. The evaluation uses an input-output model (or Leontief model), which is a quantitative macroeconomic model based on the interdependencies between different economic sectors or industries. The approach relies on input-output tables that describe the inputs used by each industry, the outputs produced by each industry, and the relationship between industry output and final demand among various users in a given year. The "synthetic industry approach," developed by H. Garrett-Peltier,[5] is used to analyze the expansion of green sectors based on the existing industries in the national account system. This allows the comparison of an expected traditional investment package to a hypothetical and equivalent green investment package. For a more detailed explanation of the methodology, refer to the background methodology paper.

SENEGAL

Social and Economic Overview of Senegal

Senegal is the second-largest economy in West Africa and the West African Economic and Monetary Union (WAEMU). Before COVID-19 impacted the world, between 2014 and 2019 the Senegalese economy grew by an average of about 6 percent per year.[6] The primary sector was the fastest-growing between 2014 and 2017, at 7.7 percent, on average,[7] and employed more than 60 percent of the working population in 2019.[8]

The economic growth spurt was driven by the agriculture, manufacturing, construction, mining, and financial sectors, boosted by large-scale infrastructure projects, lower oil prices, and foreign investments (PSE-PAP, 2019–2023).[9]

The "Plan Senegal Emergent" (PSE) is a reference framework for the transformation of the country's economic and social policy over the middle and long term. It aims for Senegal to reach emerging market economy status and become a hub for the West Africa region by 2035. This development strategy relies on three pillars: 1) structural transformation of the economy with a strong capacity to export and attract investment; 2) a significant improvement in the living conditions of the population, a more sustained fight against social inequalities while preserving the resource base and promoting the emergence of viable territories; and 3) the strengthening of security, stability, and governance, the protection of rights and freedoms and the consolidation of the rule of law to create the best conditions for social peace and to promote the full development of human potential.

Senegal's economic growth continues to face challenges from social issues, however, including high rates of poverty, limited jobs in the formal sector, and water resource partitioning. Almost 40 percent of the people live below the international poverty line, and more than half experience multidimensional poverty.[10] Senegal's score on the 2021/2022 Human Development Index was below the average for Sub-Saharan Africa; it ranked 170th out of 191 countries. Computations based on data from the National Agency of Statistics and Demography of Senegal (ANSD) suggest that only around 8 percent of working-age people are in formal employment, largely because the formal economy is burdened by high regulatory rigidity and lack of opportunity.[11]

According to the PSE, the short- and medium-term economic growth of Senegal depends on achieving good performance in agriculture (including livestock, fisheries, and forestry) and increasing investment. However, climate hazards negatively impact the production of the primary sector and threaten the food security of the country. Indeed, agriculture production declined by 2 percent in 2021 despite the resurgence of growth, partly due to climatic conditions.[12] Broadly, the primary sector, including agriculture, fishing, forestry, and livestock, employs more than 60 percent of the working population.[13] The impacts of environmental issues could go beyond the primary sector. Tourism, identified by the PSE as one of the key sectors, has already suffered from the detrimental effect of climate change. For instance, the area of Saly has lost 30 percent of its infrastructure capacity due to coastal erosion.[14]

Moreover, water resource management is a crucial issue in Senegal. Water availability is ensured by sufficient rivers and groundwater resources, but there is a considerable unequal distribution across the country. Access to water is impeded either because it is too far from major consumption centers and development hubs or because it is difficult to mobilize to meet the population's demand for drinking water or other uses (industry, agriculture, mines, etc.).[15]

Photo: JordiRamisa/iStock

Impact of COVID-19 and Policy Responses of Senegal

As of September 15, 2022, Senegal had logged more than 88,000 COVID-19 cases and 1,968 deaths.[16] The first COVID-19 case in Senegal was registered in early March 2020. The Government swiftly reacted to the situation by declaring a national state of emergency and implementing strict containment measures, including travel restrictions, curfews, school closures, public gathering bans, and border closures.

The COVID-19 pandemic led to job losses, business closures, and important income losses. For example, high-frequency phone surveys conducted by the World Bank found that 85 percent of households in Senegal reported income losses in the first months of the pandemic. Job losses among the most vulnerable workers, including farmers, fishers, women, youth, and those without a college education, can be irreversible and affect their productivity and income growth even as economies revive. In addition, the severe impacts seen for small and micro enterprises can lead to the erosion of entrepreneurial capital and jobs that can be hard to reverse.

Moreover, the war between Ukraine and Russia has led to an increase in food and energy prices and exacerbates inflationary pressures on Senegal. The lack of fertilizers for agriculture strongly threatens the harvest and food security in Africa, especially in Senegal.

To effectively respond to the health and economic emergency, the Government of Senegal implemented a comprehensive package worth 1,000 billion West African francs (FCFA), amounting to 7 percent of GDP.[17] This economic and social resilience plan consists of four main pillars: 1) improving the health system; 2) strengthening social protection; 3) stabilizing the economy and the financial system to support the private sector and employment; and 4) securing supplies and distribution for key foodstuffs, medicine, and energy products. To support the health system, the Government has allocated FCFA 97 billion (0.7 percent of GDP) to improve testing, treatment, and prevention. In terms of social protection actions, one million households received food aid worth FCFA 64 billion, and utility payments (for water and electricity) for poorer customers were suspended for two months (FCFA

15.9 billion). In terms of economic stabilization, hard-hit sectors such as tourism and transport received direct support of about FCFA 100 billion.

The Government also set up a partial credit guarantee scheme for companies affected by the COVID-19 crisis for a total amount of FCFA 200 billion (FCFA 100 billion for credit to large companies with a 20 percent state guarantee, and FCFA 100 billion for small enterprises with a state guarantee of 50 percent). However, the uptake has been low, and the Government has revised the design of this mechanism to make it more attractive in the context of the 2020–21 recovery plan. An expedited payment of unmet obligations aimed at strengthening firms' balance sheets (worth FCFA 200 billion instead of the FCFA 121 billion foreseen in the initial budget). On the tax side, the deadline for paying suspended tax obligations was extended from 12 to 24 months to improve the liquidity of firms.

Box 1. Modeling Approach for Senegal

Photo: Sylvain Cherkaoui/Panos Pictures

In the case of Senegal, the green stimulus package is compared to an investment in the mineral extractive sector. The choice of the extractive sector as a counterfactual is based on the different country priority plans, especially the PSE. This development strategy aims at addressing the medium- and long-term social and economic challenges of Senegal to become an emerging country by 2035. This strategy is implemented through several short-term action plans called "Plan d'Actions Prioritaires (PAPs)". The two first PAPs (2014–2018 and 2019–2023) identified the mining sector as one of the high-growth potential sectors, requiring Government to prioritize investments to develop the sector including gold and phosphate mining and the creation of hub mining.

The green investment package, on the other hand, is a set of investments in both mitigation and adaptation. It includes seven groups of interventions, namely:

1) Natural capital investment: this sector includes interventions in coastal protection, aquaculture, and reforestation.

2) Energy: this sector includes interventions in hydropower, solar photovoltaic, mini-grids, and onshore wind.

3) Agriculture: this sector accounts for agroforestry, and resilient seeds.

4) Efficient retrofits: this sector includes interventions in building efficiency, industrial energy efficiency, and appliance efficiency.

5) Transport: this sector includes interventions in electric vehicles (EV), Bus Rapid Transit (BRT), and EV charging infrastructure.

6) Waste management: this sector includes interventions in biomass plants and biogas plants.

7) Water management: this sector includes flood mitigation, water demand management, and wastewater treatment plant.

The background paper gives more details on the modeling and assumptions.

Moving Toward Green and Resilient Economic Growth: Senegal

Our analysis shows that adaptation measures in Senegal would provide the highest returns in terms of jobs and economic values, among the set of green investments. Investment in adaptation initiatives could create 230 percent more jobs within five years (600 percent within 20 years) and 695 percent greater economic value in the long term (within 20 years) relative to the extractive sector stimulus package in Senegal. Climate change adaptation spending is estimated to boost employment by 14,098 job years directly and 16,571 job years indirectly (through supply chains). In contrast, the traditional package would support employment by creating 127 job years directly and 1,251 job years indirectly (Figure 1).

Analysis shows that, compared to high-carbon investments, flood adaptation, wastewater, and water demand management can generate an economic return of 380 percent while coastal protection, aquaculture, reforestation, and resilient seeds could generate more than 100 percent economic return.

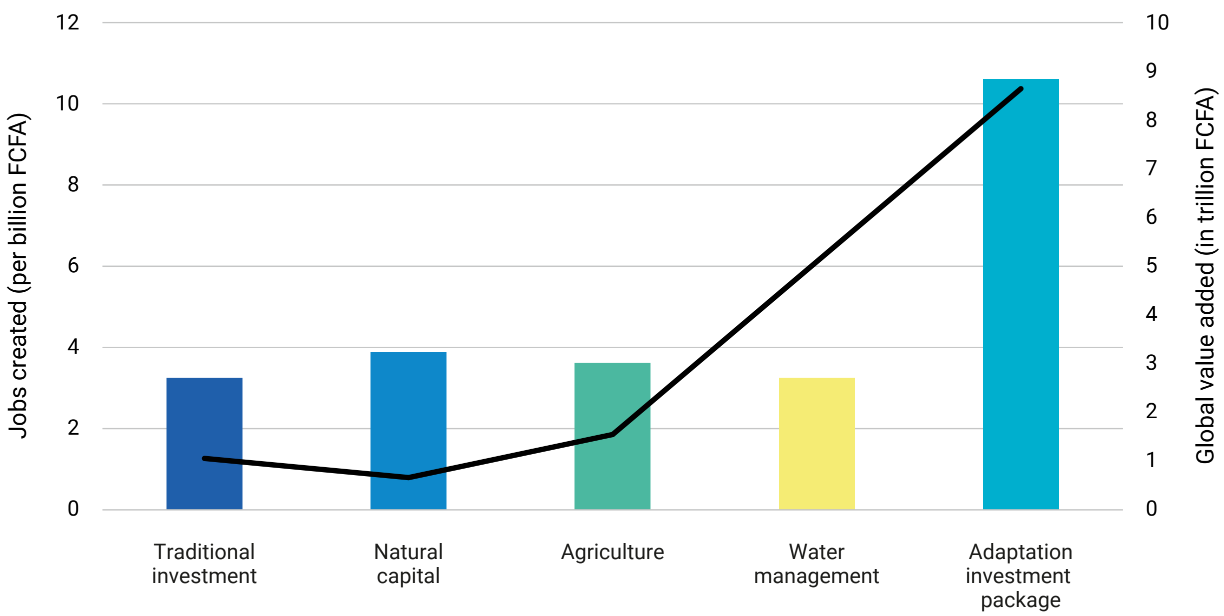
The potential for development of each of these sectors is now presented in greater detail.

Water Management

To respond to water management issues, the Government should prioritize the development of an integrated water management plan. Water management projects could include water capture and collection, water storage, water treatment (with methane emissions treatment), flood defense, drought defense, stormwater management, and ecological restoration and management. Regarding flood hazard mitigation, required investments are estimated at more than US$2 billion over 2016–2035 to strengthen drainage infrastructure and plan urban ecosystems. The Agence Française de Développement (AFD) has funded a project worth €15 million in this sector.[18]

As for water demand management, several projects have already been initiated, including a water transfer project (KMS3) and a desalination plant in the Mamelles square in Dakar. Regarding wastewater

Figure 1. Total Job Creation and Gross Value Added by Different Investment Packages: Senegal



Source: Author's calculations based on estimates

Notes: This graph displays the total jobs in the short term (5 years, left axis) and gross value added in the long term (20 years, right axis) generated by both traditional mining investment and adaptation investment packages. **"Traditional investment"** refers to investment planned in the PSE-PAP 2019–2023 to develop the gold and phosphate mining as well as the extraction mining hub. The adaptation investment package includes a set of "green" sectors, each consisting of a package of interventions. The different sectors (as well as the respective interventions covered by them) are: **1) natural capital** (including coastal protection, aquaculture, and reforestation); **2) agriculture** (including resilient seeds, and agroforestry); and **3) water management** (including wastewater treatment, water demand management, and flood mitigation). **"Adaptation investment package"** refers to the sum of natural capital, agriculture, and water management. A technical note in the appendix discusses estimation approaches and assumptions.

treatment, the Senegalese National Office for Sanitation (ONAS) has awarded the SUEZ group and its partner, the CDE consortium, the contract to design and build a wastewater treatment plant at Hann Bay in Dakar. With a capacity of 26,000 cubic meters per day, this plant is part of a program undertaken by the Senegalese Government to clean up the severely polluted Hann Bay. It will allow for the conservation of the marine ecosystem in the bay and improve the sanitary conditions of some 500,000 residents in nine of Dakar's municipalities.[19]

There are important private sector opportunities in building wastewater plants, drainage systems, and desalination/water transfer infrastructure. For example, a desalination plant could be located on the Mamelles beach and the Hann Bay for the Dakar agglomeration.

Natural Capital

The preservation of natural capital in Senegal should be the backbone of any development strategy, due to the dependence of several key economic and social sectors on this capital. Coastal retreat in Senegal contributes to the destruction of houses, tourist buildings, and fishing infrastructure, and to the disappearance of beaches and the loss of agricultural land. The Senegalese Government should be strongly engaged in the integrated management of coastal zones (ICZM), especially in the Saly and Casamance areas.

Aquaculture has been identified and welcomed as a crucial solution to address the challenges to global food security arising from climate change and increasing population (National Research Council, 2015).[20] The development of aquaculture represents an opportunity to increase the supply of fish and satisfy domestic demand and external markets to generate employment and income. (PAP 2019–2023). Considering a decline in fishing production in recent years, and an increase in demand for fishery products in Senegal, aquaculture could be a solution contributing to maintaining the production of an important food commodity for the country.[21]

Reforestation, through reestablishing natural forests, planting more native species, or increasing the density or extent of an existing forest, could slow down the progression of the Sahara Desert and reduce the extent of climate change impacts. Several initiatives on these lines have been undertaken

Photo: Joesboy/iStock

in Senegal, including the "Great Green Wall," the development and participatory management of forests (more than 30 forests with the sustainable and participatory energy and management project PROGEDE),[22] and the restoration of mangroves with Oceanium.[23]

Agriculture

Drought and floods increase the vulnerability of the agriculture sector and threaten the food security in Senegal. This requires a focused adaptive response. Agroforestry designed to introduce or better maintain forest trees could improve the quality of soil and the regulation of water flows, and restore the productivity of agricultural land. The Senegalese agriculture acceleration program (PRACAS) has identified agroforestry as one of the priority strategies for sustainable land management.[24] PRACAS supports the development of specific programs aiming at reinforcing the productivity of main crops including rice, groundnuts, onions, and off-season fruits and vegetables. One of these programs focuses on an intensive rice farming system that will reduce the


Photo: JB Russell/Panos Pictures

need for water by 40 percent relative to traditional rice farming. Further, the development of resilient seeds to adapt to environmental challenges should be one of the strategies adopted by the Senegalese Government.

Senegal should support innovative and tailored adaptation measures developed by local entrepreneurs to effectively contain the cost of climate change and preserve the economy. In addition to popular adaptive measures (agroforestry and resilient systems) in the agriculture sector, innovative natural-based solutions, energy-derived products, and information, communication, and technology (ICT) can all be mobilized to help the country adapt to climate change and increase the productivity and resilience of agriculture. For example, a Senegalese start-up called "EcoBuilders" has created environmentally-friendly and affordable storage units made from recycled tires, plastics, and natural materials, which preserve agricultural products longer than traditional storage, using zero energy. Such solutions can be an innovative response to the rise in temperatures in Senegal. New solar energy equipment such as solar dryers (for fisheries) and solar tanks (for milk) can also contribute to the conservation of agricultural products.

Moreover, the experience of integrated climate-smart villages in Senegal shows that there is great potential for the development of smart technologies in agriculture. The experience in Daga-Birame village presents a valuable example. Land degradation and agricultural vulnerability resulting from climate variability have led Senegal to adopt the concept of climate-smart agriculture (CSA). This is what motivated the Senegalese Institute of Agricultural Research (ISRA) and its partners to develop the holistic model of Climate-Smart Village (CSV) in Daga-Birame in the Kaffrine region. CSA aims to sustainably increase agricultural productivity and farmers' incomes to 1) achieve national food security and development goals; 2) build resilience and adaptation from agricultural and food systems to climate change; and 3) mitigate greenhouse gas emissions. The Value Chain Initiative (VCI) uses a holistic approach to integrating different agricultural and agroforestry practices and technologies. The emphasis is on: 1) the use of climate forecasts and information; 2) the choice of resilient varieties and good practices for adaptation to climate change; 3) the practice of agroforestry, with fruit trees and fodder species with a short production cycle; 4) concerted management of inter-village silvopastoral areas; and 5) diversification of crops (maize, watermelon, market gardening) and sources of income, with the creation of small forestry and agricultural enterprises (baobab fruit, peanuts, poultry farming, etc.).[25]

Further, renewable energy can also contribute to adaptation and increase the cost-efficiency of agriculture. While solar dryers can be used in fisheries and agriculture and improve the transformation and conservation of products, solar tanks are very effective to preserve milk in sunny areas that are poorly connected to the power grid, particularly under high temperatures, as is the case in most of the silvopastoral areas in Senegal. There are already several initiatives of this kind under way with the installation of seven solar pumps in Kayar, 28 solar dryers in areas with fisheries, as well as several multifunction solar platforms in the Kolda and Sédhiou regions for grain milling, conservation, and transformation of food products.[26]

CÔTE D'IVOIRE

Social and Economic Overview of Côte d'Ivoire

The Ivorian economy was growing with an average of 8 percent during the last decade. Growth was dynamic across all sectors, including crops, some modest diversification in manufacturing (the number of exported goods increased from 164 in 2000 to 184 in 2017), and buoyant services, which benefited from strong domestic demand and investments. Strong export performance, alongside moderate import growth, also supported a positive trade balance and a narrowing current account deficit.[27] Thanks to its strategic position and the dynamics of its economy, Côte d'Ivoire is seen as West Africa's economic hub.

Due to its high dependency on natural resource exportation, the nation's economy is inherently vulnerable to environmental challenges and remains exposed to commodity price cycles. According to the National Development Plan (NDP) 2021–2025, the country was the world's largest producer of cocoa and cashew nuts, the world's fifth-largest producer of palm oil (and the second-largest in Africa), the world's fifth-largest producer of natural rubber (first in Africa), and the third-largest African cotton producer in 2019. Agriculture added value accounted for 20 percent of GDP in 2019, employing 40 percent of the country's working population.[28]

The National Climate Change Program (PNCC) report details the increasingly adverse impacts of climate change on the different economic sectors of the country. Recognizing these challenges, Côte d'Ivoire included diversification, environment conservation, and the fight against climate change as one of the pillars of its National Prospective Study 2040 and NDP 2021–2025.

Impact of COVID-19 and Policy Responses of Côte d'Ivoire

As of June 2022, Côte d'Ivoire had recorded relatively low rates of COVID-19 infections, with

Photo: Pascal Maitre/Panos Pictures

82,305 cases and 799 deaths. After the first cases were registered in early March 2020, the Ivorian Government implemented containment measures and strengthened its crisis management capacity. Although these containment measures were less stringent than in some developed countries (as developing economies require a balance between controlling the pandemic and preserving livelihoods), they led to a recession in the economy with a growth rate of 1.8 percent in 2020.

Although the country is on a recovery path with post-pandemic GDP growth of 7 percent,[29] several sectors of the economy were strongly affected, including education, tourism, restaurants and hotels, financial services, transport, and logistics. The World Bank Enterprise Survey[30] indicates that 37.7 percent of firms were closed (temporarily or definitely), with rates much higher in Abidjan (about 60 percent) than in secondary cities, partly driven by forced closures (hospitality, retail, education) due to lockdown measures. Almost all (94.1 percent) enterprises experienced a decline in sales, and for many firms, the decline was steep, with a drop of 67 percent compared to the previous month. The closure of schools during the pandemic associated with the loss of income has likely increased the youth drop-out rate and imperiled human capital.

An August 2020 analysis by the World Bank[31] found that 71 percent of surveyed households reported a drop in their income. Only employees of the public sector were less affected. Workers in the field of tailoring, retail services, hospitality, and transport more frequently reported that their revenue or salary had dropped, regardless of whether people were self-employed or wage earners.

The impact of job losses among the most vulnerable workers, including farmers, women, youth, and those without a college education, can still be felt even as economies revive. In addition, the severe impacts seen for small and micro enterprises can lead to the erosion of entrepreneurial capital and jobs that can be hard to reverse.

Although the Ivorian economic growth rate seems to be back to its pre-pandemic level, the fallouts of the outbreak coupled with the Ukraine-Russia crisis strongly threaten the sustainability of the recovery. The war has led to an increase in food and energy prices and exacerbated inflationist pressures. The lack of fertilizers for agriculture strongly threatens harvest and food security in Côte d'Ivoire.

To overcome the adverse effects of the pandemic, the Ivorian Government implemented a comprehensive crisis response package to address the immediate health and economic impacts. The Ivorian Government adopted an emergency health response plan worth 96 billion FCFA (or 0.3 percent of GDP). This plan aims to 1) provide free care for those with the infection and equip intensive care units; 2) strengthen epidemiological and biological surveillance (virus testing; creation of a free call center, equipping laboratories); and 3) reinforce the capacity of pharmaceutical industries and finance research on the virus.

The Government announced a package of economic measures to support the income of the most vulnerable segments of the population through agricultural input support and expanded cash transfers, provide relief to hard-hit sectors and firms, and support public entities in the transport and port sectors to ensure continuity in supply chains. In this regard, the authorities created four special Funds to be spent over two years, including the National Solidarity Fund of 170 billion FCFA (0.5 percent of GDP), the Support Fund for the informal sector of 100 billion FCFA (0.3 percent of GDP), the Support Fund for the small and medium enterprises of 150 billion FCFA (0.4 percent of GDP) and the Support Fund for large companies of 100 billion FCFA (0.3 percent of GDP). It will also provide financial support to the agriculture sector amounting to 300 billion FCFA (0.8 percent of GDP).

On April 27, 2020, to help member countries cope with the fallout of the COVID-19 pandemic, the heads of state of WAEMU declared a temporary suspension of the WAEMU Growth and Stability Pact setting six convergence criteria, including the 3 percent of GDP fiscal deficit rule. This temporary suspension will allow member countries to raise their overall fiscal deficit briefly and use the additional external support provided by donors in response to the COVID-19 crisis. The declaration by the heads of state sets a clear expectation that fiscal consolidation will resume once the crisis is over.

As with many developing nations, Côte d'Ivoire's announced spending during this period has predominantly been funded by international partners

Box 2. Modeling Approach for Côte d'Ivoire

Photo: BOULENGER Xavier/Shutterstock

For Côte d'Ivoire, the green stimulus package is compared to an investment in the mineral extractive sector. The choice of the extractive sector as a counterfactual is based on the different country priority plans, especially the NDP 2021–2025. The NDP is a national development planning model adopted by the Government of Côte d'Ivoire. This development strategy aims at addressing the medium- and long-term social and economic challenges of becoming an emerging country.

The green investment package is a set of investments in both mitigation and adaptation. It includes six groups of interventions, namely:

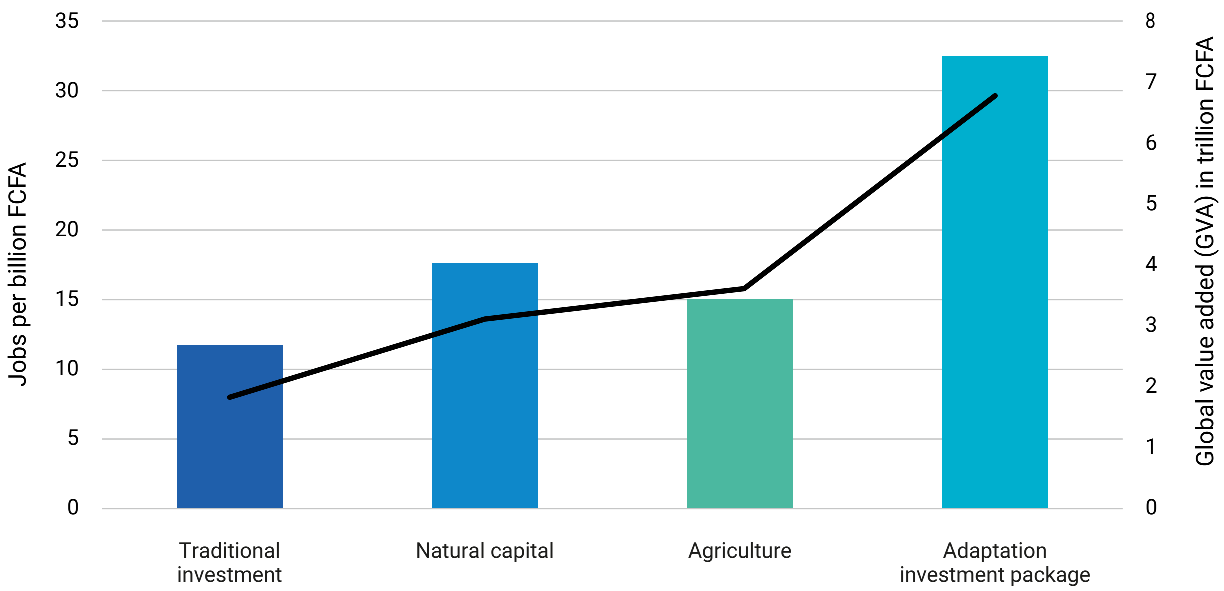
1) Natural capital investment: this sector includes the interventions in reforestation, aquaculture, and urban parks.
2) Energy: this sector includes the interventions in hydropower, solar photovoltaic, mini-grids, and onshore wind.
3) Agriculture: this sector accounts for agroforestry, resilient seeds, and solar irrigation.
4) Efficient retrofits: this sector includes the interventions in building efficiency and industrial energy efficiency.
5) Transport: this sector includes the interventions in EV, BRT, and EV charging infrastructure.
6) Waste management: this sector includes the interventions in biomass plant and biogas plant.

The technical background paper gives more details on the modeling and assumptions.

Moving Toward Green and Resilient Economic Growth: Côte d'Ivoire

Our analysis shows that among the set of green investments, adaptation measures in Côte d'Ivoire would provide the highest returns in terms of jobs and economic value. Investment in adaptation measures, among several other green interventions, has the highest social-economic returns, generating up to 180 percent more jobs within five years (400 percent within 20 years) and 265 percent more economic value in the long term (within 20 years) relative to traditional investments. Adaptation spending is estimated to boost employment by 84,792 job years directly and 66,926 job years indirectly (through supply chains). In contrast, the traditional high-carbon investment package would increase employment by 1,854 job years directly and 497 job years indirectly.

Figure 2. Total Job Creation and Gross Value Added by Different Investment Packages: Côte d'Ivoire



Source: Author's calculations based on estimates

Notes: This graph displays the total jobs in the short term (5 years, left axis) and gross value added in the long term (20 years, right axis) generated by both traditional mining investment and adaptation investment packages. **"Traditional investment"** refers to investment planned in the NDP 2021–2025 to expand the mineral extraction sector. The adaptation investment package includes a set of green sectors. Each green sector contains several interventions. The different green sectors (as well as their respective interventions) are: **1) natural capital** (urban parks, aquaculture, reforestation); and **2) agriculture** (resilient seeds, agroforestry, and solar irrigation). **"Adaptation investment package"** refers to the sum of natural capital and agriculture. A technical note in the appendix discusses estimation approaches and assumptions.

Analysis indicates that aquaculture and reforestation can generate an economic return of 165 percent in the long term, while resilient seeds, agroforestry, and solar irrigation systems could generate more than 100 percent economic returns compared to high-carbon investments.

Natural Capital

Reforestation, through reestablishing natural forests, planting more native species, or increasing the density or extent of an existing forest, could slow the progression of the Sahara Desert and reduce climate change impacts. The recent COP15, hosted in Abidjan in May 2022, confirmed this commitment through the implementation of a project aiming at planting 12 million trees in 2022.

Fisheries and aquaculture are crucial in the West African region due to their contribution to food security and nutrition. This sector contributes to poverty eradication and the Sustainable Development Goals (SDGs) through job creation, livelihood diversification, biodiversity conservation, and sustainable resource management. With sea erosion and pollution, it is crucial to develop aquaculture to ensure food security and preserve fish quality.

There is growing recognition that urban parks can be part of the climate solution through mitigation and protection of people and infrastructure from increasing heat waves, especially in the case of Abidjan.

Agriculture

Agroforestry designed to introduce or maintain forest trees could improve the quality of soil and regulation of water flow, and restore the productivity of agricultural land. Solar irrigation systems could considerably improve the regeneration and productivity of the soil. In addition, there is space to develop smart agriculture farms to leverage technology and the synergy of adaptative solutions. This can be especially productive in the center-west region of the country.

POLICY RECOMMENDATIONS

Based on the findings of the analysis for Senegal and Côte d'Ivoire, three key recommendations can be derived to unleash the potential of a green economy and ensure economic prosperity and sustainable development.

Public Finance Should Mainstream Climate Investment in Order to Attract Private Sector Actors

Investment in adaptation is no longer an option, but a priority, in order to preserve economic growth, ensure food security and attenuate the detrimental effects of climate change on the coastline, agriculture, and water availability. Governments should develop a holistic approach to integrating public and private adaptation initiatives. Governments can prioritize public investments in adaptation programs with positive externalities, address market imperfections and policies that make the adaptation of the private sector inefficient, and mobilize revenues for and distribute the benefits of adaptation. Better planning can enable an increase in the share of public investment in adaptation, and/or increase the efficiency of public adaptation initiatives.

There is a Need for Proactive Action on Innovative Finance Sources and to Work Toward Eligibility for Sustainable Bonds for Adaptation

Current adaptation finance flows are insufficient to meet growing adaptation needs on the continent. Innovative climate finance may allow grants or different funding sources to be combined with traditional climate loans, which enables investment in new sectors and facilitates the development of large-scale programs with improved effectiveness, impact, and replicability. Green and sustainable bonds, together with the increased level of transparency that they bring, can help secure market financing for future investments. To be able to attract financing, countries should create enabling conditions and incentives.

Promote an Adaptation-Mitigation Approach

Adaptation measures in mitigation projects could address potential climate risks, making mitigation projects more resilient to a changing climate. Renewable energy, including hydropower, solar photovoltaic, solar individual systems, and onshore winds, have considerable potential to provide energy access to rural communities by increasing interconnected networks. Climate change adaptation was perceived as a project safeguard that would provide benefits to local communities and project developers, as well as global benefits because carbon storage would be more permanent, particularly for forestry projects.

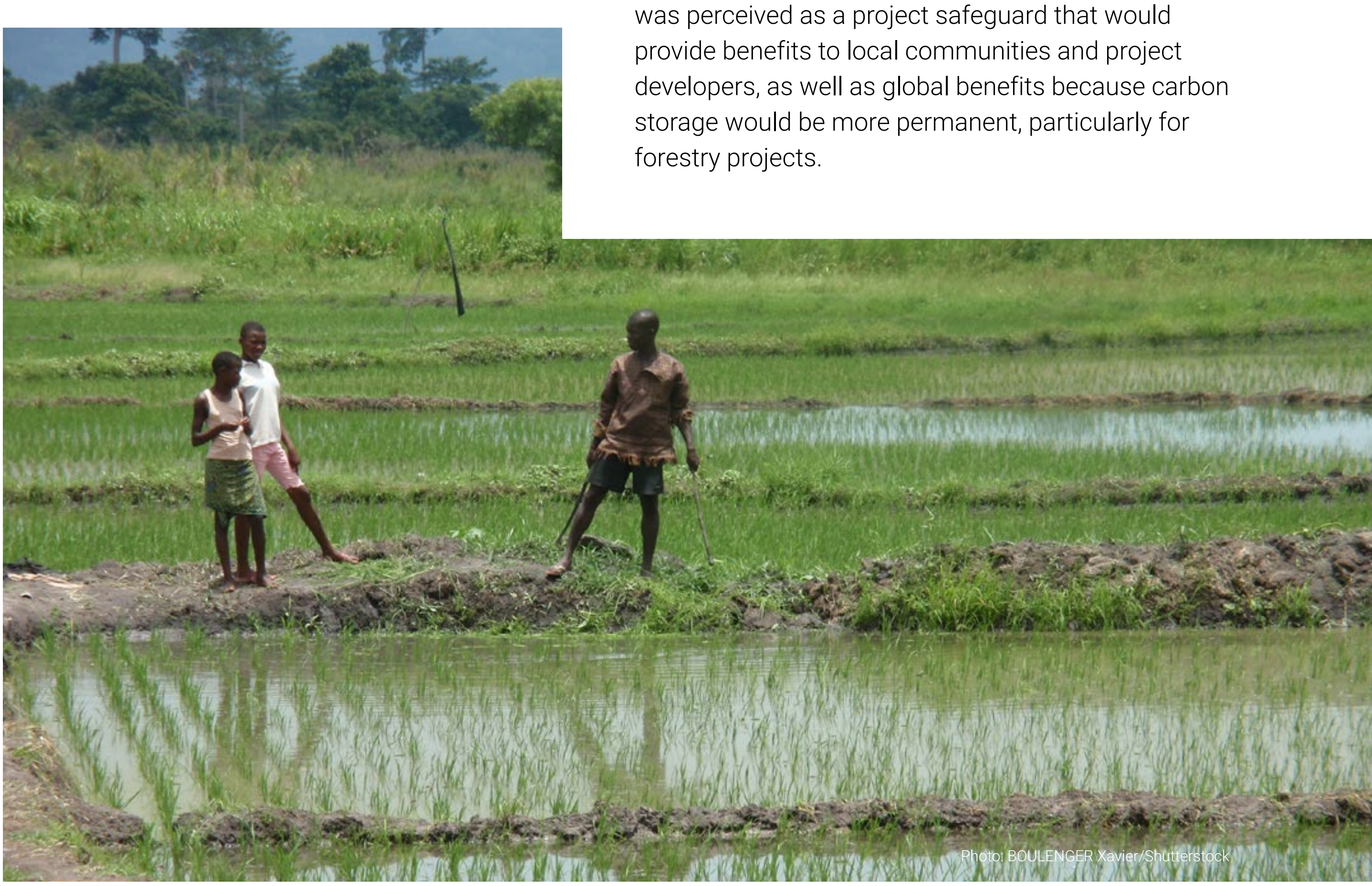


Photo: BOULENGER Xavier/Shutterstock

The Private Sector

KEY MESSAGES

- The private sector in Africa generates two-thirds of the continent's economic output. Companies in Africa must prioritize adaptation to climate change to reduce risk, maintain productivity, and ensure the broader stability of the African economy.
- Innovative measures in adaptation can not only make companies and their supply chains more resilient, but they can also open new markets in areas like construction and nature-based solutions and new avenues for employment.
- Insurance organizations in Africa can act as a catalyst for the use of risk models and analytics to navigate best-suited climate adaptations. The financial services sector can also play a significant role by creating new products, monitoring climate risk and incentivizing adaptation actions.
- Corporates are also helping upstream and downstream stakeholders build resilience through knowledge-sharing and innovation. Private enterprises thus have a key role to play in helping

communities and the broader economy adapt to the changing climate.

- To maximize these positive outcomes, collaboration across the private sector, public sector (such as by public–private partnerships) and financial and insurance sectors will be key.

We know that the annual adaptation costs are expected to reach at least US$140 billion a year by 2030. And frankly, public finance is not going to be enough. We are going to need private finance.”

Alok Sharma
COP26 President

CLIMATE RISKS TO CORPORATES IN SUB-SAHARAN AFRICA

Sub-Saharan Africa is facing a disproportionately high physical climate risk, which threatens to jeopardize hard-won development gains and disrupt citizens' lives and livelihoods.

By 2030, Africa may be home to more than 500 million people severely and moderately exposed to climate hazards in a 1.5°C warming scenario. If the world sees a 2°C increase in average temperature by 2050, the number of Africans exposed to one or more physical hazards related to climate could almost double from approximately 460 million people today to more than 900 million, an 80 percent increase over two decades.[1] Africa will become subject to intensifying climate hazards (such as extreme heat, extreme precipitation, drought, and decreased water supply), leading to severe climate impacts such as water shortages, reduced food production, loss of lives, biodiversity loss, and reduced economic growth.[2] It is estimated that close to an additional 40 million people in Africa will fall back into extreme poverty by 2030.[3]

Nevertheless, climate hazards manifest locally, meaning that risk profiles vary between and within African regions. West Africa, the Sahel, Central Africa, and North-Eastern Africa could continue to see increases in heavy precipitation and pluvial flooding. North Africa may experience water stress and decreases in mean precipitation. South and East Africa may experience an increase in average tropical cyclone wind speeds and associated heavy precipitation, while South-Western Africa may experience increases in aridity and agricultural and meteorological droughts.[4] Figure 1 shows that climate-exposed populations are mainly in West Africa, with pockets of high exposure in North and East Africa.

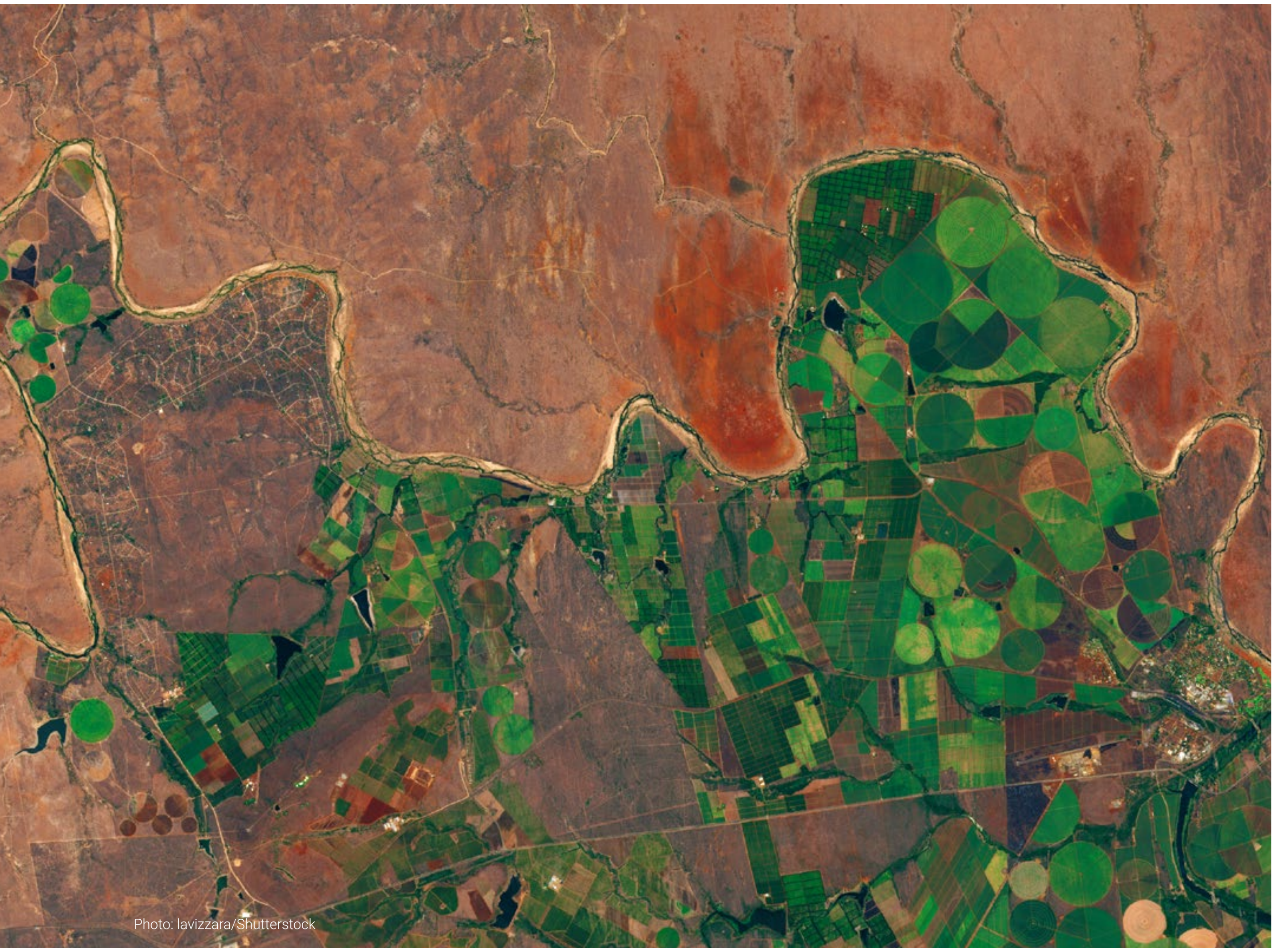
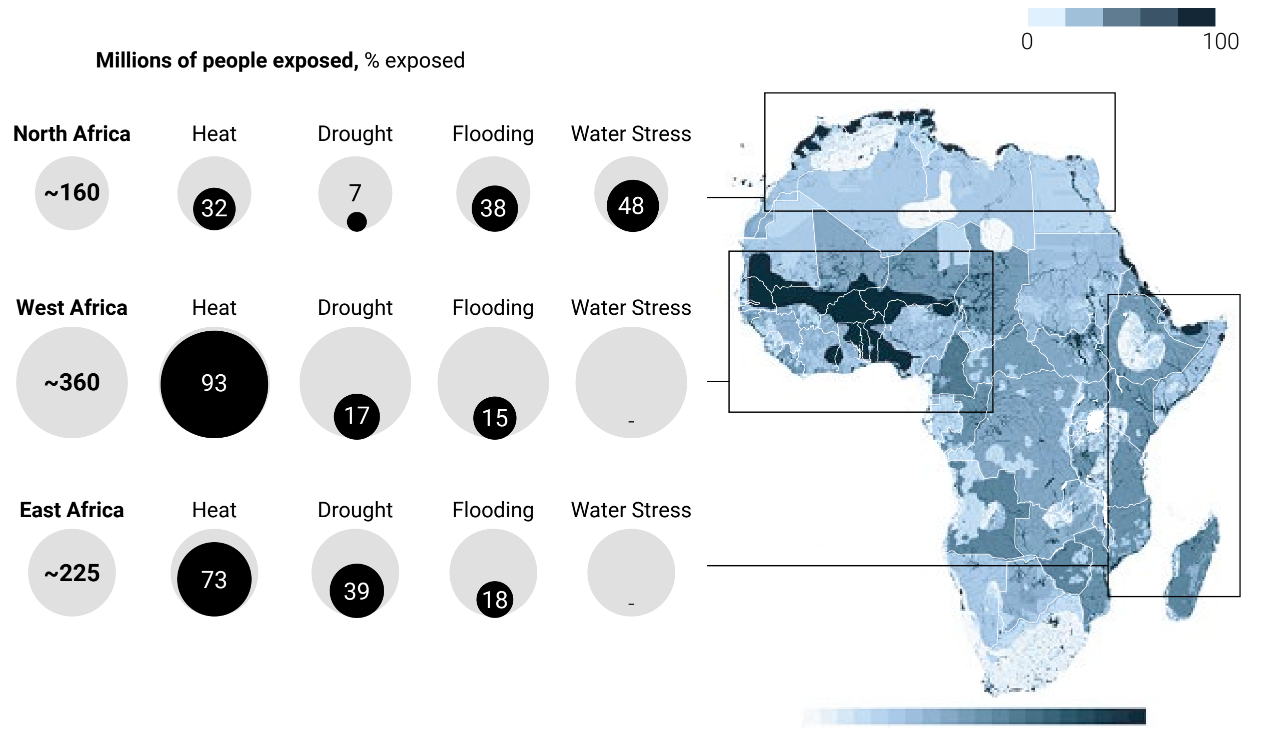


Photo: lavizzara/Shutterstock

Figure 1. People Exposed to Climate Hazards Under a 2°C Warming Scenario by 2050



Source: "Green Africa: A growth and resilience agenda for the continent" by McKinsey & Company, based on IHS Markit; International Labour Organization (ILO); NASA Earth Exchange; National Center for Atmospheric Research Integrated Assessment Modeling; Socioeconomic Data and Applications Center; Woodwell Climate Research Center; World Resources Institute (WRI)

Different climate hazards are expected to translate into direct socioeconomic risks across five key systems. Climate risks to livability and workability, food systems, physical assets, infrastructure services, and natural capital leave certain value chains on the continent more vulnerable to impacts from climate change. These impacts across the five key systems capture the entire range of climate risks, as together these systems represent the collective impact of climate hazards on human beings, human-made physical assets, and the natural world.

Livability and workability refer to the ability of an area to sustain human life and activity and the capacity to engage in outdoor occupations. A large increase in heat and humidity increases the impact on the health and productivity of workers, reducing labor capacity because workers must take breaks to avoid heatstroke and because the body naturally limits its efforts to prevent overexertion. As discussed in the *State and Trends in Adaptation 2021* report, even if the world can stay within a 1.5°C warming by the end of the century, estimates suggest that in Western Africa, 4.6 percent of working hours will be lost, which equates to around nine million full-time jobs.

Many sectors, such as healthcare, construction, and agriculture, will likely experience significant impacts to the labor force's conditions of employment. African countries could see higher impacts on workability than richer nations around the world given the lower adaptation capacity to heatwaves currently. The agricultural sector plays a central role in the economy; in 2019, 52.9 percent of the total workforce was employed in agriculture across Sub-Saharan Africa.[5] The economic importance of this largely outdoor and labor-intensive process highlights how heat and humidity are likely to have substantial impacts on workability in agriculture across the continent.

Food systems include the production and distribution of agricultural products and the associated revenue and livelihoods. The agricultural sector (including crop production, livestock, fisheries, and aquaculture) plays a key role in Africa's food systems by supporting food security, nutrition, jobs, and incomes. Climate science suggests that increased climate hazards are likely to cause an increase in global agricultural yield volatility along with a decrease in global crop productivity, leading to negative outcomes for food systems. Crop yields for important staples like maize and wheat are declining in the tropics as a result of climate change, and crop production could drop by 5 percent for every 1°C increase in temperature over historical values.[6] A 2020 UN report found that in Africa, staples such as rice and wheat could be among the hardest-hit crops, with estimated average yield losses of 12 percent and 21 percent, respectively, by 2050.[7] The report also estimated that by 2050, the overall agricultural yield in East Africa could be reduced by 8 percent. More urgently, the McKinsey Global Institute has estimated that by 2030, wheat farmers in Ethiopia will be 11 percent more likely than in 2020 to see a reduction in output of 10 percent or more in any given year.[8]

Physical assets, such as industrial plants and equipment, housing, and land, form an economic system that is vulnerable to climate hazards, such as flooding and wildfires. In addition to commercial and residential real estate, key sectors at risk include mining, energy, and manufacturing. The statistically expected damage to capital stock from riverine flooding could double by 2030 from today's levels, and quadruple globally in a 2°C warming world by 2050.[9] Real estate assets may depreciate over the next ten years due to increases in risk and job losses from climate hazards and could then affect habitability and economic growth.[10]

Infrastructure services refers to the network of assets that serves a community, such as utility grids (energy infrastructure), water treatment management and sewerage networks (water infrastructure), and roads, bridges, and railways (transportation infrastructure). Each infrastructure has differing vulnerability to climate hazards, including flooding, forest fires, hurricanes, and heat, and could be destroyed or severely impacted, leading to a decline in the services they provide or a rise in their cost. Climate hazards can lower the reliability of utility services such as energy and water; heat vulnerability or water scarcity can lead to the rationing of water supply; utilities located in flood-prone areas may experience water infrastructure and saltwater intrusion impacts, which reduce their efficiency and resilience; and high temperatures can overload power plants as energy demands from air conditioning increase. Power systems and other infrastructure services could also become less productive under very hot conditions, which in turn can have knock-on effects on other sectors. African countries' electricity supplies are also threatened by increased interannual variability and uncertainty in hydropower generation, especially with more frequent and more severe droughts.[11] Extreme precipitation, storms, and severe heatwaves could also destroy the existing electricity networks and grids, further disrupting the electricity supply.

Finally, **natural capital** refers to ecosystems, such as glaciers, forests, and oceans, which provide important resources and services to society. Changes in natural capital from climate hazards can disrupt key sectors (for example, tourism) that rely heavily on climatic patterns, such as seasonal shifts and weather conditions, and on the use of physical assets, land, and ecosystems. Research suggests that significant biome shifts are expected in Central and Southern Africa, which could affect the livelihoods of the communities that rely on tourism.[12] In Kenya, a 2019 study found that 54 of 844 wildlife species (6 percent) assessed in the Greater Mara Ecosystem and 101 of 793 species in the Maasai Mara National Reserve (13 percent) would no longer find the areas climatically suitable by 2050.[13]

While direct impacts from climate change are experienced more significantly in certain systems and value chains in Africa, cascading impacts across all systems can magnify vulnerabilities. Cascading impacts refers to the transmission of direct impacts across interconnected sectors and regions. These ripple effects can affect economic, financial, and social systems, and differ in scope—from a stranded asset impacting downstream parts of the supply chain to the destabilization of a country. According to the Stanford Environment Assessment Facility, a 2°C temperature rise by 2050[14] is likely to dramatically increase the proportion of climate-induced tensions from 6 percent to 13 percent of total armed conflicts.[15]

Box 1. A Focus on Water Resilience

Photo: helovi/iStock

African countries' water supplies vary seasonally and year by year. Projections of future precipitation are deeply uncertain, but variability is increasing, and extremes are increasingly common, with more frequent and severe droughts but also more floods.[16] Saltwater intrusion, which can be exacerbated by groundwater depletion, also poses growing concerns in coastal areas.

The availability and quality of water is crucial for drinking water, food systems, industrial processes, infrastructure services, and ecosystems. African countries' heavy reliance on rainfed agriculture and on hypdropower make water insecurity a particularly serious concern with climate change.[17]

Climate risks present increased cross-cutting hazards to many organizations reliant on water usage and may require heightened attention to and management of water stresses. Based on disclosures by more than 500 companies, CDP has estimated that water insecurity threatens US$425 billion in value, with about 40 percent of the risks anticipated within one to three years.[18] For example, in the mining sector in Africa, climate and nature impacts are already materializing in different forms; in particular, severe flooding and storms are disrupting mining sites in Burkina Faso and other West African countries.[19] The disruption of transportation routes due to flooding, complications in the environmental rehabilitation of mine sites, and direct competition and conflict with local communities (which may perceive water use in mining as a direct conflict with their own water rights and needs) are examples of the impacts of water stress on industrial operations.[20]

Africa's fast-growing population and expected increase in water resource unpredictability call for climate adaptation solutions for water resource management. Investing in better water management services is becoming ever more important for all actors impacted by some or all of the climate risks discussed above. For example, increased investment in water management and water reuse technologies, as well as water consumption conservation, can help the mining sector become more efficient and adapt to the unpredictability of droughts and drier temperatures across the region. In response, integrated water planning and management across sectors (such as energy, land, forest, ecosystems, and agriculture) could make water use more efficient and reduce environmental impacts. More water storage could also help when discharges are low. Physical protections (such as flood-prevention structures, better irrigation systems, upgraded canals, precision land leveling, and proper implementation and enforcement of building codes) and management tools (such as land-use planning laws and early-warning systems) are also needed to manage risk.[21]

CLIMATE CHANGE IMPLICATIONS ON CASH FLOW AND GROWTH OF PRIVATE COMPANIES IN SUB-SAHARAN AFRICA

The private sector[22] in Africa currently generates two-thirds of the continent's investment, 75 percent of its economic output, and 90 percent of employment. Across multinationals and micro-, small and medium-sized enterprises (MSMEs), climate hazards are expected to increase the costs for private-sector actors by impacting assets and worker productivity and by disrupting operations and value chains. Revenue may also decrease due to changes in demand related to fluctuating population, income, and migration patterns. Finally, as increased costs and reduced revenues are expected to affect cash flow and company performance, unfavorable expected rates of return for investors may affect international investment attractiveness and thus the flow of investment into perceived high-risk countries.

Climate hazards are expected to translate into higher costs, ranging from asset restoration to disruptions to the supply chain. First, climate hazards are expected to translate into challenges for workers' wellbeing and safety, as well as higher costs tied to productivity reduction. As discussed earlier, heat stress will be a significant factor in worker productivity unless adaptation measures are implemented.

Second, heat stress, flooding and drought can impair the functionality of and accessibility to on-site infrastructure and capital, translating into higher costs for maintenance and repair and requiring investment in more efficient and resilient technology. For example, South Africa, Zambia, Malawi, Benin, Mozambique, and Kenya have the largest number of businesses reporting detrimental water-related impacts globally, which includes physical damage to property from flooding and extreme weather events.[23]

Third, climate hazards may impact upstream and downstream value chains and increase the procurement and distribution costs of companies. Grid inefficiencies and impacts to transport infrastructure driven by climate risks create disruptions that reduce the reliability of utility services and can increase operational and procurement costs. Similarly, climate hazards can disrupt upstream value chains and increase producers' off-site costs when key infrastructure and transport routes or distribution warehouses and services are damaged, inaccessible, or destroyed. For low- and middle-income countries, the World Bank has estimated that globally, disruptions to water, power, and transportation services cause losses of over US$150 billion every year.[24]

Climate hazards are expected to put pressure on revenues by altering the demand base of the private sector. An increasing number of companies have been considering the impact of climate change on their own operations as climate risks impact their revenues through customer base loss due to displacement, changes in income or supply-chain paralysis.[25] The World Bank projects that by 2050, climate change may be a driving force for over 100 million Africans to migrate within their countries, away from areas with lower water availability and crop productivity or rising sea level and storm


Photo: Jonathan Erasmus/iStock

surges.[26] One 2007 study in Namibia concluded that even under the best-case climate change scenario at the time, a quarter of the population would need to leave vulnerable sectors, such as agriculture, fisheries, and tourism, and find new livelihoods by 2050 (see “Insert: Migration and climate change” in this report for further details on projected levels in Africa due to climate change). As populations migrate, their demand for products may change in conjunction with their income shifts, offering the possibility for new market opportunities for private-sector actors in the relocation destination.

Additionally, climate change is expected to have an impact on the cost of financing and insurance, which may hamper the ability to fund growth. Over a third of the expected US$2.5 trillion increase in insurance premiums is likely to be driven by climate change.[27] As critical assets and infrastructure are damaged, cascading risks could magnify the economic damage and fiscal impact of climate-related disasters, potentially making affected companies less attractive recipients of investment. The negative effect of physical damage could be exacerbated by a subsequent decrease in funding for recovery and future economic growth, due to perceptions of heightened risk. For example, flooding is expected not only to damage properties but also to raise insurance costs, affect the property values of exposed capital, and in turn reduce property tax revenue for communities, which could hinder socio-developmental gains.

Rising climate extremes are also expected to reduce the availability or increase the price of insurance, increasing the risk of financial instability. In Africa, insurance penetration is already very limited. The insurance market was valued at US$68 billion in 2018, with 80 percent of premiums concentrated in South Africa, and much of the rest in just a few countries, such as Egypt, Morocco, Nigeria and Kenya, mainly involving large corporations.[28] Insurance premiums tend to be high for MSMEs, which in turn struggle to assess and provide insights into residual risk exposure and struggle to lower uncertainty.[29]

“

We happy to be working with the GCA and signing a Memorandum of Understanding, where they’ll provide technical assistance to help us source and originate debt. And we’ll be working with several Development Finance Institutions and climate funds to provide risk mitigation for the private sector investors, including sovereign wealth funds, pension funds, insurance companies and asset managers.”

Zainab Faisal Kufaishi
Head of Middle East and Africa, and Senior Executive Officer, Invesco

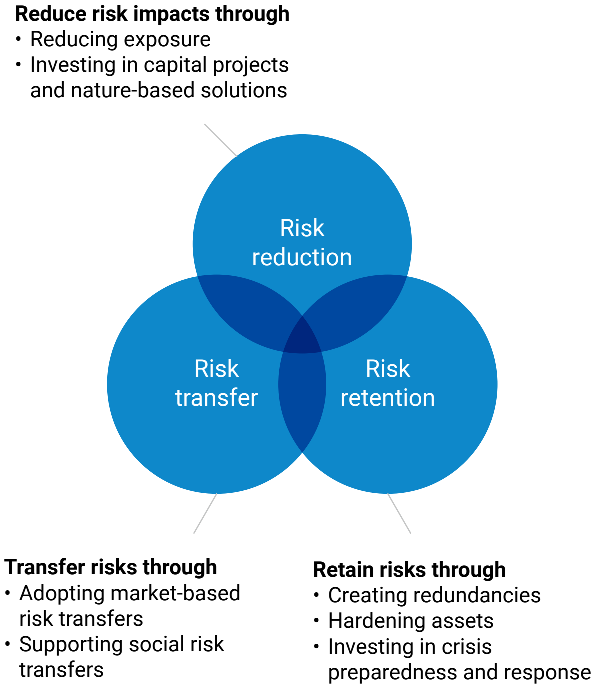
ADAPTATION ACTION BY CORPORATES TO REDUCE AND MANAGE CLIMATE RISKS

Climate-risk assessments can help companies target their risk mitigation countermeasures. Leveraging different climate and socioeconomic scenarios, such as the reports by the Intergovernmental Panel on Climate Change, companies can understand their exposure to hazard changes in frequency and intensity. Those must then be translated into direct and cascading operational, financial, and social impacts on companies. However, limitations and lack of granularity in climate and socioeconomic data can be salient bottlenecks in risk quantification. These limitations can range from sparse time series to complex circulation patterns, lack of locally relevant damage functions to assess vulnerability, or lack of asset values across the supply chain.

To overcome this, some uncertainty handling techniques can be applied, such as using downscaling processes with bias correction to match the observed historical patterns of climate change, or using ensemble means to attenuate model error across individual models. Collaboration across stakeholders can also improve data quality and availability. Some large companies have developed knowledge networks with academia, scientists, and government research institutions to address this challenge, and could share their findings with peers to enhance sectoral capacity building. The expansion of climate-risk information such as forecasts, economic analyses and identifying trends enables better climate adaptation for targeted approaches. The opportunity for insurance organizations in Africa to act as a catalyst for the use of risk models and analytics to navigate best-suited climate adaptations is clear through their role in identifying risks associated with the assets and activities of organizations. Firms across the continent are then likely to benefit from investing in building knowledge of their contextual climate risks and will seek to gain a competitive advantage in being able to navigate future investments and better adapt to hazards.[30]

A range of adaptation measures to reduce, retain, or transfer climate-related risks can help private-sector companies navigate their exposure to climate change.

Figure 2. Measures to Negotiate Climate-Related Risks



Source: McKinsey Global Institute staff

Photo: Mikkel Ostergaard/Panos Pictures

When it comes to **risk reduction**, companies can reduce their exposure by relocating their sites or supplies away from high-risk areas. In addition, private-sector actors can invest in projects that strengthen the resilience of their capital and infrastructure against extreme weather and climate conditions. For example, the OCP Group, a global fertilizer producer based in Morocco, has collaborated with public authorities to invest in desalination stations and wastewater recycling plants to reduce water pollution and address water stress pressures, thereby lowering the risk of water scarcity for its production system and for the livelihoods of communities in North Africa.[31] The OCP Group has also partnered with research centers to introduce new higher-yielding varieties of quinoa to farmers, helping to reduce food insecurities caused by drought and water stress.

Further, the private sector has additional opportunities to capture co-benefits and reduce its exposure to climate risks by investing in nature-based solutions (NBS). While it can be costly and take a long time to set up and generate substantial income, preserving ecosystems by leveraging Africa's vast NBS potential can generate added benefits such as an increase in biodiversity, access to the carbon credits market, and support for the security of local communities.

For example, an NBS initiative called the Great Green Wall has evolved from the idea of a 7,000 km belt of trees planted across the width of Africa to a comprehensive vision for restoring 100 million hectares of degraded land. This project builds resilient land-use systems with the capacity to adapt to uncertainty and climatic extremes and to enhance the livelihoods of local people and provide long-term solutions for improving environmental and socioeconomic conditions in the zone. The Great Green Wall Initiative can safeguard roads in African cities by improving stormwater management, and at the same time reduce the need for and costs of engineered solutions such as stormwater drains. It has the potential to create 10 million environmentally oriented jobs and improve the productivity and livelihoods of people, while at the same time restoring ecosystems in countries such as Mali, Niger and Senegal.

Regarding **risk retention**, companies can take steps to create redundancies, harden assets, and invest in emergency response. Creating redundancies mainly includes developing distributed and diversified networks to avoid being reliant on a sole origination point for supplies. Hardening assets means fortifying them against climate hazards or developing new products and services that can sustain chronic and physical hazards. For example, in the aftermath of Cyclone Idai, 14Trees was founded as a joint venture between private company Holcim and the UK's development finance institution, British International Investment. By deploying innovative construction technology such as 3D printing, 14Trees aims at accelerating the provision of affordable housing and infrastructure in Africa, especially in the aftermath of natural catastrophes. Just as importantly, with its record speed of construction and optimized material use, such technology can reduce the carbon footprint for building new homes by up to 70 percent, and sustains skilled job creation with the hiring and development of local experts, from 3D machine operators to materials specialists working with local builders for carpentry, roofing and painting.[32]

Finally, investing in crisis preparedness and response includes developing and boosting the adoption of early-warning systems to forecast extreme events and create time to adopt response policies, which would ultimately help avoid physical damage costs. The World Bank estimated in 2012 that if early-warning systems in low- and middle-income countries were upgraded to European standards, annual losses to assets of between US$300 million and US$2 billion would be avoided.[33]

As far as **risk transfer** is concerned, private-sector companies can leverage different mechanisms. There is a wide array of available investment instruments, risk-financing mechanisms and broader finance-relevant solutions that financial actors are already mobilizing in support of climate resilience across Africa. Financial instruments can be used to finance activities that build physical resilience to climate change impacts, reducing physical risk, and can also be used to respond to risks where physical climate impact cannot or has not been eliminated. Risk transfer mechanisms can be designed to compensate climate-related losses if a contingent variable falls outside an established range (for example a predetermined drop in commodity prices). For example, the African Risk Capacity is a sovereign risk pool and early-response mechanism designed to provide insurance to countries in the event of a contingency.[34] The African Risk Capacity's mission is to help members of the African Union protect the food security of their vulnerable populations. As an insurance risk pool, the African Risk Capacity has the objective of capitalizing on the natural diversification of weather risk across Africa, allowing countries to manage their risk as a group in a financially efficient manner to respond to probable but uncertain risks.

As a final step, companies could consider embedding climate-risk management into their governance, strategy and risk management processes. For example, when planning to invest in a new building, companies could consider the potential impacts of climate hazards. Anticipation of risk can lead to proactive choices in structural design and location to increase the building's resilience, such as designing it to withstand what used to be a weather event occurring once in 200 years. This could be more cost-effective than making retrofits in the future.[35] Companies in South Africa are increasing their awareness around embedding climate-risk assessments within their organizations at all stages of operations to address climate change, and even reporting their efforts through the Task Force on Climate-related Financial Disclosures, which provides guidance on how the financial sector can incorporate climate-related issues in its decision-making.[36]

> **“Nearly 80 percent of the trillions that will be needed for adaptation has to come from the private sector. The private sector stands to gain enormously from making its operations and supply chains more resilient. At the same time, it provides ideas, solutions, technology, innovation to help countries and societies to build their resilience to climate change.”**
>
> **Feike Sijbesma**
> Honorary Chairman, Royal DSM and Co-Chair of the Global Center on Adaptation

Box 2. Challenges Faced by MSMEs in Africa in Adapting to Climate Risks

Due to their limited diversified activities and internal capabilities, MSMEs in Africa can face significant barriers to identifying and adapting to climate risks.

Climate-risk assessment

MSMEs tend to focus on the current or recently experienced direct impacts of extreme climate events, while they have limited access to information on forecasted climate impact and events. In contrast to large companies in Africa, MSMEs often lack the capacity to generate data and information through risk assessments that use multiple climate models.

Business networks and collaboration between MSMEs and large corporations can help foster a more significant push toward adaptation in Africa. For example, sharing information from value-chain risk analyses conducted by large companies can help MSMEs understand and quantify their risks, and inform their decisions on elements such as insurance and infrastructure. Such measures are likely to also benefit large companies in the long term. Business networks can also play a vital role in building capacity and raising awareness for MSMEs. For example, the National Business Initiative, a group of national and multinational companies in South Africa cooperating on sustainable development efforts, provides MSMEs with resources on adaptation and climate finance.

Adaptation measures

MSMEs often find it difficult to relocate their assets and infrastructure or redistribute their supply networks when they are affected by transport, energy, and connectivity issues caused by climate hazards. This is mainly because their business activities may be restricted to a limited number of locations and supplier relations, and because they lack the capital and access to financial services to relocate or diversify their activities, or to develop emergency response mechanisms.

Therefore, MSMEs might undertake adaptation measures that are not capital-expenditure intensive and that focus instead on sectoral collaboration. Adaptation pathways that seek the collaboration of government, the private sector and civil society—known as multi-stakeholder partnerships—are becoming an increasingly important development paradigm in Kenya, for example. Through action and investment from donor-funded and public sectors—in areas such as research, data access, relationship development, business incubation and access to finance—multi-stakeholder partnerships are supporting private-sector actors in delivering adaptation resources to small-scale producers. This includes farmers in remote regions, who would otherwise fall outside of market inclusion, thus improving stakeholder engagement for different levels of the value chain. Partners within the PREPARED Project (Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development) in Kenya,[37] funded by the United States Agency for International Development, have invested in weather station upgrading and capacity building in the Kenya Meteorological Department. This has enhanced the quality of climate data and supported access for insurance companies to a robust index to determine commercially viable premiums for weather-index crop insurance for poor farmers.[38]

THE ROLE OF PRIVATE ENTERPRISES IN ADAPTATION MEASURES OF COMMUNITIES AND THE BROADER ECONOMY

Private enterprises can effect change within supply chains while producing adaptation-related products and services that can benefit households.

Within their supply chains, companies can help upstream and downstream stakeholders build their resilience. In addition to building resilience in their own core activities (for example, by hardening assets, diversifying sources of procurement to avoid bottlenecks, selecting upstream and downstream companies that actively invest in their resilience), companies can help suppliers and vendors build their own resilience by sharing climate-related information and co-building disaster response capabilities. As an example, Enel, a multinational energy company active in five African countries, has been creating climate-risk forecasts and assessments via in-house experts, which are then shared with wider stakeholders.[39] Both Enel and its stakeholders can use this information to adapt activities to heatwaves, floods and other physical hazards that present risk to assets and operations in Africa. Sharing of information by large companies with the expertise and capacity to conduct thorough value-chain risk analyses can help smaller-scale players (for example, MSMEs) that lack equivalent capabilities. Especially for smaller companies, insurance premiums can be decreased through better risk data that lowers uncertainties and provides insight into residual risk exposure.

Companies can also provide adaptation-related products and services to help households and communities become more resilient. By taking climate change into account, adaptation-related technologies help reduce climate risk and contribute to improving development outcomes. These may include adaptation-related products such as air conditioning or drought-resistant seeds; adaptation-related services such as innovative insurance products; and provision of data and information more broadly. In addition to socioeconomic and finance-based systems, nature offers significant untapped potential to solve climate-related issues across Africa.[40] As an example, the multinational chemicals company DSM has produced enzymes for the food and beverage industry that can potentially reduce water consumption, which is key in regions that are expected to face an increase in water stress.[41] As another example, the OCP Group produces fertilizer tailored to local conditions, and trains farmers in Kenya, Nigeria, Ghana, Togo, Burkina Faso, Senegal, and Cote d'Ivoire in sustainable farming practices that improve land management, yields and incomes.[42]

In addition to contributing to boosting adaptation, companies can also play a role in swift recovery

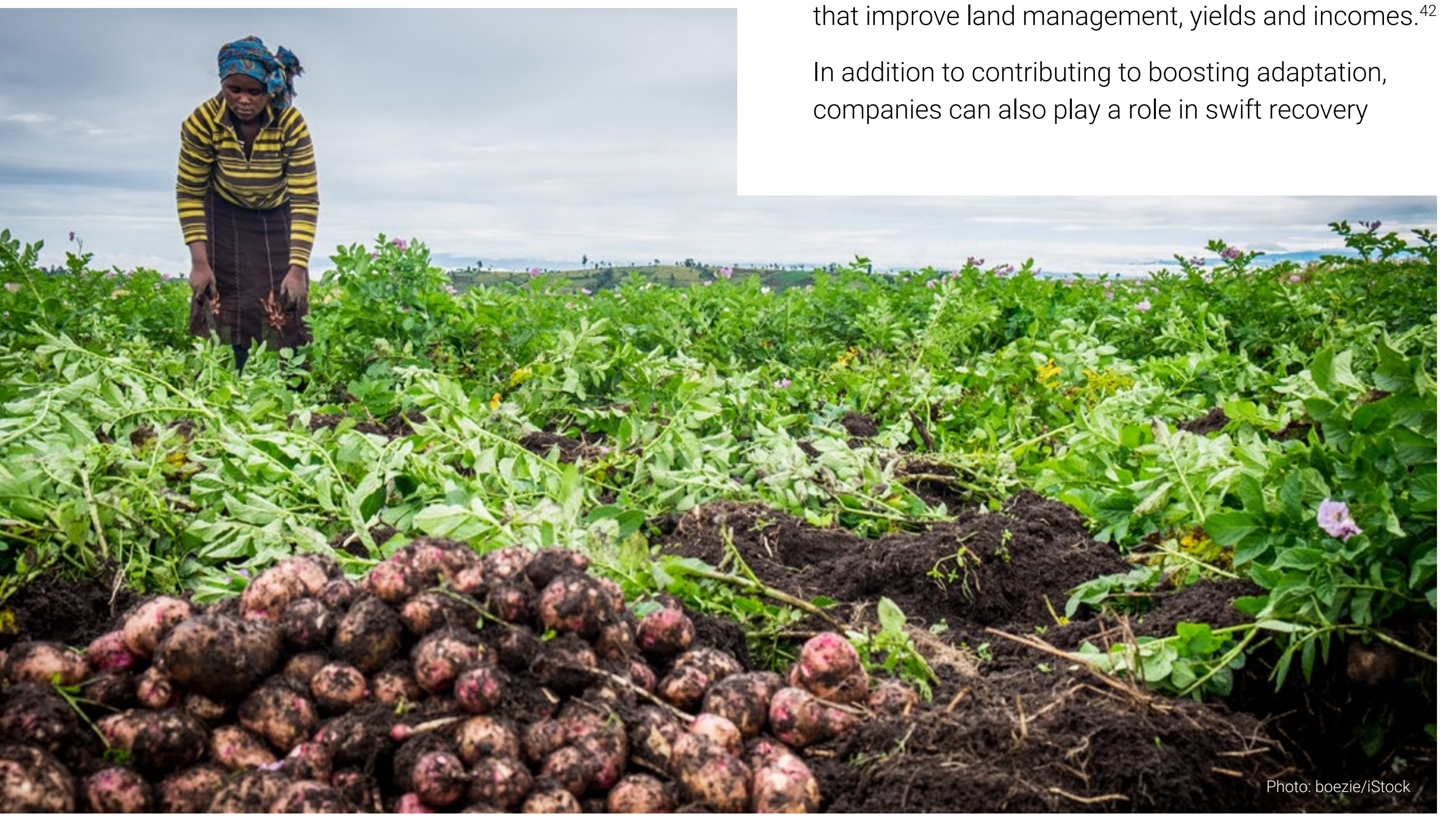


Photo: boezie/iStock

from shocks. There are notable benefits from leveraging private-sector supply chains to bring aid immediately after natural disasters, sometimes faster or more effectively than government agencies. For example, Coca-Cola contributed bottles of water and logistical support to communities in Mozambique, Zimbabwe, and Malawi in the aftermath of Cyclone Idai.[43] More recently, in the light of the global pandemic health crisis, financial institutions in Nigeria formed a US$2.5 billion financing initiative to promote domestic manufacturing and other critical industries.[44]

While the physical effects of climate change can negatively impact jobs, proactive adaptation can protect jobs and even improve socioeconomic outcomes. Between 2008 and 2015, the International Labour Organization (ILO) estimates, Africa lost an annual average of 376 working-life years per 100,000 people of working age due to environment-related disasters caused or exacerbated by human activity.[45] This measure represents lost employment time, with its corresponding negative effects on production and GDP. Increasing the resilience of supply-chain stakeholders can help safeguard existing jobs and improve disaster-risk responses. It may also spur adaptation action to protect or shift jobs in sectors that face chronic climate risks, such as the threat of water scarcity in Africa's hydropower sector.

In addition to avoiding job losses and displacement, resilience can help support job creation in new adaptation markets. Resilience can also maximize green transition potential by safeguarding investments in promising sectors, such as energy and manufacturing. For example, the development of a cross-laminated timber industry in Africa could create more than 100,000 jobs by 2030 across the value chain and over three million jobs in the longer term, as cross-laminated timber is a low-carbon alternative to cement and steel in the construction industry.[46]

Box 3. MSMEs can Provide Climate-Adaptation-Related Products and Services with Positive Effects on Employment

A survey of MSMEs in Africa by the Global Center on Adaptation (GCA) found that 95 percent saw opportunities for business expansion while managing climate risks:

- 81 percent identified new products
- 22 percent found new markets for existing products
- 60 percent identified opportunities for new markets.[47]

For example, MicroInsurance Services in Malawi provides weather-related information in addition to risk insurance, capitalizing on demand for information on adverse climate impacts. Other MSMEs have found their market in providing organic fertilizer or farm machines powered by renewable electricity. Innovation by MSMEs can meet market needs while contributing to employment. MSMEs are the main engines of job creation in most countries in Africa. In addition, because they are smaller and more local, MSMEs can create adaptation solutions that meet local needs.

For example, the ILO's Zambia Green Jobs Programme in 2013–2018 aimed to create 5,000 green jobs and improve the quality of at least 2,000 jobs, specifically in MSMEs, to boost the sustainability and competitiveness of these companies. These jobs in the construction sector, mainly filled by young people, were expected to improve the incomes and livelihoods of over 8,000 households.[48]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COLLABORATION ACROSS THE PRIVATE, PUBLIC, AND FINANCIAL AND INSURANCE SECTORS IS REQUIRED IN ADAPTATION

Within the private sector, companies may collaborate to share information and unlock transformational outcomes. Large companies can undertake risk assessments to generate information about climate impacts on their operations and supply chains. MSMEs often lack the capacity to do the same, and the resilience of a country's private sector may then be improved by sharing climate data and adaptation knowledge with multiple stakeholders, including MSMEs.[49] As an example, Acre Africa has partnered with telecommunications and finance organizations, gathering joint expertise to distribute microinsurance products, such as mobile-based weather-index insurance, multiperil crop insurance, and livestock coverage to over 1.7 million farmers in the region.[50] Similarly, The National Business Initiative, a voluntary coalition of South African and multinational companies working toward sustainable growth and development in South Africa, provides resources on adaptation and climate finance to MSMEs.[51] Finally, intercompany collaboration can reduce costs through economies of scale. For example, companies may join to create a particular piece of infrastructure that is relevant for the whole sector.

The public sector is a key enabler of private-sector action due to its role in setting overarching national priorities; building a clear regulatory framework to support these priorities; and offering support via technical assistance, data sharing and access to capital. In this sense, National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) are key resources to establish long-term expectations and indicate priority areas for private-sector participation. To ensure credibility and usefulness, both NAPs and NDCs need to be consistent with macroeconomic parameters and budgets. In terms of regulation, governments have a direct impact in shaping markets, such as creating green building standards that reduce energy use, requiring companies to conduct climate-risk assessments or incorporate resilience into public procurement criteria.[52]

Direct support from the public sector can take the form of capacity-building initiatives or de-risking mechanisms that lower the cost of capital. As an example, the public sector may share information or conduct training about climate-related risks to reduce uncertainty and guide decision-making for the private sector. Social protection programs can be effective at reducing climate risk.[53]

MSMEs are likely to benefit most from such programs, as they are less likely to have the in-house capacity to produce climate-risk data themselves. The GCA survey of African MSMEs found that 29 percent lack climate data, while 17 percent of MSMEs said they lack knowledge on climate impacts.[54] Climate information services have also been identified as a priority by the Africa Adaptation Initiative, which currently ranks Sub-Saharan Africa last among all regions in terms of land-based observation networks. Access to adequate information can also facilitate adaptation-related financing. Robust information on climate hazards, exposures and vulnerabilities can help prove the adaptation relevance of a project, potentially allowing access to more favorable loans.

The financial services sector plays a role by creating new products, monitoring climate risk and incentivizing adaptation actions. As an example, parametrized insurance can reduce transaction costs in writing and administering insurance policies while protecting against climate events by minimizing their financial damage. There is also a role for innovation, resulting in products such as a municipal bond "wrapped" into a catastrophe bond.[55] This instrument minimizes the need to assess climate risk for investors holding the bond, thus encouraging investment. Innovation is key for project funding as well, since investments in adaptation can sometimes result in short-term income losses that make it difficult to obtain traditional project funding.[56] Potential solutions may include alternative currencies or blended financing. In addition, increased monitoring of climate risk facilitates risk management, especially for private banks, who will need to increase risk monitoring to prepare for the growing call for climate disclosures. Finally, banks can make loans contingent on climate adaptation criteria to incentivize action by companies or make finance-specific adaptation-related actions.

Box 4. Improving Resilience via Public–Private Partnerships (PPPs)

Robust PPP frameworks can help allocate risk to best manage uncertainties while maximizing benefits. According to the World Bank's Private Participation in Infrastructure database, Africa has secured less than 7 percent of global PPP investments over the last decade. Most African countries (35 out of 54) have PPP legislation and units, but the majority do not include elements of climate resilience and adaptation. Improvements to PPP frameworks can incorporate these elements as well as increase investor confidence by making the frameworks more robust overall.

PPPs used to provide public infrastructure can help economies become more resilient and support development overall. For example, the 2000 flood destroyed roads and rail lines in Mozambique, disrupting logistics internally and to Zimbabwe, resulting in economic losses and the lowest level of economic growth in two decades. In collaboration with the World Bank Group, the Public-Private Infrastructure Advisory Facility, and the African Development Bank, among others, the GCA established the Climate-Resilient Infrastructure Officer Program to incorporate climate adaptations into PPPs. As part of the GCA Africa Adaptation Acceleration Program (AAAP), this project is working with the Ministry of Finance and the National PPP Unit in Ghana to enhance climate adaptation and resilience of the $570 million Accra–Tema Motorway PPP.

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Box 5. Potential Areas for Future Research on the Private Sector and Adaptation in Africa

To build climate resilience, companies need to understand the full breadth of their climate risk, as well as the practical options they have to reduce risk and capture new opportunities.

However, limited availability and lack of granularity in climate and socioeconomic data in Sub-Saharan Africa can be salient bottlenecks in climate-risk quantification. Limitations can range from lack of availability in robust climate data (with relevant climate variables, thresholds, and uncertainty handling), to lack of locally relevant damage functions to assess vulnerability and lack of exposure data (with asset and activity values). Thus, further research is needed to make available the necessary climate and socioeconomic data to feed into risk quantification of direct losses. Going further, as a substantial portion of the value at risk lies with indirect impacts, further research is needed to quantify the potential financial and job losses due to upstream and downstream supply-chain disruptions (for example, due to transport network disruption, or energy infrastructure shocks).

Based on a robust understanding of direct and indirect value at risk from climate change, the private sector can then move to weighing adaptation options, investment plans, and operationalization. To support companies in this journey, further research is needed to convert identified risks into investment needs, and more precisely investments that can be carried by the private sector. This requires an understanding of potential adaptation choices (capital and non-capital intensive; co-benefits with decarbonization, nature and socioeconomic development), and business models that can work for the private sector. Additional areas for research that are key to operationalization would be contractual models that can allocate risks efficiently across value chains (for example, by protecting vulnerable smallholders), and insurance models that can extend coverage in Sub-Saharan Africa.

Access to Global Climate Finance – The Technical Assistance Program

KEY MESSAGES

- To address the problem of the adaptation finance deficit in Africa, Pillar 4 of the Africa Adaptation Acceleration Program (AAAP) is focused on innovative financing. One of its core elements is a Technical Assistance Program (TAP) that aims to reduce barriers to large-scale access to multilateral climate funds in Africa and significantly increase the flow of adaptation finance to the region.
- Given the central role of the Green Climate Fund (GCF), the unprecedented volumes of funding it offers, the range of financial instruments it provides, and its different access modalities, the TAP initially focuses on accessing GCF resources.
- All African countries are eligible for TAP, but in the interests of practicability, a gradualist approach is being adopted, starting with a small number of countries and gradually expanding to others. During the first year of implementation, the TAP has engaged stakeholders in about 12 countries, including Burkina Faso, the Democratic Republic of the Congo, Niger, Nigeria, Seychelles, Côte d'Ivoire, Senegal, and Ghana.

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- The Global Center on Adaptation (GCA) engagement strategy through TAP aims to foster country ownership and alignment with national priorities, laying the ground for a long-term partnership for adaptation finance mobilization and implementation. In addition, where practicable, the GCA encourages the consolidation of isolated sectoral initiatives into large programs and pushes for the acceleration of ongoing processes in line with the objectives and approach of the AAAP.

“

With the AAAP, Rwanda will benefit from innovative climate adaptation finance with the cross-cutting nature of climate interventions in different sectors.”

Claudine Uwera
Minister of State in Charge of Economic Planning, Rwanda

INTRODUCTION

Many African countries need institutional and technical capacity building in regard to planning for, accessing, and delivering climate finance, including when engaging with multilateral climate funds. In response to this need, Pillar 4 of the Africa Adaptation Acceleration Program (AAAP), focused on innovative financing, includes a Technical Assistance Program (TAP) that aims to reduce barriers to large-scale access to adaptation finance in Africa and significantly increase the flow of adaptation finance to the region. For a detailed presentation of the AAAP overall, see chapter "The Africa Adaptation Acceleration Program (AAAP)."

This chapter aims to draw the first lessons learned after one year of implementation to measure the progress and achievements of the program, and identify areas for improvement to achieve more significant impact and sustainability. To this end, the Global Center on Adaptation (GCA) conducted a series of semi-structured interviews using a questionnaire customized to the stakeholders involved in implementing the TAP, including National Designated Authorities (NDAs), officials from different ministerial departments, Accredited Entities (AEs), development partners, and GCA programs.

The chapter consists of three sections. The first section provides a brief overview of the main actors operating in the landscape of adaptation finance in Africa and their respective roles in channeling climate adaptation finance to the region. This section also provides a quick focus on the Green Climate Fund (GCF), given its pivotal role, the unprecedented volumes of funding it offers, and the range of financial instruments it provides. The second section spells out the rationale for the TAP, presenting its main components and implementation approach. This section also presents best practices and preliminary lessons learned from the first year of TAP implementation. The third section summarizes key findings through the review of the first year of implementation of the TAP. It makes recommendations for improvements in the program's implementation approach, and also on what policies and actions African governments and other actors can take to strengthen direct access. This section will finally provide an overview of TAP's plans for 2023–2025.

A BRIEF REVIEW OF THE LANDSCAPE OF ADAPTATION FINANCE IN AFRICA

The landscape of adaptation finance is extremely complex for potential recipients who seek sources

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of funding for individual projects. Navigating it can be particularly challenging due to the diverse characteristics and requirements of funding sources.

The needs of African countries for financing adaptation to the impacts of climate change are significant and cannot be covered by a single financial mechanism. Actions to close the adaptation financing gap must therefore target multiple sources, both public and private, international and domestic, while exploiting complementarities.

Multilateral climate funds are catalytic in facilitating and accelerating financing in perceived high-risk adaptation projects by providing instruments like first-loss or junior equity, repayment guarantees, and grants to mobilize private investments.[1] Given the central role of the GCF, the unprecedented volumes of funding it offers, the range of financial instruments it provides, and its blended funding strategy, the TAP initially focuses on accessing GCF resources. This is especially true since the same capacity developed to access the GCF will allow access to any other multilateral climate funds.

The basic requirements for accessing GCF funding include:

- **Having in place an ambitious and coherent national climate strategy/policy:** Funding requests submitted to the GCF must demonstrate alignment with national priorities;
- **Having in place a National Designated Authority (NDA) and Focal Point:** NDAs are government institutions that provide broad strategic oversight of the GCF's activities in the country and communicate the country's priorities for financing low-emission and climate-resilient development;
- **Identifying Direct Access Entities through which funding proposals are submitted to the GCF.** Direct Access Entities (DAEs) are to be endorsed by the NDA before applying for accreditation to the GCF;
- **Developing a pipeline of projects that fulfill GCF requirements:** Ideally/increasingly based on the GCF Country Program and relevant Entity Work Program.

Through the TAP, the GCA's intervention targets all these levels to create an enabling environment for better performance in the mobilization of public financing for adaptation.

TAP FOR ACCESS TO ADAPTATION FINANCE

Main Features of TAP

The TAP is designed to be one of the core implementation programs to mobilize sources of climate finance under the "Innovative Financial Initiatives for Africa" pillar of the AAAP. The TAP is tackling the main barriers that African countries face in accessing adaptation finance at scale. These include significant gaps in adaptation planning and decision-making; poor technical capacities for adaptation project development and implementation; and lack of valorization of the groundbreaking direct access modality.

To overcome these barriers, the TAP also strives to avoid the shortcomings that have often characterized many readiness programs so far. One such flaw is a piecemeal approach in supporting direct access: the focus is mainly on preparing and submitting the required supporting documents, not simultaneously on building institutional and technical capacities for adaptation project development and implementation. Another problem is a sector-based or small-scale approach in developing projects, leading to small-size projects that do not address the problem at the scale needed. Lastly, there are often lengthy procedures for securing and implementing readiness grants, generating delays in accreditation application and funding proposal submissions.

The TAP includes three inter-related components:

- Building capacities for adaptation finance planning and decision-making, laying the ground for a long-term partnership for adaptation finance mobilization and implementation;
- Strengthening direct access by facilitating new accreditations and supporting the upgrade of existing National Implementing Entities (NIEs) while ensuring complementarity with the international access modality;
- Promoting inter-sectoral, large-scale, and transformational adaptation projects and programs through inclusive consultative processes aligned with national and regional priorities.

Engagement with Countries

All African countries are eligible for TAP, but a gradualist approach had to be adopted, starting with a reasonable number of countries and gradually expanding to others. In line with the objectives and approach of the AAAP, it was important to consider the synergies of TAP activities with other AAAP projects; to find opportunities to aggregate small and isolated initiatives into larger, cross-sectoral adaptation programs; and to give priority to "acceleration" over "origination" of initiatives.

The selection of "priority" countries was based on these guiding principles, taking into account the AAAP countries or regional focus. The main criteria used include:

- Level of vulnerability using the ND-GAIN Index;[2]
- Being covered by one or more of the GCA programs;
- Having submitted a National Adaptation Plan (NAP) or having a NAP process under way;
- Potential for structuring regional Adaptation and Resilience (A&R) initiatives/likelihood of adaptation financing initiatives/instruments that are ready for replication, scaling up, or acceleration;
- Membership of (among others):
  - Least Developed Countries (LDCs) and/or Small Island Developing States,
  - The Climate Vulnerable Forum and The Vulnerable 20 (V20) Group, and
  - Regional balance: taking into account representation of Regional Economic Communities (RECs) and also official languages.

Based on this, an initial "longlist" of 21 priority countries was established. A shortlist of countries was then created, considering ongoing processes related to adaptation finance and accreditation (NAP process, GCF country program, recent hands-on capacity-building activity, started application for accreditation or endorsement of an accreditation candidate). The shortlist of countries was also prepared through an ongoing engagement process. During the first year of implementation, the TAP has engaged stakeholders in about 12 countries.

The shortlist of countries where activities were launched includes: Burkina Faso, Democratic Republic of the Congo (DRC), Niger, Nigeria, Seychelles, Côte d'Ivoire, Senegal, and Ghana. In parallel, the African Development Bank (AfDB) portfolio is being explored for large-size projects/programs that could be fast-tracked toward GCF funding.

Once the selection of countries was completed, the country's engagement started identifying priorities and consultative frameworks for enhancing adaptation finance and decision-making. More specifically, this involves:

- Identifying key stakeholders and their roles, including NDAs, DAEs, national/regional institutions with a good potential for accreditation, and potential adaptation project sponsors (including civil society organizations, private sector players, farmers' organizations, and agribusinesses, among others);
- Prioritizing needs for support about adaptation finance; and
- Drafting a work program.

The GCA engagement strategy through TAP aims to foster country ownership and alignment with national priorities, laying the ground for a long-term partnership for adaptation finance mobilization and implementation. To date, progress in the implementation of the TAP has taken various forms, including:

- Country engagement to identify priority areas for support;
- Supporting Climate Public Expenditure and Institutional Reviews to build capacity for adaptation finance planning and implementation (Côte d'Ivoire);
- The development of adaptation country-project concept notes in four countries (Burkina Faso, DRC, Niger, and Nigeria);
- Enhancing the climate rationale of a multi-country (Ethiopia, Togo, Senegal, and Guinea) funding proposal operated by an international AE (AfDB);
- Support for the preparation of a direct access accreditation application (Ghana); and
- Support for the operationalization of the Nationally Determined Contribution (NDC) and strategy for domestic sources of climate finance (DRC).

CASE STUDY 1: Country Engagement with the Democratic Republic of the Congo (DRC)

The DRC's NDA for the GCF was among the first to express interest in the TAP, as early as August 2021. Subsequently, the DRC's Deputy Prime Minister, who also holds the charge for Environment and Sustainable Development, was invited to the Friends of GCA High-Level Dialogue: Accelerating Adaptation Solutions Ahead of COP26, organized by the GCA at its headquarters in Rotterdam on September 6, 2021.

Among other things, this Dialogue presented the AAAP, developed jointly by the GCA and the African Development Bank, to demonstrate the ambition required to support the communities most vulnerable to climate change. Under its Innovative Financial Instruments (IFI) pillar, the AAAP aims to close the adaptation finance gap, while enhancing access to adaptation funding. This pillar is highly aligned with the needs of countries like the DRC. This has fostered a strong buy-in from high-level authorities. Hence the invitation was extended at the end of the event by the Deputy Prime Minister to the CEO of GCA to visit Kinshasa to further strategic discussions on how the DRC can benefit from the AAAP program.

A GCA delegation visited Kinshasa in December 2021 and held bilateral meetings with high-level authorities and development partners, as well as more technical working sessions with different categories of stakeholders. The main outcome of this mission was a joint work program with the Government of the DRC, covering four areas: 1) integration of climate change into budgeting and finance; 2) operationalization of the NDC and development and implementation of the country's domestic carbon market; 3) strengthening the DRC's access to GCF funding; and 4) supporting the implementation of pre-COP27 activities.

The work program is currently under implementation with the development of a first adaptation project Concept Note in February 2022 (area 3) and the first follow-up mission in April 2022. Under area 3, the GCA will deliver support to the GCF accreditation of the Equity Banque Commerciale du Congo (Equity BCDC). The operationalization of the NDC (area 2) and the support to the pre-COP27 activities are also under implementation since August 2022. The implementation of the work program is being monitored on an ongoing basis through remote exchanges and regular visits to the country.

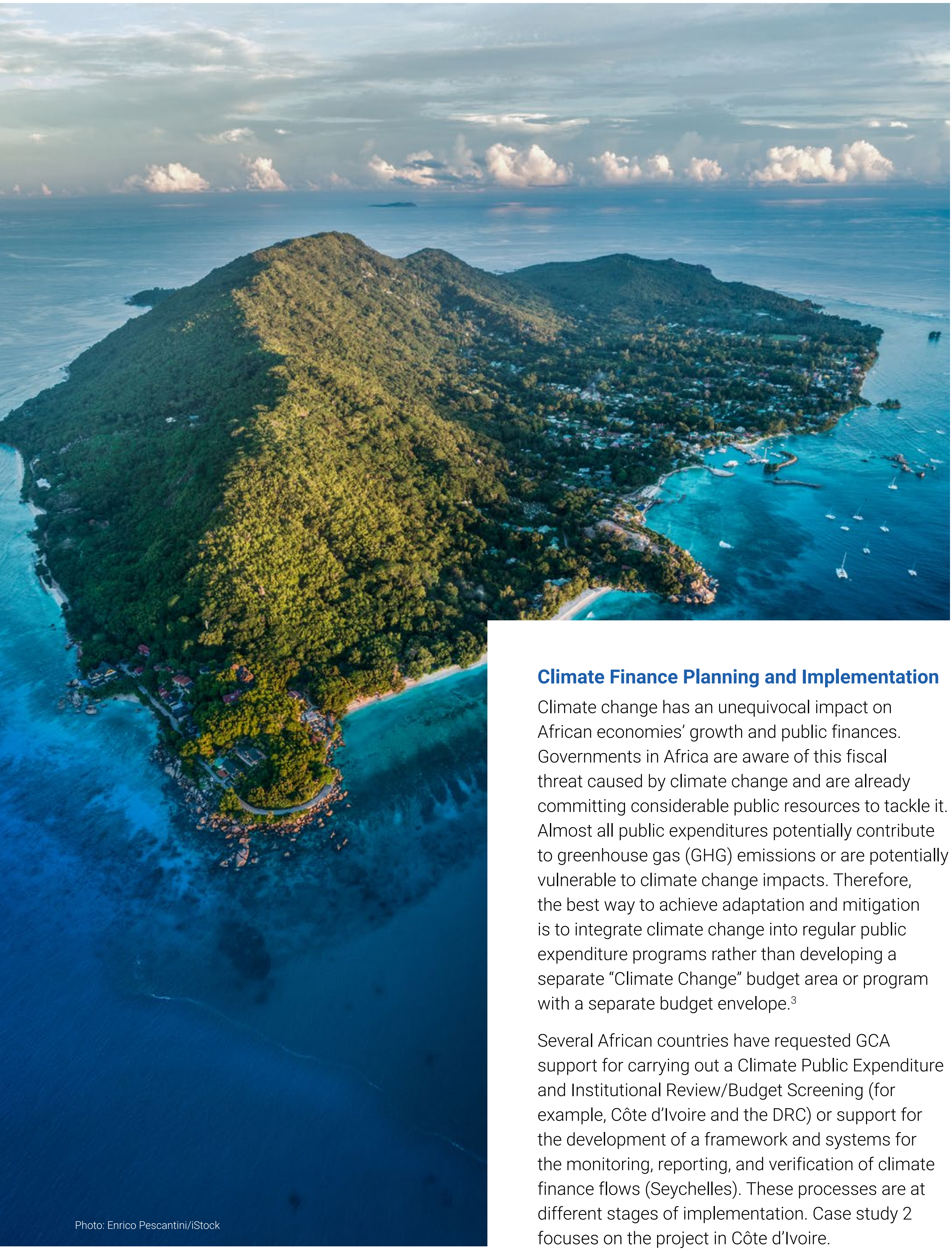

Photo: Enrico Pescantini/iStock

Climate Finance Planning and Implementation

Climate change has an unequivocal impact on African economies' growth and public finances. Governments in Africa are aware of this fiscal threat caused by climate change and are already committing considerable public resources to tackle it. Almost all public expenditures potentially contribute to greenhouse gas (GHG) emissions or are potentially vulnerable to climate change impacts. Therefore, the best way to achieve adaptation and mitigation is to integrate climate change into regular public expenditure programs rather than developing a separate "Climate Change" budget area or program with a separate budget envelope.[3]

Several African countries have requested GCA support for carrying out a Climate Public Expenditure and Institutional Review/Budget Screening (for example, Côte d'Ivoire and the DRC) or support for the development of a framework and systems for the monitoring, reporting, and verification of climate finance flows (Seychelles). These processes are at different stages of implementation. Case study 2 focuses on the project in Côte d'Ivoire.

CASE STUDY 2: Climate Public Expenditure, and Institutional Review and Budget Screening in Côte d'Ivoire

Côte d'Ivoire has access to international and local markets, having issued US$16.63 billion in bonds by October 2021, and is now preparing to launch its first Sovereign Sustainable Bonds. In 2021 the Government also published a Sustainable Bond Framework with three types of Environmental, Social and Governance (ESG) instruments: Social Bonds, Green Bonds, and Sustainability Bonds (the last to finance/refinance expenditures within the eligible Green and Social Categories of the framework).

GCA and the Ministry of Economy and Finance of the Republic of Côte d'Ivoire have entered into a Memorandum of Understanding through which GCA, in collaboration with UNDP and Rothschild & Co, will provide technical assistance and capacity building to the Government of Côte d'Ivoire to accelerate the process of issuing its Sovereign Sustainable Bond, supporting the country to unlock private sector capital to finance green investments aligned with its NDC and National Development Plan (mitigation and adaptation). Likewise, GCA intends to increase the share of A&R investments to be financed by the Sustainable Bond, advancing the resilience capacity to climate shocks.

Therefore, upon request from the Government of Côte d'Ivoire, GCA will provide technical assistance and capacity building to the Government of Côte d'Ivoire to (1) identify eligible green expenditures to be financed by the Ivorian Sovereign Sustainable Bonds, and (2) perform a Climate Public Expenditure and Institutional Review (CPEIR) for the Republic of Côte d'Ivoire. This will enable a better appreciation of national efforts in terms of A&R financing, including in reporting on the implementation of commitments made through the NDC.


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Planned activities include: 1) a review of the budget to identify and select eligible ESG expenditures, with a focus on adaptation and climate change mitigation expenditures, known as green expenditures; 2) a review of public spending and the institutional framework for climate action; 3) the establishment of a classification and coding system for climate expenditures; 4) the establishment of a climate budget tagging system; 5) the establishment of a coordination mechanism for the climate expenditure classification and coding system; and 6) training and capacity development for relevant officials to apply the climate expenditure review methodology to the budgets and expenditures under their supervision.

Enhancing Direct Access

When it became operational in 2010, the Adaptation Fund (AF) was the first climate fund to introduce the groundbreaking innovation of direct access. Developing countries are allowed to access climate funds through national and regional entities, in addition to the traditional international access modality. Since then, this access modality has become a "must" that has been adopted by the Global Environment Facility (GEF) and later by the GCF. Direct access strengthens a developing country's ownership of the implementation of climate-related projects and programs. In addition, recent literature suggests that national direct access to multilateral climate funds could promote climate change adaptation investment that focuses more on the needs of vulnerable local communities when compared to indirect access through international agencies.[4] An analysis by the World Resources Institute concluded that the introduction of direct access in the realm of climate finance opened new opportunities to strengthen country ownership and increase the capacity of institutions in developing countries.[5]

However, to take full advantage of the direct access modality, developing countries need to have institutions ready and able to complete the accreditation process and develop and implement high-impact climate projects.

The accreditation process requires meticulous efforts from DAEs to understand the complex standards and requirements and to ensure compliance with them. If gaps are found, the entity must restructure institutional settings and operational frameworks and nurture additional technical capacities.[6] According to the GCF's Independent Evaluation Unit (IEU), challenges in accreditation are attributed to various reasons pertaining to the design and implementation of the accreditation process, as well as the capacities of entities. There is evidence that DAEs face difficulties in providing all documentation in English and complying with all standards, which often requires them to develop and redraft policies.[7] Hence, the need for tailor-made support for the accreditation of national entities is precisely the area where the TAP is intervening to support countries and entities to expedite the accreditation process.

The following case studies focus on GCA's technical assistance to Senegal and Ghana concerning direct access to the GCF.

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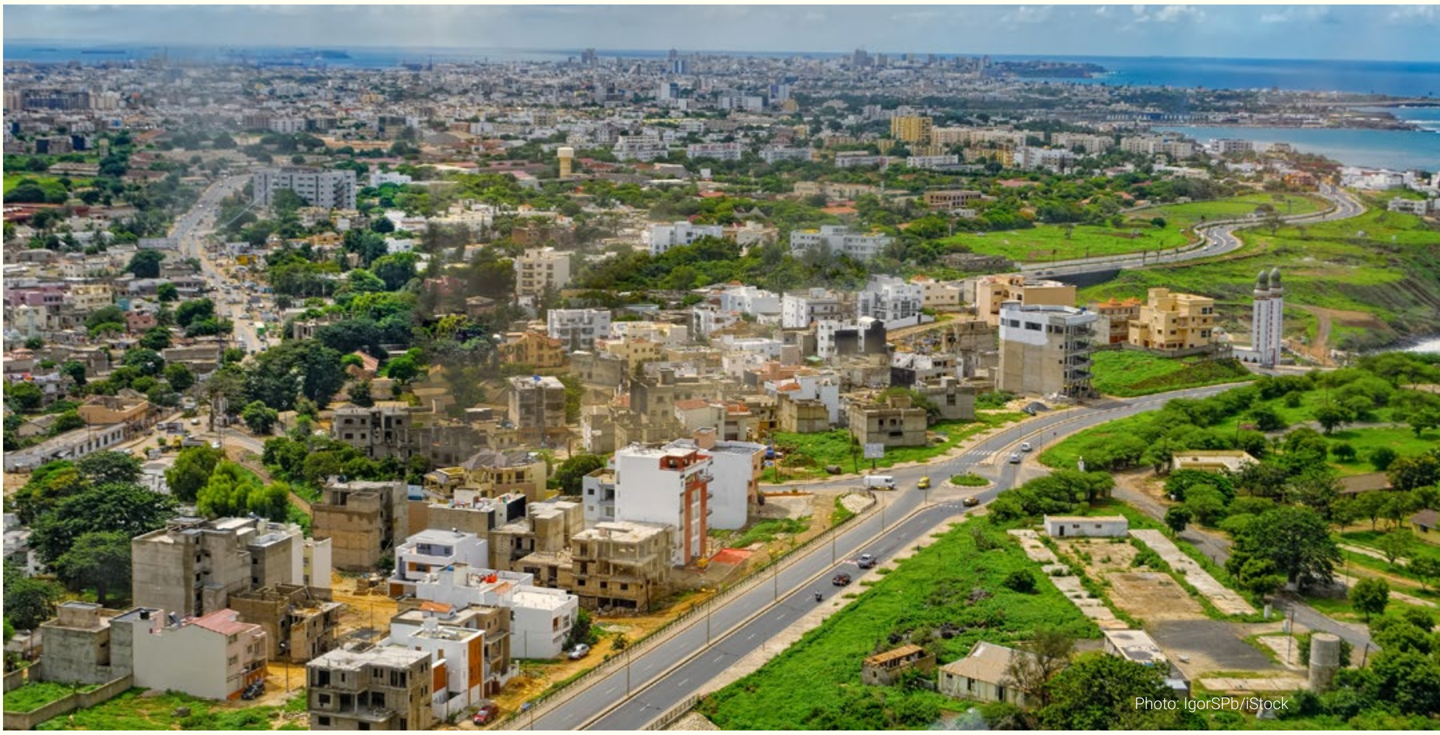


Photo: IgorSPb/iStock

CASE STUDY 3: Supporting Senegal's Accreditation Strategy for Direct Access to the GCF

Senegal's National Designated Authority (NDA) has adopted a clear strategy for the accreditation of national entities, aimed at giving the country the means to make the most of all the financial instruments of funds such as the GCF. In 2015, the first national entity with an environmental background (the Ecological Monitoring Center) and with good experience in public and adaptation projects was the first DAE of the AF. However, it only allowed Senegal to submit direct access projects for the grant instrument, which excluded the private sector.

Five years later (in 2020), Senegal got accredited a second national entity (La Banque Agricole) which is a leading bank in the financing of agricultural development in Senegal, with the mission to facilitate access to credit so as to promote sustainable economic activities in rural, urban and peri-urban areas, to collect domestic savings, and to perform all banking operations. In doing so, Senegal was already paving the way for greater involvement of the Senegalese private sector in climate action.

In 2022, the NDA of Senegal for the GCF submitted a request to the GCA to provide technical assistance to support the Sovereign Strategic Investment Fund S.A (FONSIS) and the Priority Investment Guarantee Fund (FONGIP) in their application to become a DAE of the GCF. FONSIS is a limited company wholly owned by the Government of Senegal with a new vision of development aimed at using the powerful lever of private equity for sustained growth by creating jobs and wealth. As for the FONGIP, it is the only public guarantee fund set up by the Government of Senegal to facilitate access to financing for economic actors and the implementation of structuring projects in priority sectors of the economy. The GCA has signed Letters of Intent with each of these four entities to support them in either accrediting to the GCF or building their capacity as DAEs.

Photo: GravityGh Studios/iStock

CASE STUDY 4: Enhancing Direct Access in Ghana

The Government of Ghana gives high priority to climate adaptation strategies. The country requires US$9.3–15.5 billion of investment to implement the 47 NDC measures from 2020 to 2030. From this amount, US$5.4 billion would be required for the 31 conditional programs of action, mainly from public, international, and private sector sources and carbon markets. While mobilizing substantial domestic funding, Ghana relies nevertheless on international support to achieve its 2030 contributions. To diversify its channels for the delivery of climate finance and to strengthen national ownership, the Government of Ghana has requested support from GCA for the accreditation of the Ghana Infrastructure Investment Fund (GIIF) to the GCF.

This request was a continuation of the technical assistance that GCA was already providing to the Government of Ghana, including the Accra Rapid Climate Risk Assessment and Ghana Roadmap, under the African Infrastructure Resilience Accelerator (AIRA) pillar of the AAAP. The technical assistance provided to GIIF extends and complements that provided by Agence française de développement (AFD) to this entity, while the projects listed in Ghana's roadmap are likely candidates for GCF funding through GIIF after it receives accreditation with GCA support.

The mandate of GIIF is a good asset for accreditation with the GCF, but it currently lacks the technical capacities, experience, policies, and procedures to efficiently seek GCF accreditation. In addition, the

GIIF commenced operations in 2015, and seven years can be too short a time span to show track records of availability and implementation of policies and procedures.

The initial support provided by TAP consisted of two workshops: a first workshop to familiarize GIIF staff with the accreditation process, and a second one where the scope and details of the technical assistance were discussed. In between, there were regular email exchanges to better identify needs. The technical assistance has been under way since July 2022 and covers both the preparation and submission of the application and the strengthening of GIIF's capacity to prepare the institution to play its role as an AE. GCA's support will put an emphasis on quality control to ensure that the most relevant documents are submitted. It will also help GIIF in responding effectively and efficiently to comments and clarification requests from the GCF Secretariat as well as the Accreditation Panel (AP).

Finally, this technical assistance will gradually extend to the development and implementation of adaptation projects, which is the purpose of accreditation.

Photo: Samuel Sefa/iStock

Designing, Submitting, and Implementing Projects and Programs

Developing and submitting bankable funding proposals is crucial for accessing climate finance. The AAAP's strategy for project origination emphasizes country ownership and alignment with national priorities. Therefore, relevant national stakeholders are key counterparts for GCA, and climate adaptation policies and strategies are key reference documents. In addition, whenever circumstances warrant, the GCA encourages the consolidation of isolated sectoral initiatives into large programs and pushes for the acceleration of ongoing processes in line with the objectives and approach of the AAAP.

Thus, at the request of the NDAs of Burkina Faso, the DRC, Niger, and Nigeria, the GCA is providing technical assistance in each of these countries for developing project concept notes to be submitted to the GCF. These draft concept notes were developed through an inclusive consultative process. The technical assistance was launched in January–February 2022, with the first field missions in the four countries. The process has been delayed due to political turmoil in some countries (the coup in Burkina Faso in January 2022), but more importantly difficulties in accessing some data. The GCA has maintained regular exchanges with the respective DNAs to find appropriate solutions. A parallel screening of the AEs operating in the different countries will be carried out to identify the most appropriate AE for each project and country. Submissions are expected before the end of 2022.

The case study presented here focuses on the Staple Crops Processing Zone (SCPZ) program with AfDB as the AE.

"

We have to do things differently. We have to look at the quantity, quality and access of adaptation finance."

Ville Skinnari
Minister for Development Cooperation and Foreign Trade, Finland

Photo: hadynyah/iStock

CASE STUDY 5: Supporting the Revision and Resubmission of the Staples Crops Processing Zones Funding Proposal

The AfDB and the GCA are pooling their efforts to accelerate adaptation finance flows to Africa. In 2021, the AfDB engaged with four countries (Ethiopia, Guinea, Senegal, and Togo) to develop and submit the SCPZ Funding Proposal to the GCF. The total program financing cost is US$427 million, with a request for GCF grant financing of US$129,980,000 and loans of US$44 million. The program aims to reduce climate change vulnerability and GHG emissions within the agricultural value chains in these four highly indebted poor countries in Africa. This will help stimulate productivity and value addition, and competitiveness, generate employment and increase incomes of the most vulnerable people and communities in these countries in ways that will also contribute to the achievement of targets set for their respective NDCs.

After review, the GCF's Independent Technical Advisory Panel (ITAP) raised important issues relating to currently available surface water and groundwater and how it will be impacted by projected climate changes, as also changes in the future water demand related to agriculture in the SCPZ.

The AfDB requested support from the GCA to address the GCF comments so as to resubmit the funding proposal, targeting the GCF 34th Board Meeting in October 2022. Under TAP and in close collaboration with the AAAP's AIRA pillar and its business line on water and urban development, GCA conducted a study on the impact of projected climate on the SCPZ basins water resources, in order to address these issues and support the resubmission of an improved proposal to GCF in June 2022.

LESSONS LEARNED AND RECOMMENDATIONS

Stakeholders and counterparts have found the TAP to be an effective program to create the conditions for improved access to adaptation finance and effective and transformative use of public climate funds, particularly GCF. The TAP core principle of country ownership has also been appreciated. Not only are the work programs built on national priorities, but more importantly, national counterparts are directly and entirely involved in the planning and implementation of activities. The program's openness to partnerships and collaborations was also identified as an asset.

Because the TAP program was launched during the COVID-19 pandemic, initial engagement with countries has been chiefly virtual, which has affected communications, coordination, and practical implementation. The implementation of the initial TAP projects has thus been delayed at times. Fortunately, the TAP is designed to be implemented progressively and flexibly. As lessons are learned, the approach and implementation arrangements are reviewed and updated for more significant impact and efficiency.

The issue of data is a crucial one, both in terms of availability and access. Through interactions with country counterparts, it was found that the confidentiality and sensitivity of some economic data may constitute a significant challenge when undertaking national budgeting and finance activities. Furthermore, the formulation of adaptation project concept notes was impeded by the availability of or access to climatic and socioeconomic data related to the targeted intervention areas.

The areas for improvement identified through interviews with TAP counterparts and partners include the following.

Maintaining a regular presence in partner countries: The lack of human resources and the fact that institutions sometimes operate in silos can slow down or even compromise the implementation of activities. A presence in the field makes it easier to facilitate consultations between institutions and deal more effectively with deadlocks.

Prioritizing integrated multi-year work programs through cross-sectoral consultative processes and in coordination with other GCA programs: This allows for a more programmatic approach to GCA intervention in each country. This also makes it possible to anticipate procurement plans and save time on recruitment.

Developing a roster of experts based on the different components of the TAP: TAP interventions span multiple areas of expertise and having such a roster in place will save time in recruitment processes.

Strengthening partnerships with other readiness providers, with the GCF and the AF at the forefront: GCA resources could be used as "seed money," allowing countries to quickly carry out initial studies needed to inform the design of funding proposals. In the same vein, the GCA and these funds could also collaborate on workshops to build the capacities of countries in the preparation of funding proposals. Finally, areas of collaboration could also encompass the piloting of the GCF's Project-Specific Assessment Approach (PSSA)[8] once it is operationalized.

Implementing these recommendations should allow the GCA to achieve the AAAP's objectives for the TAP program to leverage US$1.55 billion by 2025 through 15 A&R projects and programs, with funding from public climate funds. It should also allow for getting six new DAEs accredited to the GCF and the AF, and two existing GCA DAEs having their accreditation standards upgraded.

Section 2
Sectors

Photo: Fredrick Omondi/CTA ACP-EU

The Africa Adaptation Acceleration Program (AAAP)

Photo: hadynyah/iStock

KEY MESSAGES

- The Africa Adaptation Acceleration Program (AAAP) is Africa's response to the impacts of the climate crisis. It is an Africa-owned and Africa-led response to the continent's expressed needs and priorities to reduce its vulnerabilities as well as harness opportunities.
- More than 30 African heads of state and other global leaders have rallied behind the AAAP, endorsing it as a key vehicle to operationalize the Africa Adaptation Initiative's mandate. No other adaptation initiative has achieved this level of consensus in the African continent.
- Through AAAP, the African Development Bank (AfDB) and the Global Center on Adaptation (GCA) and are mobilizing US$25 billion by 2025 to accelerate adaptation action in Africa through interventions in four priority areas/pillars: food security, resilient infrastructure, youth innovation and job creation, and innovative climate finance.
- Since its launch in April 2021, the AAAP Upstream Financing Facility, managed by GCA, has enabled the mainstreaming of adaptation into investments worth over US$3 billion. GCA's interventions with the AfDB, World Bank, and other development

partners are delivering high-yielding adaptation dividends and accelerating adaptation impacts through large-scale investments, innovations, knowledge, and technical assistance initiatives.

- Drawing from the AAAP practical experience, GCA and AfDB are exploring with partners the possibility of scaling up the model of AAAP to other regions in the world, including South Asia and Small Island and Developing States.

"Through the AAAP, we're making progress in addressing the climate emergency. The Ghana Roadmap for Climate Resilient Infrastructure, which was launched earlier this year, provides an investment blueprint for adaptation in Ghana, highlighting in stark terms the cost of inaction. By 2050, climate impacts could lead to some US$4 billion in damages to the transport sector."

H.E. Nana Akufo-Addo
President of Ghana and Chair of the Climate Vulnerable Forum

INTRODUCTION

The Africa Adaptation Acceleration Program (AAAP) is Africa's response to the impacts of the climate crisis. This flagship program for Africa has been endorsed at the largest-ever gathering of the African Heads of State and Government focused on adaptation, and welcomed by President Ali Bongo Ondimba of Gabon for actualizing the vision of the Africa Adaptation Initiative (AAI). The AAAP delivers on the ground to support African countries for a faster, stronger post-COVID-19 economic recovery based on climate-resilient development pathways. Through AAAP, the African Development Bank (AfDB) and the Global Center on Adaptation (GCA) are mobilizing US$25 billion by 2025 to accelerate adaptation action in Africa through interventions in four priority areas/pillars: food security, resilient infrastructure, youth entrepreneurship and job creation, and innovative climate adaptation finance.

Since its launch in April 2021, the AAAP Upstream Financing Facility, managed by GCA, has enabled the mainstreaming of adaptation into investments worth over US$3 billion. GCA's interventions with the AfDB, World Bank, and other development partners are delivering high-yielding adaptation dividends and accelerating adaptation impacts through large-scale investments, innovations, knowledge, and technical assistance initiatives. The AAAP Upstream Financing Facility is aligned with the effective regional implementation of the new International Monetary Fund (IMF) Resilience and Sustainability Trust, the replenishment of the African Development Fund, and the leveraging of innovation and multi-stakeholder partnerships.

This chapter discusses the progress of the AAAP, covering the history of its conception and high-level African support. This is followed by a description of the four AAAP pillars and the approved projects in each business line, including the GCA's and AAAP's value-add, projected impacts and early results. Achievements in knowledge generation and management for adaptation and resilience investments are also discussed. The last section presents an outline of future plans for AAAP.

OVERVIEW OF THE AAAP

Description of the AAAP Conception and High-Level African Support

The AAAP is an Africa-owned and Africa-led response to the continent's expressed needs and priorities to reduce its vulnerabilities to climate change as well as harness the opportunities that result from climate change. African leaders have asked for this program and endorsed its design, which has benefited from extensive consultations with African governments, development partners, and knowledge institutions, including through an Annual Partnership Program. The AAAP was first presented at the Climate Adaptation Summit in January 2021 and received a strong support from global and African leaders. The Summit was the largest gathering ever of global leaders on

Photo: Global Center on Adaptation

Table 1. Summary of Business Lines under Each AAAP Pillar

AAAP Pillar	Business lines
Agriculture and Food Security	• Climate-smart digital technologies in agriculture
African Infrastructure Resilience Accelerator	• Public–Private Infrastructure Resilience Accelerator • National Infrastructure Risk and Resilience Programs • NBS Investment Innovation Program • Capacity Building through the Climate-Resilient Infrastructure Masterclass • Climate-Resilient Water Services • The City Adaptation Accelerator
Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience	• Youth Adaptation Solutions Challenge • Mainstreaming Adaptation Jobs
Innovative Financial Initiatives for Africa	• Technical Assistance Program to Access and Leverage Climate Adaptation Finance (TAP) • Financial Tools Instruments and Mechanisms (TIM) • Resilient Financial Systems

adaptation. The AAAP was officially launched on April 6, 2021, at the Leaders' Dialogue on COVID-19 and climate emergency. More than 30 African heads of state and other global leaders rallied behind the AAAP, endorsing it as a key vehicle to operationalize the AAI mandate. The program's objective is to mobilize US$25 billion to accelerate climate change adaptation actions across Africa. Following this event, a communiqué was issued by African leaders. This communiqué underlined the importance of climate resilience being a key element of Africa's economic recovery plans by countries integrating measures to address the twin threats of climate and COVID-19.

The 19th Chair of the African Union, H.E. Félix Tshisekedi of the Democratic Republic of the Congo (DRC), endorsed the program as addressing Africa's adaptation needs and priorities, while the United States Secretary of the Treasury Janet Yellen, speaking on behalf of US President Joseph R. Biden, congratulated the GCA and the AfDB for establishing the AAAP and pledged his support to the program. No other adaptation initiative has achieved this level of consensus in the African continent.

The AAAP is the translation of the AAI into actual projects and programs on the ground. The AAAP builds on the priority areas identified by the countries in their Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs) and accelerates momentum through large-scale proof-of-concept investments, innovations, and knowledge and technical assistance initiatives. Following multiple stakeholder engagements, and based upon additional voiced demands and priorities of the African Heads of State and Government, African countries identified key areas where action was most needed and investments in adaptation and resilience building could yield high dividends. These include agriculture and forestry, water resources, disaster risk reduction, biodiversity and ecosystems, and human settlements. The program is continuously evolving as the priorities and financial needs of African countries are further refined. Implementation on the ground is ensured by GCA's role as Lead Coordinating Partner of the AAI.

AAAP's Four Pillars

The AAAP focuses on four main pillars and, within them, specific business lines derived from the NDCs, NAPs, and other national and regional climate change strategies, where action is most needed, and where investments in adaptation and resilience building can yield high dividends to achieve the Sustainable Development Goals (SDGs). The four key pillars and their business lines are:

- **Agriculture and Food Security:** with a goal to scale up access to climate-smart digital technologies, and associated data-driven agricultural and financial services, for at least 30 million farmers in Africa. The program also has the aim of supporting food security in 26 African countries and reducing malnutrition for at least 10 million people.
- **African Infrastructure Resilience Accelerator (AIRA):** with a goal to scale up investment for climate-resilient urban and rural infrastructure in key sectors such as water, transport, energy, and waste management to help the continent close the infrastructure gap and achieve sustainable development in the face of climate change. The program aims to integrate climate resilience into about US$7 billion worth of infrastructure investments.
- **Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience:** with a goal to support one million youth with entrepreneurship skills and job creation, and to ensure that millions of new jobs being created will support adaptation. The program supports developing skills and knowledge on adaptation, promoting equality and equal opportunities, building the entrepreneurial capacity of African youth, and facilitating access to funding and mentorship to youth-led businesses, half of which will be women-led, in the adaptation space.
- **Innovative Financial Initiatives for Africa:** with a goal to build the capacity of African countries to drive adaptation at a much greater scale by planning differently and accessing the key sources of adaptation finance. In addition, this AAAP pillar aims to support the design of

Box 1. Recent Activities in each AAAP Pillar Dealing with Food Security

Recent global developments have imposed a considerable new burden on the existing challenges to food security in Africa. Millions face hunger as a result of rising food prices as a result of the war in Ukraine, which has affected the imports of key staples such as maize and wheat. Price spikes in essential agricultural inputs such as seeds and fertilizers has also made agriculture and food security in Africa more precarious. This only strengthens the need for adaptation and building resilience in agriculture in Africa, to create a greater self-sufficiency as a buffer against global shocks and their knock-on effects. Presented here is an example of recent activities in each AAAP pillar showing how each have been dealing with the crucial question of food security. Of the US$3 billion leveraged in MDB-approved investments, US$870 million is directly related to agriculture, livestock, and food security.

- **Pillar 1:** Climate-Smart Digital Technologies for Agriculture and Food Security activities in 26 countries.
- **Pillar 2:** Infrastructure:
  - Ghana: identifying climate risks for the most critical links in the national infrastructure network supporting farm-to-market connectivity.
  - Adaptation action in seaports of Banjul, The Gambia, and Cotonou, Benin, to help reduce amplifying effects on food availability and prices in West Africa when the port's operations are impacted by climate shocks.
- **Pillar 3:** Youth and employment:
  - In Sudan and Nigeria, mainstream adaptation in skills building and small and medium-sized enterprise (SME) financing for agribusiness.
- **Pillar 4:** Innovative finance:
  - Strengthening the US$235 million Staple Crops Processing Zone (SCPZ) Program in Ethiopia, Togo, Guinea, and Senegal to help resubmit its proposal to the Green Climate Fund (GCF).

innovative public and private financial instruments, ranging from resilience bonds and debt-for-resilience swaps to aggregation mechanisms for adaptation investment assets and monetization of adaptation benefits.

The four pillars are closely interlinked and will get Africa on the right track toward sustainable and resilient development. Examples of interconnections across pillars include: adaptation jobs for youth in infrastructure, resilient infrastructure for food security, and innovative financing for nature-based solutions. These areas all respond to important investment opportunities. Investing in climate-resilient business models is good economics.

AAAP PILLARS AND HIGH-LEVEL RESULTS ACHIEVED AS OF THE END OF JUNE 2022

Climate-Smart Digital Technologies for Agriculture and Food Security

The Climate-Smart Digital Technologies for Agriculture and Food Security (CSDAT) pillar aims at harnessing the powers of digital technological innovation and digitalization to improve agricultural productivity and strengthen climate resilience. The goal of the pillar is to achieve sustained uptake of digital adaptation solutions for at least 30 million farmers in Africa and to improve food security in 26 countries. Specific business lines of CSDAT include: thought leadership on climate-smart digital technologies in agriculture; supporting the design, mainstreaming and adoption of climate-smart digital technologies into agriculture projects and programs; enhancing the capacity of relevant persons and institutions to implement projects with climate-smart digital technologies; and monitoring, evaluation and learning on the implementation of climate-smart digital solutions.

The CSDAT pillar builds resilience into food security and rural wellbeing investment projects funded by different multilateral development banks (MDBs), beginning with AfDB and the World Bank. Current projects under CSDAT include regional and national projects on livestock, national adaptation, and food security resilience projects in different parts of Africa. As of June 2022, the CSDAT pillar had influenced and leveraged MDB projects that will benefit 4.7 million direct beneficiaries. In addition, the CSDAT pillar is working on other investment projects estimated at US$1 billion.

African Infrastructure Resilience Accelerator

The AIRA covers Infrastructure and Nature-Based Solutions (NBS), climate adaptation in the water sector, and urban resilience. Specific focus areas delivered through AIRA include: Public–Private Infrastructure Resilience Accelerator; National Infrastructure Risk and Resilience Programs; NBS Investment Innovation Program; capacity building through the Climate-Resilient Infrastructure Masterclass; Climate-Resilient Water Services; and the City Adaptation Accelerator.

The AIRA pillar builds resilience into infrastructure investments by delivering upstream analysis and support to develop information and metrics on climate hazards, exposure, and vulnerabilities to assets, services, and people. The technical assistance addresses key barriers to integrating adaptation and innovative NBS to build resilience. Focused support for national and local governments helps develop climate-resilient infrastructure investment packages that will be financed through innovative financing instruments.

Currently, completed and ongoing projects under AIRA are spread across 18 countries: Senegal, Kenya, Uganda, The Gambia, Benin, Ghana, Tanzania, Liberia, Gabon, Guinea, Madagascar, Chad, Burundi, Burkina Faso, Mali, Mauritania, Niger, and Ethiopia. These projects, at a national and asset-level scale, cover multiple infrastructure sectors such as energy (renewable energy, transmission and distribution, mini-grids, etc.), transport (highways, railways, ports, etc.) and water (dams, water treatment plants, etc.).

Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience

The Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience pillar aims to unlock the untapped potential of youth in Africa to drive resilience and green enterprise. The vision is to promote sustainable job creation at scale by 2025 through youth entrepreneurship and innovation for action in climate adaptation. Activities of this pillar are built across the following business lines: strengthening environments that support youth-led climate adaptation entrepreneurship and youth participation in adaptation policies; scaling up youth innovations for climate action; building youth capacity for employability and unlocking access to finance, and mainstreaming "adaptation jobs" into MDBs operations and projects.

With a sustained joint vision to unlock a further US$3 billion in credit for adaptation action for innovative youth-owned enterprises, with a gender mainstreaming target of 50%, the Youth pillar has so far funded entrepreneurs across the continent to scale their adaptation businesses as part of the African Youth Adaptation Solutions Challenge (YouthADAPT Challenge). The sponsored adaptation solutions cut across the agriculture and waste management sectors and across enterprises that are addressing on-ground climate challenges faced by vulnerable communities in their regions on the African continent. Further, the Youth pillar of the AAAP has successfully partnered with the Climate Investment Funds (CIFs) at the World Bank in this endeavor to directly strengthen the productivity and growth of 10,000 youth-led enterprises to increase climate resilience and develop the skills of one million African youth to prepare them for climate-resilient jobs and green entrepreneurial opportunities. A successful outcome of this YouthADAPT Challenge has been increased capacity building and a 60% growth in jobs, thus contributing to the pillar's overall job creation target.

The Youth pillar has also supported three key projects at the AfDB to ensure that 30% of the total jobs to be created are adaptation jobs. This includes providing funding for the development of adaptation capacity building and education curricula. Future endeavors include working with African governments to support legal, policy, and regulatory reforms and remove structural barriers to create an environment conducive to resilient enterprise development.

Innovative Financial Initiatives for Africa

The AAAP's IFI pillar is developing and implementing financial instruments and mechanisms to support the implementation of adaptation actions by raising finance from various public and private financiers. This pillar answers a pressing need to address a steep deficit in funding for adaptation today in Africa today. As the Finance chapter of this report reveals, only US$11.4 billion was tracked in adaptation finance in Africa annually in 2019 and 2020, when the estimated amount required for the continent is over US$50 billion annually through to 2030. There is a lack of reliable and sustainable sources of finance for the adaptation programs and projects currently under development. Compared to the various types of financing instruments and grants that are available for climate change mitigation, there are few places where private and public sector project developers can get the necessary resources for adaptation. The availability of finance from bilateral donors is the most critical component of addressing Africa's climate finance needs. It is also important to expand other multilateral pools of finance, such as the MDBs and the climate funds, as well as leverage the private finance that will be needed to address the continent's adaptation and resilience needs.

Further, most of the funds currently available for adaptation come from the public sector. For example, one of the most sustainable sources of finance for climate change is the GCF, which has the aim of helping developing countries adapt to the impacts of climate change. However, the GCF rarely provides grants to the private sector. Consequently, the private sector is not incentivized to participate in developing programs and projects for adaptation. To support the development of resilient green growth in Africa, there needs to be a step change by developing a deeper understanding of the needs and capabilities of the private sector. This can be done by establishing effective communication channels and using market-focused strategies and a wide array of financial instruments. In addition to addressing the barriers that prevent companies from entering the market, development cooperation providers should also be able to help them develop effective strategies and implement policies.

PROJECTED IMPACTS AND EARLY RESULTS OF THE AAAP-SUPPORTED PROJECTS

This section describes approved projects in each of the four AAAP pillars. It presents the GCA's and AAAP's value-add in the approved projects. The projected impacts and early results for each AAAP focus area are also discussed.

Pillar 1: Climate-Smart Digital Technologies for Agriculture and Food Security

Mapping needs and creating access to climate-smart digital technologies among farmers and pastoralists, with a focus on gender equity, is a key element of

the larger project of adaptation envisioned by the AAAP and the GCA. This section describes GCA's contributions to and expected outcomes for several resilience and capacity-building programs under way in Africa today.

Program to Build Resilience for Food and Nutritional Security in the Horn of Africa (BREFONS): The Horn of Africa region is characterized by increasing temperatures and high variability in rainfall as well as an intensification of floods with serious socioeconomic consequences such as a drop in crop yields, climate-related disasters, ecosystem degradation, and climate-sensitive diseases. More than 40 percent of the population in the region is undernourished due to food insecurity and inadequate livelihoods. While some 25 million people are already at risk of food shortages in the region, the unusual desert locust upsurge in the last two years is an additional threat to food security and livelihoods, especially for the most vulnerable communities. Their access to food is at risk of being further exacerbated by the COVID-19 pandemic, resulting in rising food prices.

GCA has worked with the AfDB project team and Alliance of Bioversity-CIAT to provide upstream technical assistance to ensure climate-smart digital technologies for adaptation are integrated into the design of this project benefiting six countries (Kenya, Ethiopia, Sudan, South Sudan, Djibouti, and Somalia). The Digital Adaptation Profiles for Kenya and Ethiopia have been prepared, and the technical report on the support on agricultural insurance under the Horn of Africa Initiative is completed. A playbook has been prepared to identify and implement digital agricultural adaptations in Africa.

GCA has also provided upstream technical assistance to ensure climate-smart digital technologies for adaptation are integrated into the project. Specifically, GCA carried out the following activities:

- Identifying key agriculture adaptation constraints that can be addressed by digital technologies and developing solutions
- Assessing the conditions and opportunities for digital applications for drought index insurance
- Identifying opportunities for digital agricultural adaptation solutions through the preparing of climate risk and digital agriculture profiles
- Supporting stakeholders to identify and implement opportunities through the preparation of a digital agricultural adaptation toolkit
- Building the capacity of policymakers and enabling policy interventions to ensure uptake of digital solutions using the toolkit.

The following are the expected results and impacts of the project:

- 30 percent increase in agricultural (crops and livestock) productivity
- 30 percent increase in annual income per capita
- 1.3 million farmers and pastoralists using climate services, e.g. drought index insurance with a gender focus
- 30 percent increased uptake of climate risk financing and insurance solutions
- 55,000 additional jobs created for youth and women
- 750,000 farmers and pastoralists benefiting from extension on using digital advisory services
- 10 climate products and services for agriculture and livestock developed

GCA is presently engaging with AfDB and beneficiary countries to support the feasibility study and technical design of national digital advisory services in three of the six countries; to support project mechanical and electrical services on Digital Climate Information and Advisory Services (DCAS) during project implementation requested by the Intergovernmental Authority on Development trade bloc (IGAD) Program Implementation Unit; to contribute to experience capitalization (the process through which an experience is identified, validated, and documented, leading to learning and identification of good practices which can then be adapted, improved, adopted by others, and up-scaled, leading to a greater impact) on the implementation of DCAS in project countries; and to co-organize knowledge sharing and capacity building events on DCAS to support the program.

Program for Integrated Development and Adaptation to Climate Change in the Zambezi Basin (PIDACC-Zambezi): PIDACC-Zambezi was developed as a direct response to addressing identified challenges in the river basin and ensuring that its communities and ecosystems are resilient to contribute to regional development. The challenges include persistent poverty due to a large rural population relying on rainfed agriculture, competing water uses, an infrastructure deficit, environmental degradation, and increased risk of disasters caused by extreme weather events linked to a changing climate.

The PIDACC-Zambezi program aims to address these transboundary problems through three main components: building communities' resilience, strengthening integrated landscape management, and supporting adaptive capacity. The project covers eight countries: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe.

Under AAAP, GCA is providing technical assistance to increase, on a sustainable and resilient basis, productivity, incomes and capacity of agro-silvo-pastoral households in the river basin to better adapt to climate change risks. Working in partnership with AfDB and International Water Management Institute (IWMI) representatives, GCA seeks to facilitate the mainstreaming of climate adaptation in the design of the PIDACC-Zambezi project. The project is expected to result in the following outcomes and impacts:

- 400,000 farmers adopt climate-smart agriculture (CSA)
- 30 percent increase in adoption of DCAS


Photo: Clayton Smith/WorldFish

- 25 training/policy facilitation events on DCAS
- 3,000 individuals participate in policy facilitation events on CSA and digital climate adaptations
- 5,000 individuals trained on digital tools to scale up CSA (at least 60% female and youth)

GCA has been invited by the AfDB to provide inputs on the project indicators, to join in the Project Appraisal Mission of the project, and to continue further to the implementation of the project after it is formally approved by the Board by the end of the year.

Ethiopia Food Security Resilience Project (FRS): As a result of climate change, smallholder farmers in Ethiopia suffer from greater variability and extreme weather events, increased temperature, and declining rainfall in a country where 85 percent of farmers depend on rainfed agriculture. Ethiopia is currently in the middle of one of the worst droughts for 50 years, which follows 12 to 18 months of erratic and failed rains, which has dried up many water sources. The war in Ukraine and subsequent rising wheat, fuel and fertilizer costs are also worsening the country's food crisis. The project was developed to increase the resilience of food systems and Ethiopia's preparedness for food insecurity in project areas.

GCA is contributing to the adaptation of smallholders and accelerating food security resilience in Ethiopia through the project by executing the following activities: 1) mapping of 14 priority value chains identified by the World Bank and Ethiopia to assess climate risks for smallholders in crop/livestock sub-sectors; and 2) assessment of opportunities and constraints to deploy digital adaptation tools to address issues identified in the 14 value chains using the playbook developed by GCA, "Identifying and Selecting Digital Climate-Smart Adaptation Solutions in Africa."

GCA will carry out technical studies on climatic risk to the food systems and the potential for digital tools to address the challenges. It will mainstream these into the design and implementation of the project and conduct capacity building of stakeholders and institutions in the country to implement digital tools for improved resilience to food insecurity.

Key expected results and impacts of the project include:

- 2.4 million farmers adopt resilience-enhancing technologies and practices (30% female)
- 15 percent reduction in food-insecure people in program targeted areas
- 20 percent increase in yields of targeted crops in targeted households
- 25 percent increase in volume of agricultural products sold

GCA will continue to carry out the appropriate studies as agreed with the World Bank and the beneficiary country.

Zambia Growth Opportunities Project (ZAMGRO): Zambia has a mono modal rainfall regime, and as a result weather patterns have a great influence on agricultural activities in the country and in turn on food security, nutrition, and income of rural households. However, investment in climate resilience, including in DCAS in particular, has not been forthcoming from both the public and private sectors of the economy. Working in partnership with the World Bank and Indaba Agricultural Policy Research Institute (IAPRI), GCA is contributing to promoting agricultural diversification, sustainability and resilience of the agri-food sector in the country.

GCA provides the following support to the project:

- Assessing climate risks of major value chains (maize, groundnuts, sorghum, rice) and identifying appropriate digital adaptation solutions to reduce their impacts
- Organizing training and capacity-building sessions on DCAS for farmer leaders, extension agents and youths
- Facilitating multi-stakeholder policy engagement sessions to promote private sector investments in scaling up digital adaptation solutions
- Identifying potential opportunities for adaptation jobs through the project

Pillar 2: African Infrastructure Resilience Accelerator

Building climate-resilient infrastructure, and accurately modeling future climate risks, is critical for securing infrastructure projects and their beneficiaries from climate change hazards in key sectors like transport, water and energy. In many parts of Africa, GCA is contributing to making infrastructure resilience a priority in policymaking and planning. These projects include:

National Infrastructure Risk and Resilience Program – Ghana: GCA has worked with the Government of Ghana and its partners (United Nations Office for Project Services, University of Oxford, and the United Nations Environment Programme) to implement a national infrastructure risk and resilience assessment in Ghana to model the systemic risk of climate change on infrastructure assets and services. This analysis quantifies adaptation needs and helps to prioritize a pipeline of adaptation investment options.
In Ghana, the national assessment is already influencing investments on the ground. Finally, the data and recommendations are currently also being integrated into the Ghana NAP.

Box 2. The Desert to Power G5 Sahel Financing Facility

Photo: Lidia Daskalova/Shutterstock

The US$380 million Desert to Power G5 Sahel Financing Facility will finance renewable energy investments in Burkina Faso, Chad, Mali, Mauritania, and Niger. Renewable energy can significantly contribute to climate change adaptation and create opportunities for innovative practices to address climate change. Renewables-based adaptation solutions promote mitigation and reinforce adaptation efforts synchronously across many sectors. GCA will bring cutting-edge climate analytics to strengthen adaptation and resilience measures in designing the solar assets, operations, and transmission systems for the program. GCA's support will ensure more than 500 MW of solar generation capacity financed by the AfDB is climate resilient, facilitating electricity access to some 695,000 households.

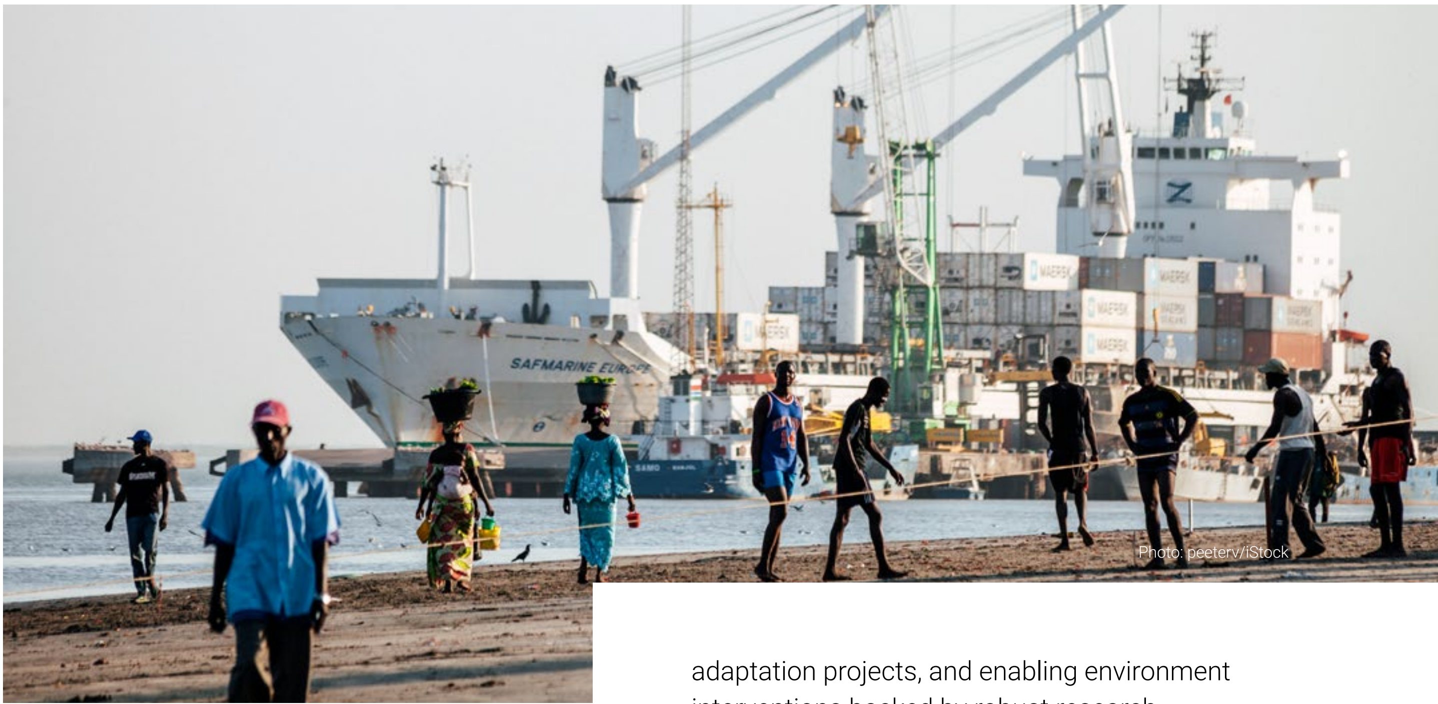


Photo: peeterv/iStock

The analysis revealed the pronounced impact of flood, drought and landslide hazards on infrastructure assets and the services they provide to people:

- In a high-flood scenario by 2050, damages to transport assets can reach US$3.9 billion, triple the estimated US$1.3 billion Ghana invested in this sector in 2019. Furthermore, 13–14 million people, of which 80% are women, risk losing access to healthcare due to disruptions in the transport sector in the eastern, central and western regions.
- Future energy availability for about a quarter of a million people in rural parts of Ghana is threatened by drought, given their reliance on wood fuel for household energy generation. Equally, climate risks threaten major components of electricity generation and transmission due to exposure to drought and flooding.
- 54 percent of dams assessed are exposed to floods and 23 percent to drought under a high hazard by 2050. The Weija dam, supplying 80 percent of the drinkable water for Accra's metropolitan area, was found to be particularly exposed to flood risk.
- The key output of this initiative was the Resilient Infrastructure Roadmap. This document proposes 35 adaptation options for funders and investors to invest in Ghana's future, prioritized by government stakeholders, offering impactful, evidence-based adaptation projects, and enabling environment interventions backed by robust research and analysis.

GCA is building on the learning of this national program to implement a similar approach in Bangladesh and in other African countries, such as Kenya and Senegal, through local institutions.

Public–Private Infrastructure Resilience Accelerator – Banjul Port 4th Expansion Project: The port of Banjul, in The Gambia, serves as a logistics hub and is a key link to neighboring Senegal. AfDB and European Investment Bank (EIB) are considering financing the proposed expansion of the port. However, the impact of climate risks needs to be addressed in the project. Under AAAP, GCA is providing technical assistance to conduct a high-resolution climate risk assessment and to develop a climate adaptation investment plan for the project.

In this project, GCA leverages expertise in stress-testing port assets and services against data-driven climate hazard scenarios, including NBS, into the port design and in quantifying the role and value of existing natural assets. Furthermore, GCA convened multi-stakeholder climate risk dialogues that brought together over 40 representatives from the Government, Gambia Ports Authority, AfDB, EIB, and other institutions in the country to validate the analysis and prioritize adaptation investment options for the project.

Vulnerability stress tests and climate hazards identification were completed, while 20 adaptation options were proposed across physical, social and institutional measures. Prioritized adaptation investment estimated at US$10.3 million will mitigate economic damage estimated at US$27 million. The adaptation options and investment estimation can be further scaled up to support other infrastructure projects under AAAP, not limited to the port sector.

Scaling Up GCA's Climate-Resilient Infrastructure Masterclass across Africa: GCA launched the Knowledge Module on Public–Private Partnerships (PPPs) for Climate-Resilient Infrastructure in collaboration with the World Bank, AfDB, EIB, and the European Bank for Reconstruction and Development, among other MDBs and technical partners. The objective of the Masterclass is to build the capacity of PPP practitioners to mainstream adaptation and resilience into infrastructure PPP projects. It includes: 1) a Climate-Resilient Infrastructure Officer (CRIO) Handbook with tools and knowledge to integrate adaptation across the PPP project cycle; 2) a self-paced online course available on GCA's website; 3) a Certification Exam accredited by APMG International; and 4) the Masterclass on Climate-Resilient PPPs. The Masterclass is a key component in supporting the implementation of projects under AAAP and building the capacity of local practitioners.

The first global Masterclass held in September 2021 brought together 46 practitioners (one-third of which were women) from 25 countries. The Knowledge Module webpage has been accessed over 3,700 times. The CRIO Handbook was accessed almost 1,500 times and downloaded 700 times. Over 450 practitioners have started to take the CRIO Online Course. GCA will tailor the content of the Masterclass to the African context and develop case studies on infrastructure PPP projects. The Masterclasses will be scaled up across Africa (and in Bangladesh) through partnerships with local institutions to build the capacity of investment officers from MDBs, government officials and private sector representatives.

N'Djamena Urban Resilience Project: The World Bank has initiated a flood modeling study for the flood-prone city of N'Djamena, the capital of Chad, as part of the preparation of an urban resilience project worth US$150 million funded by a grant from the International Development Association (IDA). The objective is to reduce the impact of flood risk and reinforce climate-resilient urban services and planning in N'Djamena. GCA is providing the following support on this project:

- **Conducting Gender Vulnerability Assessment:** This will identify and quantify gender gaps that are related to 1) direct impacts of the increasingly frequent pluvial and fluvial floods and periods of water stress in N'Djamena; and 2) indirect impacts of floods and water stress (including inadequate water supply and sanitation, solid waste management, green spaces, early warning systems, and jobs). A clear, logical chain from a gender gap, to gender action, to gender indicators will be developed as well.
- **Conducting a Prioritization Study of Green Infrastructure Options for Flood Risk Reduction:** Two or three of the most likely future growth scenarios for N'Djamena will be developed. Future flood-risk-reducing infrastructural investments (both green and grey) will be stress-tested under the most likely scenarios highlighted in the flood modeling exercise, which also aims to understand flood impacts on services and people, and not just assets. Subsequently, options for flood risk mitigation measures will be identified and prioritized.
- **Developing a Local Community Engagement Strategy:** This will ensure flood risk reduction options (including NBS) respond to the development needs of local community beneficiaries.

The gender vulnerability assessment has already been completed, while the prioritization assessment is being initiated. The assessment will not only strengthen the climate resilience of the project but will also provide valuable lessons on urban resilience building in fragile environments.

Freetown Water, Sanitation and Hygiene (WASH) and Aquatic Environment Revamping Program: This AfDB-financed project works to improve water supply and sanitation services while ensuring the sustainability of the vital aquatic ecosystem in the Western Area/Freetown peninsula of Sierra Leone. More specifically, project activities work to 1) rehabilitate and expand water treatment, transmission, storage and distribution systems; 2) improve solid and liquid waste collection, treatment and disposal services; 3) provide infrastructure and enhance capacity for the effective protection of the Western Area Protected Forest/Watershed; and 4) promote good sanitation, hygiene and child nutrition practices of the primary beneficiaries while facilitating their participation in the improvement of WASH services. Recently, AfDB has applied for GCF financing to integrate climate resilience considerations within the project design.

GCA is supporting the finalization of the GCF funding proposal by mobilizing integrated water resources management (IWRM), gender and economics expertise to identify and prioritize climate adaptation activities. GCA is uniquely positioned to provide this technical assistance through its ability to offer integrative advisory services at the nexus of environment, gender and economic development.

Through its technical support, GCA has the potential to strategically integrate climate resilience into nearly US$190 million in project finance. This will directly benefit an estimated 1.4 million people (51 percent of which are women) by providing climate-resilient and safe water service delivery (through new access for 1 million people and restoration of regular daily water service for 400,000 people). The project will further create over 2,700 jobs and restore the Freetown peninsula watershed, thereby reducing the impact of extreme climate events on living conditions.

A GCF funding proposal will be completed, with the potential for GCA to provide follow-on technical support in the implementation of funds (should they be awarded). The focus will be on strengthening the climate resilience outcomes of IWRM and gender aspects of the parent project.

Water Supply and Sanitation Program, Phase III (WSSP III): This project in Uganda will support the construction of water supply and sanitation schemes for small towns and rural areas across all the regions of the country. The main activities will include the construction of small-town and rural piped water supply systems, provision of water for production through valley tanks and earth dams, and the establishment and support of utility management to sustain the benefits of the project. Sanitation interventions include environmentally friendly institutional and public water borne toilets, implementation of regional fecal sludge management facilities, and general sanitation and hygiene promotion in the project area.

GCA will provide the following support to the project: 1) understanding climate risk and technical assistance to design adaptation measures based on climate risk assessment; 2) understanding climate risks to WSSP service delivery assets and increasing flood resilience of these assets; and 3) sector program support.

Liberia Urban Resilience Project: This World Bank-financed project works to increase flood resilience and access to urban infrastructure in selected neighborhoods and to improve urban management in Liberia. Project activities will be implemented in the capital (Monrovia) and three secondary cities: Buchanan, Gbarnga, and Ganta. In particular, the project will finance investments in 1) climate-resilient infrastructure and urban upgrading (e.g. flood risk management infrastructure, community and market upgrading); and 2) strengthening integrated resilient urban development capacity (e.g. development of a climate-informed Greater Monrovia Spatial Development Plan, improved solid waste management).

GCA is uniquely positioned to provide this technical assistance through its ability to deliver integrative advisory services at the nexus of climate adaptation, community engagement, and environmental conservation. GCA has acquired global expertise in engaging on similar topics involving community participation in the implementation of climate adaptation infrastructure, as done in informal settlements in Bangladesh and Kenya. GCA will provide this technical assistance in partnership with Slum Dwellers International (SDI) and YMCA Liberia.

Through its technical support, GCA will strengthen community participation in 1) prioritization of climate resilience investments (e.g. flood risk management infrastructure) as well as 2) preservation of Greater Monrovia's ecologically sensitive wetlands, which provide climate resilience benefits regarding flood risk management. It is expected that 11,000 people will directly benefit from enhanced flood resilience and improved urban living and working conditions.

GCA will begin enumeration of community vulnerabilities and needs in two areas of Monrovia in partnership with the World Bank and the Government of Liberia. In particular, GCA will work to build municipal and national capacity by providing training in a to-be-developed community engagement

Photo: BleagLee Waste Management

strategy to scale up this approach for other climate resilience projects in Liberia.

Pillar 3: Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience

Youth awareness and involvement is crucial to the prospects of adaptation in Africa. The AAAP envisages youth participation as a source of ideation, agency and enterprise in devising local and market-based ventures and creating jobs that are aligned with the wider objectives of the program. Some of these initiatives are:

The African Youth Adaptation Solutions Challenge: In September 2021, the AAAP launched the YouthADAPT Challenge, an annual competition and grant award that targets youth-led businesses to inspire and implement youth-led adaptation solutions. The aim is to harness the entrepreneurial spirit of Africa's young people. More details of the Challenge are presented in Youth and Entrepreneurship of the report.

Some significant outcomes of the Challenge include youth capacity building with 25 hours of training received, job creation with 60 jobs created, investor readiness and scaled-up business solutions, and positioning these enterprises to better access further financing to support their growth. The enterprises have begun to show early indications of these outcomes. Some have seen their revenues rise by up to 50 percent since joining the accelerator; some have doubled their production capacity; and others are entering new markets.

The AAAP is also involved in mainstreaming adaptation jobs for the youth in three AfDB projects.

1. **Digital and Creative Enterprise Program (i-DICE), Nigeria:** i-DICE is a private sector-driven response to address existing challenges in the technology and creative industries as part of the Nigerian Government's efforts to create decent jobs for youth. Climate change, skills for employability and entrepreneurship, and start-up investment readiness and financing are important sub-components of the program. The AAAP supports i-DICE by identifying opportunities to create climate adaptation-aligned jobs within the project. It also aims to identify the required skills that will be included in skill development and capacity-building programs to improve the qualification of youth for adaptation jobs.The AAAP aims to generate at least 30 per cent of the total jobs created by i-DICE. This target translates into 165,600 direct jobs and 1,674,000 indirect jobs created over five years.
2. **The Youth Enterprise Development and Capacity Building Project (YEDCB), South Sudan:** The YEDCB project aims to enhance employability and job creation for young women and men aged 18–35 years in South Sudan. Specifically, the project will address the limited entrepreneurship capacity of South Sudan's young population; unlock access to finance; create market linkages and access to information; and address the capacity challenges of government institutions for enhanced public service delivery, especially to support SME development and youth economic empowerment.

   As a part of its support to the project, the AAAP is driving the unveiling of entrepreneurship opportunities and jobs in climate adaptation and climate resilience across different sectors such as agriculture, manufacturing, aquaculture, and fishing, among others. Apart from assessing the opportunity to create adaptation jobs within the project, the AAAP is supporting the creation of a training curriculum for adaptation-related skills in key areas. The AAAP aims to create at least 1,600 of the project's 5,573 jobs target in adaptation programs. The AAAP aims to train at least 900 youth in adaptation business development and entrepreneurship by the end of the project.

3. **Nigeria Special Agro-Industrial Processing Zones (SAPZ) Program:** The SAPZ program is designed to harness Nigeria's high agricultural potential through targeted support to select agro-production zones in the country. The selected areas include the Federal Capital Territory (FCT) and seven states in Nigeria. The program will support economic and social development programs of the Federal Government of Nigeria and the participating States, contributing to rural infrastructure development, improved access to agricultural markets, increased farm productivity, and the promotion of agricultural technology, agribusiness, and job creation. The AAAP will support the mainstreaming of adaptation jobs and skills within the various agriculture value chains by guiding the program to identify and measure adaptation jobs and supporting curriculum development and training on adaptation-aligned skills. The goal of the AAAP is to create at least 150,000 direct and indirect jobs, representing 30 per cent of the total job creation target of the program.

Pillar 4: Innovative Financial Initiatives for Africa

To stimulate action on finance for climate adaptation programs, the AAAP IFI program is designing and implementing instruments and mechanisms that will encourage the private and public sectors to participate in developing these activities. It will also help African countries articulate the needs of their NDCs and long-term strategies. The IFI has identified five key areas stimulating private sector investment in developing climate change adaptation programs through its various initiatives. These include establishing pilot instruments and blended finance mechanisms that will encourage the private and public sectors to participate in adaptation investment activities and use non-financial resources such as technical knowledge. Work on these initiatives is currently progressing as follows:

Technical Assistance Program to Access and Leverage Climate Adaptation Finance (TAP): This program is helping countries to build capacity for adaptation finance planning and decision-making; to support the accreditation of new and existing African direct access entities (DAEs), and to develop and submit a paradigm-shifting portfolio of adaptation projects and programs to international climate funds. Currently, TAP is supporting 14 countries with activities that include accreditation and re-accreditation of DAEs to the GCF; development of project concept notes for GCF consideration; enhancing the adaptation climate rationale of funding proposals to the GCF, the adaptation fund, and the CIFs; and climate public expenditure reviews. The TAP program is presented in detail in the chapter "Access to Global Climate Finance – The Technical Assistance Program."

Financial Tools Instruments and Mechanisms (TIM): This program levers the offering and adoption of financial instruments focused on adaptation and resilience (A&R) to enable the investment of A&R projects and initiatives to mobilize finance from institutional investors in international and domestic markets. TIM offers technical assistance for structuring blended finance and capital markets solutions such as green bonds and private debt and equity funds or adopting adaptation taxonomy for traditional green lines of credit. Currently, GCA is supporting the upcoming Sustainable Sovereign Bond of the Government of Côte d'Ivoire to increase the share of adaptation investments in the use of bond proceeds. GCA supports asset management firms such as Invesco, a US$1.6 trillion asset-management firm looking for blended finance solutions to mobilize private-sector investors to reduce the adaptation finance gap.

The Adaptation Benefits Mechanism (ABM): The ABM is being piloted by the AfDB and is designed to mobilize private sector finance for adaptation activities. The ABM seeks donors or philanthropic investors who are willing to purchase adaptation benefits to help meet the adaptation needs of developing countries. The revenues from the sale of the adaptation benefits are designed to address the financial barriers associated with most adaptation projects, thereby making financially unattractive adaptation projects attractive or affordable to private sector investors, impact investors and the public sector. In 2022 the Bank expects to register the first ABM pilot projects to demonstrate how the instrument will work. The ABM acts as a results-based payment mechanism in which project or activity developers have the flexibility to define the results for which they wish to be paid.

To demonstrate the ABM and to use public sector funds to leverage private sector input, the Bank is proposing to create and capitalize on the African Adaptation Benefit Fund or AABF. The AABF will be a multi-donor trust fund that will sign Adaptation Benefit Purchase Agreements (ABPA) with project developers. In return for their investments, donors to the fund will receive a basket of Certified Adaptation Benefits from registered adaptation benefit projects. In addition, funds will be used to provide technical assistance to early project developers and to support some of the running costs of the ABM Executive Committee. Once established, the ABM is expected to be self-funded through modest payments for registration and issuance. Further information on the ABM is available at www.ABMechanism.org.

The African Green Financing Facilities Fund or AGFFF: The AGFFF is designed to help create and capitalize national green banks and national climate change funds in African countries. The green bank model illustrates how a financing facility, such as an existing national development bank or fund, can be capitalized using blended finance principles and can, in turn, leverage financial investment into adaptation and mitigation projects. A number of countries globally are developing green banks; at least two are under development in Africa. The AfDB has identified a pipeline of at least six countries with a clearly stated desire to create a green bank or a national climate change fund to help finance their adaptation needs.

The Africa Disaster Risks Financing (ADRiFi) Programme: ADRiFi is a disaster risk insurance program that helps develop disaster risk insurance products and raise funds to support the payments of insurance premiums. Insurance is one of the major risk-management instruments used for managing climate change risk in the developed world, but insurance products are almost completely absent in the developing world. Subsistence farmers, in particular, are often reluctant to invest in improved seeds or fertilizers because their investment is at risk of variable climatic conditions such as poor or late rains, unseasonal temperatures and pest outbreaks. In such events, they risk losing all of their investment and so they tend to act conservatively. Furthermore, farmers typically have no experience with insurance instruments and do not understand how it operates. As a result, uptake of insurance products is often insufficient to justify the costs of developing a product.

ADRiFi seeks to address these barriers by raising awareness and educating clients, designing products and helping raise funds to pay the premiums for a short period until users become familiar with and appreciate the benefits of an insurance product. The IFI will help add ADRiFi to establish a financing instrument or access other financial instruments to overcome these barriers and create insurance products to pool the risks of climate change.

The African Financial Alliance on Climate Change: In developed countries, perceived risks tend to relate to greenhouse gas (GHG) emissions and the threat of regulations creating stranded assets and disinvestment from fossil-fueled assets, leading to efforts such as the Task Force on Climate-Related Financial Disclosure (TCFD) and the Carbon Disclosure Project. Many African financial ecosystems are more at risk from climate-related impacts and adaptation risks. The African Financial Alliance on Climate Change (AFAC) will work with all sectors of the African financial economy to raise awareness and develop standards and tools to raise the ability of African investors to manage climate risk. Private sector investors are reluctant to invest in activities that they do not understand. Adaptation activities are particularly vulnerable to this problem. AFAC will raise capacity and build awareness among the private sector of the risks associated with various kinds of investments in the face of climate change.

PARTNERSHIPS

Partnerships and Consultations Between the AAAP and African Leaders

The AAAP Partnership Approach is aligned with GCA's overall approach to partnerships as set out in its Partnerships Policy. The approach supports the three business lines of GCA on advocacy and agenda setting, knowledge acceleration, and programs and action. The AAAP Partnership Approach is demand-driven, as an African-owned and African-led program stemming from its endorsement by African leaders, to actualize their vision for adaptation as set out in the AAI in COP21 Paris. These endorsements for and buy-in of the AAAP are anchored in the different agenda-setting and advocacy sessions convened prior to and following the launch of the AAAP in October 2020. These sessions include the following:

May 2020, GCA and AAI Policy Dialogue: GCA and AAI conducted a joint policy dialogue on Integrated Responses to Building Climate and Pandemic Resilience in Africa, which all 54 African leaders endorsed. The outcomes included policy recommendations on incorporating climate resilience into COVID-19 response measures; and a framework was adopted for assessing the triple dividend of health-economic-climate benefits of interventions.

August 2020, GCA Africa Framework and Approach Engagement with AAI and the AfDB: A GCA Africa framework and approach engagement conducted with the AAI and AfDB resulted in the following outcomes: political consultation plans were developed and implemented, and systems for sharing information and knowledge were established.

September 2020, High-Level Launch of GCA Africa Regional Office and Partnership Forum: The launch of the GCA Africa Regional Office and first Partnership Forum marked a key step in informing the establishment and program design of the AAAP. The Partnership Forum brought together stakeholders from across the continent to discuss how GCA Africa can support their efforts to accelerate climate adaptation, ensuring an alignment across the continent while delivering accelerated action for communities across Africa. The Forum was convened by Dr Akinwumi Adesina, President of the AfDB Group, and the Chairs of the Board of the GCA, 8th Secretary-General of the UN Ban Ki-moon and Mr Feike Sijbesma. Key highlights from the Forum included the following: 1) the presentation of the GCA Africa 2020–2021 Workplan and focus areas of the AAAP: food security, water, NBS and infrastructure, finance, and youth leadership; and 2) the agreement on the next steps following the input from the Forum, which included updating the work plan to be tailored to the most pressing needs and ongoing initiatives on the continent, and seeking additional expert review in bilateral consultation and virtual workshops where necessary.

January 2021, Launch of the AAAP at the Climate Adaptation Summit: The Climate Adaptation Summit 2021 featured GCA's first annual ministerial dialogue with over 50 ministers and leaders from international organizations to scale up global cooperation to accelerate climate adaptation. During the Dialogue, the GCA and the AfDB announced that they were joining forces to use their complementary expertise, resources, and networks to launch a bold new AAAP outlining the four key areas of focus that the program will prioritize including agriculture, infrastructure, youth, and innovative finance. The launch featured key statements from Akinwunmi Adesina, President of the AfDB, indicating that the launch marked the start of a bold global effort to ensure that developing countries have the climate financing they need to implement and scale up climate adaptation solutions. Speaking from the perspective of the GCA, the co-chair of the GCA Board, Feike Sijbesma, indicated that the launch of the program came from the need to develop a strategic and integrated approach to adaptation and develop bold innovations and solutions to the global challenge.

April 2021, Leaders' Dialogue on the Africa COVID-Climate Emergency: The Leaders' Dialogue on the Africa COVID-Climate Emergency was convened on April 6, 2021, to ramp up the needed support for climate adaptation for Africa in the wake of the COVID-19 pandemic and following the launch of the AAAP. The convening gathered over 30 heads of state and global leaders who displayed solidarity in committing to prioritize actions that help African countries adapt to the impacts of climate change and to "build forward better" through the AAAP. A key outcome of the dialogue was a strong commitment to the AAAP by leaders and partners present, with most African leaders commending the program's alignment with their national priorities.

September 2021, GCA High-Level Dialogue on The Adaptation Acceleration Imperative for COP26: The GCA High-Level dialogue was organized on September 6, 2021, in Rotterdam. The Dialogue was co-convened by the Chair of the GCA Board, 8th UN Secretary-General Ban Ki-moon; CEO of the GCA, Prof. Dr. Patrick Verkooijen; Managing Director of the IMF, Kristalina Georgieva; and Co-Chair of the Board, UN High-Level Climate Champion on Private Sector for COP26, Feike Sijbesma. The Dialogue gathered over 50 leaders from the international climate and development community. A key outcome from the Dialogue was an outline of vital steps needed for COP26 to serve as a springboard for an urgently needed large-scale acceleration in adaptation and

Photo: GCA

resilience building. These steps centered on the following:

- Sustaining ambition and continuing to raise ambition levels annually
- Rebuilding confidence in international climate finance and taking further steps, including leveraging pandemic recovery resources for climate financing
- Seizing opportunities to spur collaboration and partnership building while promoting bold and innovative partnership

October 2021, GCA Africa Partnership Forum 2021: The GCA Africa Adaptation Acceleration Day was held on October 26, 2021, building on the AAAP, to sustain momentum for adaptation across the African continent. The day featured the GCA Africa Partnership Forum 2021 with the theme "Delivering Adaptation Together," convened as a sequel to the first Partnership Forum to focus on collaboration and partnership opportunities for implementing the AAAP, as Africa's roadmap for enhancing key resilience-building initiatives. The Forum sought to validate African resilience-building priorities, shed light on ongoing initiatives, and confirm alignment with these, while receiving reflections that would ensure that momentum for real and ambitious action was sustained in the build-up to COP26. The session was hosted by the Government of Kenya and the University of Nairobi with opening remarks delivered by President Uhuru Kenyatta, President of Kenya. Key outcomes from the Forum included the following:

- The launch of the State and Trends in Africa Adaptation Report 2021
- An inaugural GCA CEO's annual lecture series on the state of adaptation acceleration with a special focus on Africa

November 2021, GCA Africa Adaptation Acceleration Summit: The Africa Adaptation Acceleration Summit was held on November 2, 2021, in the margins of COP26. The largest-ever summit on adaptation, it featured over 30 African and global leaders. The Summit was organized to provide a platform for new commitments and action toward building resilience to climate change across Africa and the AAAP; to present new contributions and innovative financial mechanisms to deliver on the global financing goals agreed as part of the Paris Agreement; and to catalyze the transformative partnerships needed to deliver the SDGs and the African Union's Agenda 2063. The session was hosted by the President of the Democratic Republic of Congo and African Union Chairperson, His Excellency President Félix Tshisekedi, and moderated by the CEO of the GCA, Prof. Dr. Patrick Verkooijen.

Key outcomes from the Summit included:

- An endorsement by the African Union Chair and President of the DRC, President Félix Tshisekedi, of the AAAP as the preferred channel for funding climate adaptation in Africa.
- Announcement of a £20 million funding toward the AAAP by the UK Government
- Other announcements of a US$3 billion annual funding by 2024 from the US Government toward climate adaptation for Africa
- Further calls for increased financing for Africa's adaptation, by other leaders present
- Calls for brokering partnerships to deliver action

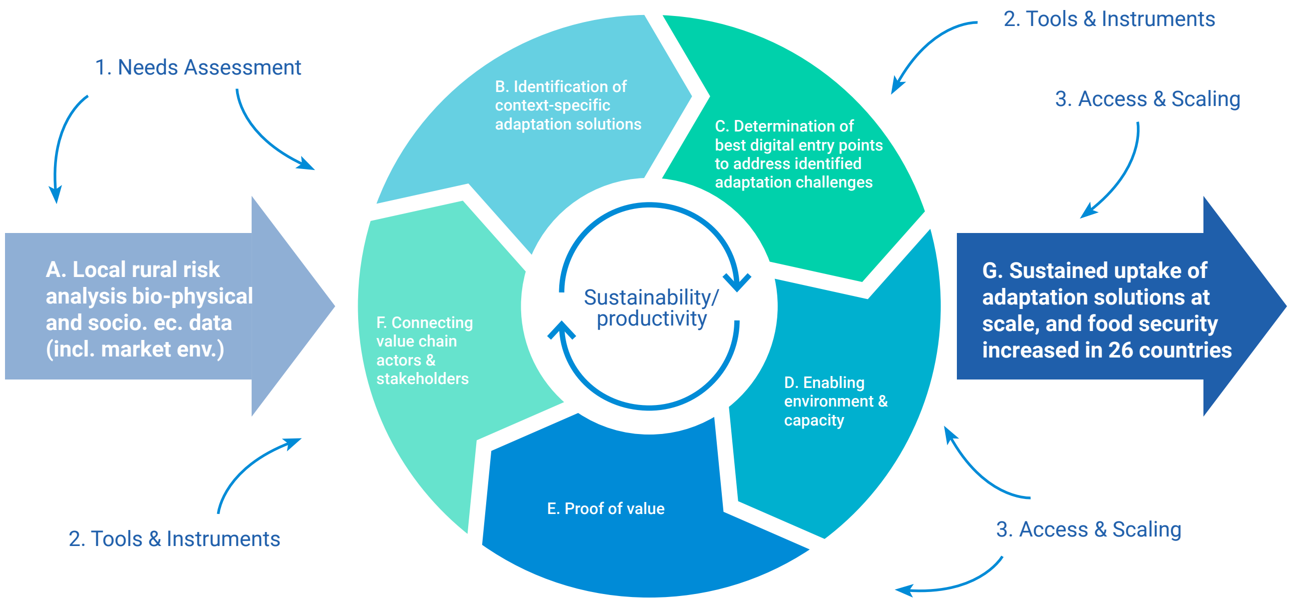
Categories of AAAP Partnerships

To support GCA's three business lines, the AAAP Partnership Approach focuses on three main categories of partners, including Development Finance Institutions (DFIs) and MDBs, African institutions that seek access to climate funding and private financial institutions where the AAAP seeks to mainstream climate adaptation knowledge.

Development Finance Institutions and Multilateral Development Banks: The core purpose of these partnerships is to mainstream adaptation in projects, with DFIs/MDBs being the largest financiers of climate change projects in Africa. Having commenced and tested the model with the AfDB and the World Bank, efforts at building partnerships with other institutions are currently being made. Partnership agreements have already been signed with the EIB and the International Fund for Agricultural Development (IFAD), and program implementation plans are now being defined. Efforts are ongoing to sign partnership agreements with the European Bank for Reconstruction and Development (EBRD), where similar models will be tested and adopted.

African institutions that seek access to climate funding: This category of partners falls within the AAAP Technical Assistance Program (TAP), which aims to greatly enhance the level of adaptation finance flowing from multilateral climate funds to the African continent. It also works with African countries to carry out public expenditure reviews to

Figure 1. Smallholder Adaptation Accelerator



highlight budgets across different sectors that can be counted as adaptation. Institutions that the AAAP enters into partnerships with include institutions that have already been accredited to receive climate finance from the GCF but require support in bringing forward proposals for financing. On the other hand, organizations that are yet to be accredited are being supported to finalize this process. These partners are spread across various geographical locations, and current active projects are in Senegal, Ghana, the DRC, and Seychelles.

Private financial institutions where AAAP will mainstream climate adaptation knowledge: This category of partnerships seeks to leverage the capital of private sector investment and asset management firms to set up adaptation-specific funding and to mainstream climate adaptation knowledge, thereby expanding asset classes in such firms. A key example is the Invesco Ltd. asset-management firm, which is looking for blended finance solutions to scale adaptation finance with private-sector institutional investors in the most vulnerable countries. The AAAP provides advisory support and promotes knowledge sharing and best practices in adaptation, including adaptation taxonomies and adaptation impact metrics to support institutional investors.

Sub-Grantees and Implementing Partners: In addition to the three categories of partners, the GCA utilizes partners to support the delivery of the upstream activities of the AAAP. GCA matches its global expertise as the solutions broker on adaptation and resilience with on-the-ground stakeholders with specific local context knowledge with a strong track record of delivering resilience building and adaptation. To ensure this, a dedicated call for partners has been set up on a rolling basis. These partners are then brought on board in sub-grantee arrangements, following extensive assessments and evaluation of their ability to support the work of one or more pillars of the AAAP and due diligence assessment of their institutional credibility. The call targets African not-for-profit organizations with extensive experience in climate adaptation and resilience building, focusing on one or more of the AAAP pillars.

Youth Entrepreneurs focused on adaptation: GCA also works closely with a key stakeholder grouping to support the creation of good adaptation solutions in Africa by entrepreneurial youth. The AAAP rolls


Photo: BleagLee Waste Management

out a YouthADAPT Challenge, run in partnership with climate innovation centers on the continent, which equips youth-led SMEs by providing adaptation solutions to scale up their solutions and maximize embedded job creation opportunities. In addition to funding these ideas to scale, training and capacity-building on adaptation are provided to equip such entrepreneurs with starting tool packs for business delivery. In 2021, 15 businesses across several countries were winners of the Challenge and ongoing activities to hone their business management capacities are being provided.

THE AAAP UPSTREAM FINANCING FACILITY

The technical assistance, policy advice, analytical work, and capacity building work described in this chapter is supported by the AAAP Upstream Financing Facility housed in the GCA. This Upstream Financing Facility supports transformational adaptation shifts at the country level, the supporting research and monitoring for rapid extraction and replication of lessons, and the policy support to steer the economic directions at the national and regional level.

The AAAP Upstream Financing Facility aims to ensure with high confidence that all AAAP investments are as highly effective as possible and underpinned by the best data, science, and global practice on adaptation as managed by GCA teams.

The GCA-administered Upstream Facility has an influencing funding leverage ratio of 1:100, meaning that every dollar invested in the Upstream Facility influences 100 dollars of resilient investments. In only 18 months of operation, the Facility has already helped prepare US$3 billion of AAAP investments. GCA is mobilizing US$250 million for this Facility over five years to bring the best global and local adaptation practice to every AAAP investment.

KNOWLEDGE AND TOOLS

This section discusses the AAAP's achievements in knowledge generation and management for adaptation and resilience investments. Evidence-based knowledge for action continues to guide the implementation and further shaping of the AAAP.

The key knowledge products and tools developed through the AAAP activities include the following: Smallholder Adaptation Accelerator (SAA), Macro-economic Evaluation of Adaptation, Knowledge Module on PPPs for Climate-Resilient Infrastructure, National Infrastructure Risk and Resilience Program in Ghana, City Adaptation Accelerator, Rapid Climate Risk Assessment (RCRA), Accelerator Training for SMEs, and Adaptation Jobs: A Guide for Maximizing Employment Outcomes of the AAAP. They are presented here organized under the rubric of the respective AAAP pillars to which they are most closely tied.

Pillar 1: Climate-Smart Digital Technologies for Agriculture and Food Security

Smallholder Adaptation Accelerator (SAA): The SAA was developed as an implementation vehicle for the CSDAT pillar of the AAAP. Interventions under the SAA ensure that digital technologies are designed for and targeted to smallholders and agri-SMEs, including women farmers, devise a commercially viable business model to deliver digital solutions and build the capacity of smallholders and other value-chain actors to use digital technologies in agricultural practices. The SAA describes the upstream (mainstreaming and needs assessment) and the downstream (tools and instruments) activities and the strategy to promote access and scaling required for sustained uptake at scale of climate-smart technologies. Upstream activities for mainstreaming and needs assessment center around knowledge and analytics, such as the local rural-risk analysis and identification of adaptation solutions focusing on geographic entry points for climate-smart digital technologies (A and B in Figure 1). Downstream support involves matching user needs around the supply of information and strengthening the local enabling environment and capacity (C and D). The steps to integrate the two are proof of value activities at the local level and connecting value actors and stakeholders (E and F).

Macroeconomic Evaluation of Adaptation: In a show of their strong resolve to act on global climate change and response to the 2015 Paris Agreement, 52 African countries submitted their NDCs by 2021 to the United Nations Framework Convention on Climate Change (UNFCCC). Almost all of these countries included NAPs in their NDCs, while six countries had developed a separate NAP. The NDCs reflect efforts by individual countries to reduce national GHG emissions and adapt to the impacts of climate change. The NAPs are strategic planning documents in which each country lays out its medium- and long-term priorities and interventions for adapting to climate change. GCA, working in partnership with AKADEMIYA2063 and national institutions in two countries (Kenya and Mali), supported the mainstreaming of adaptation into agricultural policies and expenditures by providing technical assistance to inform and facilitate the effective implementation of NAPs as well as identify adaptation pathways and related policy options. The following tasks are being carried out:

- Defining agriculture adaptation and socioeconomic indicators at the household and community level to characterize adaptation interventions proposed under the NAPs.
- Identifying and quantifying targets and goals for adaptation in agriculture contained in country NAPs.
- Evaluating the feasibility of NAPs based on required investments and related impacts and outcomes as well any issues regarding consistency, complementarity, and possible tradeoffs between individual adaptation goals and targets.
- Identifying alternative adaptation in agriculture pathways and related policy options to inform and facilitate the effective implementation of country NAPs.

The draft national reports on NAPs for the two countries have been prepared. The results of the Kenya report have been presented for comments and validation by stakeholders during the consultative Meeting on Country Adaptation Support Program (CASP) Kenya. About 30 participants representing the government, private sector and NGOs drawn from the agriculture, environment, energy, and other sectors participated in the meeting. A similar national consultative forum is being planned for Mali.

Pillar 2: African Infrastructure Resilience Accelerator

Knowledge Module on PPPs for Climate-Resilient Infrastructure: Governments, including in Africa, are increasingly turning to PPPs to attract private capital for infrastructure projects and bridge the existing investment gap. Yet, while there is a strong body of knowledge on guidance for PPPs and literature on climate risks, resilience, and infrastructure, countries and practitioners lack information on how to bring those two fields together. This requires detailed quantitative data and qualitative information to develop a rigorous analysis of how infrastructure PPP projects have integrated climate adaptation and resilience, to share best practices and lessons learned and build the capacity of practitioners.

The launch of the Knowledge Modules on PPPs for Climate-Resilient Infrastructure helped address this gap by providing a pragmatic step toward helping countries draw the private sector into financing climate-resilient infrastructure. The first Masterclass for Climate-Resilient Infrastructure PPPs ensures that GCA's innovative work can be transferred to drive longer-term change in the systems that currently design and finance infrastructure investments in Africa. It includes the delivery of two knowledge products on NBS and Locally Led Action (LLA), which enable PPP practitioners to build climate resilience and NBS for infrastructure into the design of PPP projects.

Results of the National Infrastructure Risk and Resilience Program in Ghana: The national assessment was initiated by GCA and developed under the leadership of the Ministry of Environment, Science, Technology and Environment (MESTI) in collaboration with the University of Oxford, the United Nations Office for Project Services (UNOPS), and the United Nations Environment Programme (UNEP). The national assessment focused on the energy, transport and water sectors to assess climate hazards to infrastructure assets and to prioritize adaptation investments to address those risks. It proposed 35 prioritized adaptation options for funders and investors to invest in Ghana's future, offering impactful, evidence-based adaptation projects and enabling environment interventions backed by robust research and analysis.

The insights from this initiative are already influencing investments on the ground. For example, the analysis identified districts needing to shift energy generation from traditional biomass, which is vulnerable to changing climate conditions, to more resilient energy systems. Solar mini-grids were proposed as a solution to help build the resilience of communities, particularly in Volta, Brong Ahafo, and the northern regions of the country. GCA is working with the AfDB on the Scaling Up Renewable Energy Program (SREP) in Ghana to prioritize districts and communities that are most vulnerable while providing technical support to ensure that the physical assets (mini-grids and solar photovoltaic (PV) net-metering systems) are resilient. Finally, the data and recommendations from this national infrastructure assessment are also being integrated into the Ghana NAP.

City Adaptation Accelerator (CAA): The CAA creates a shared strategic framework for GCA's engagement in climate adaptation and resilience building in urban areas. The development objective of the CAA is to support cities and countries to strengthen their urban climate adaptation and resilience outcomes through enhanced understanding, planning, investments and governance and capacity building. To build urban resilience, the CAA provides support to cities and countries along the following pathway:

- **Focus cities (and countries) are identified:** City identification will be done through scoping studies, partner consultation, in particular MDBs, as well as water adaptation community (WAC) awareness-raising and experience exchange.
- **All relevant stakeholders agree on the need for adaptation and have process ownership:** Ensuring buy-in among a broad set of stakeholders, including, inter alia, municipal and national governments, local communities, and civil society, requires stakeholder mapping and agreement on the climate adaptation process to be pursued. This will entail community involvement in decision-making, as covered under the LLA toolkit.
- **The target city's situation is well understood:** This involves 1) comprehensive and RCRAs; 2) identifying opportunities and challenges related to policies, institutions, regulations (PIRs) and governance systems at national and local levels; 3) determining the efficiency of public expenditures; and 4) identifying adaptation hotspots, which include cost-benefits analysis and the weighing of tradeoffs between priorities.
- **A comprehensive climate adaptation strategy and prioritization plan are developed:** This entails strategic development surrounding climate adaptation master planning as well as capacity building in climate adaptation planning.
- **'Bankable' projects are designed, prepared and implemented:** CAA will provide technical assistance in delivering discrete, high-impact outputs to strengthen the design, preparation and implementation of climate adaptation projects. This work will be done through programs such as AAAP and AIRA and in close coordination with the GCA Climate Finance and Infrastructure/NbS team to ensure proposed solutions are financeable and of interest to potential financiers.
- **Knowledge is retained and shared with other cities:** This entails peer-to-peer learning, experience exchange and speaker series to fill knowledge gaps through WAC. Examples of good practice and tips of the trade to public sector workers, development professionals and local community leaders working on climate adaptation will be codified in knowledge notes.

Currently, the CAA is providing support to cities in Bangladesh, Chad, Ghana, Tunisia, Liberia, Sierra Leone, Madagascar, Tanzania, Guinea, Gabon, and Senegal.

Rapid Climate Risk Assessment: Africa is home to 86 of the 100 fastest-growing cities in the world, with a large number of these cities (79) falling within the "extreme risk" category of the Climate Change Vulnerability Index (CCVI). A total of 15 African capitals, and many of the continent's key commercial hubs, have significant combined risk factors stemming from rapid population, economic growth and climate risk. Understanding climate risk is key to building urban resilience. However, extensive and in-depth climate risk assessments are resource- and time-intensive. Therefore, building on the efforts of other organizations such as C40 and others, GCA has developed and implemented RCRAs.

The RCRAs consist of three sections: **City Scan**, which provides a rapid review of what has been done in the respective city regarding climate hazard and risk assessments, as well as more locally focused assessments of vulnerability and adaptive capacity. It will also provide a clearer picture of the city's water urban adaptation and resilience ambitions, strategies, plans and specific priorities. **RCRA** to provide an overview of the key climate hazards and associated risks that a city faces and to inform the decision whether an in-depth climate risk assessment is required. **City Scoping** to provide insight into past and current initiatives relevant for adaptation and resilience building and identify key stakeholders and relevant initiatives. To date, GCA has carried out RCRAs in Antananarivo (Madagascar), Bizerte (Tunisia), Conakry (Guinea), Dodoma (Tanzania), and Libreville (Gabon). These assessments are feeding into the identification of investment projects by AfDB.

Pillar 3: Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience

Accelerator Training for SMEs: The training for SMEs in climate adaptation was developed as part of the YouthADAPT Challenge accelerator program to provide the specialized adaptation and resilience and business knowledge required by SMEs emerging in the ecosystem. The course was split into core business knowledge and climate adaptation segments, including financial management, investor readiness, marketing, adaptation fundamentals, climate risks, and business and adaptation finance. Winners of the 2021 YouthADAPT Challenge are benefiting from the 12-month business accelerator program to help them scale up their businesses, deepen their impact and create decent jobs. In addition, the winning youth-led enterprises receive training, mentorship, and support to expand partnerships, knowledge sharing, and learning through a network of young entrepreneurs in climate adaptation.

Adaptation Jobs: A Guide for Maximizing Employment Outcomes of the AAAP: The AAAP, through the GCA, is collaborating with the International Labor Organization to develop a guide for maximizing employment outcomes. The guide's main objective is to provide policy and practical guidance on how AAAP investments can be designed, structured and monitored to maximize employment outcomes. This guide will support stakeholders, including AAAP program staff as well as officials and policymakers in partner countries involved in the four pillars of the AAAP.

Pillar 4: Innovative Financial Initiatives for Africa

Under the IFI pillar, three knowledge products have been developed:

Financial Innovation for Climate Adaptation in Africa: This report provided an overview of existing adaptation finance flows in Africa. The report also identified opportunities to increase the volume and efficacy of that finance. The report was launched at the Africa Adaptation Acceleration Day and presented in different forums such as Africa Climate Finance Week and COP 26 Africa Pavilion.

Green Bonds for Climate Resilience and Issuer's Guide: This guide aims to deepen the current understanding of the state of play of green bonds financing climate resilience-related assets, projects, and activities. The report contains an overview of the global state of green bonds with resilience-related proceeds, including highlights from Africa. The barriers to issuing resilience-related green bonds in four case-study countries, and recommendations on overcoming these barriers, were also detailed. An analytical tool, the Green Bonds for Climate Resilience Capacity Assessment Framework, has been developed to inform this analysis. Public and corporate issuers can use it to assess their internal capacity and external enablers to issue Green Bonds for Climate Resilience. A roadmap to scale up this promising tool is presented based on the research and findings.

The report was launched at the High-Level Dialogue on Climate Adaptation with Global Leaders ahead of COP26 and at the Green Bonds Conference 2021, Unlocking Trillions for a Resilient Future. Further, as a result of this report, GCA engaged in 2021 with the Government of Côte d'Ivoire to support them on a potential issuance of Sovereign Green Bonds in 2022, where GCA will support the adaptation components of the bond.

The Climate Risk Regulation in Africa's Financial Sector and Related Private Sector Initiatives report provided all stakeholders (both authorities and private sector players) with an understanding of:

- The state of integration of climate-related risks in the financial system on the African continent, focusing on 10 countries
- The financial stability architecture of the selected countries
- Regulations on climate-related risks by regulatory bodies and private sector initiatives.

The report highlights current challenges hindering the integration of climate risk by financial sector authorities, and offers recommendations for potential areas of support. To assess the status of climate risk integration, 25 interviews were completed with 11 financial sector authorities and 14 sizeable private sector players (banks and insurers), covering 19 countries in total. The report was launched at the

High-Level Dialogue on Climate Adaptation with Global Leaders ahead of COP26.

FUTURE PLANS FOR THE AAAP

This section summarizes the plans of the AAAP, focusing on the evolution of business lines, expanding partners, and global connections with other regions.

Evolution of business lines: As GCA and partners gain experience through project implementation on the business lines, the intention is for GCA to evolve toward new challenges once partners mainstream the tools into their institutions and work programs. The AAAP aims to evolve constantly as African countries' priorities and financial needs are further refined.

For example, under the CSDAT pillar, the AAAP will continue to provide technical assistance to identify digital tools to support the mainstreaming of adaptation into investment projects of international financial institutions dealing with agriculture; use the experience gathered so far from ongoing projects to launch new project interventions and partnerships as may be appropriate in the Central and North Africa region; and initiate steps to expand the range of international financial institutions by engaging in discussions on new projects with other international financial institutions and DFIs, such as IFAD and the French Development Agency (AFD).

Under the AIRA pillar, the Infrastructure and NBS program and the Urban and Water programs will continue to provide technical assistance and capacity-building support to integrate climate adaptation and resilience into infrastructure projects across the African continent. Building on GCA's experiences in Ghana and Bangladesh, the national infrastructure risk and resilience assessments will be scaled up to other African countries, starting with Kenya and Senegal. These national programs will support the prioritization of adaptation investment options to be financed by implementation partners such as international financial institutions, development partners, and climate funds.

The City Adaptation Accelerator will continue to expand and, based on these learning opportunities, develop a set of tools and methodologies to support urban resilience building. Examples of these tools are: the Locally Led Adaptation Toolkit for Urban Informal Settlements, the RCRA, the investment prioritization tool, the climate vulnerability assessment, and so on. A similar strategic framework will be developed for the Water program.

The AAAP will work with MDBs to integrate adaptation and resilience, focusing on NBS, into downstream investment projects. The portfolio will be diversified to further include projects in transport and logistics, urban infrastructure services, infrastructure for agriculture services, renewable energy, and information and communications technology (ICT). This will include the development of innovative solutions in disruptive technologies for infrastructure solutions and in the structuring of NBS investment cases. Further, the Masterclasses on Climate-Resilient PPPs will be scaled up through local institutions to ensure sustainability and reach a wider audience over time while supporting capacity building for AAAP projects.

Expanding partners: GCA is gradually expanding its partners, such as the AFD and other financiers, to influence and scale up the mainstreaming of climate adaptation. The AAAP will also have closer interaction with the GCA Research for Innovation team and, through them, with academia to bring the latest science and learning into the AAAP programs. GCA is also calling for partnerships through which the upstream activities of the AAAP will be delivered. This is targeted at African not-for-profit institutions with an excellent track record of working in the field of Africa's climate change adaptation and resilience.

Global connections with other regions: The AAAP has been set up to serve as a vehicle to mobilize US$25 billion of adaptation investments in Africa. Drawing from this practical experience, GCA will work with partners to scale up the model of AAAP to other regions in the world, including South Asia and Small Islands and Developing States. Also, through the Global Hub on Locally Led Adaptation, GCA seeks to work with institutions that have experience in successfully promoting and scaling up Locally Led Adaptation.

Livestock

KEY MESSAGES

- Livestock accounts for around 55 percent of total household income in pastoral systems in Africa and 35 percent for mixed crop-livestock systems, it is are also used for tasks like plowing.
- Rising temperatures, changing precipitation patterns, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa's livestock farmers. Modeling studies suggest that under higher greenhouse gas emission scenarios, global cattle production losses from heat stress alone could amount to nearly US$40 billion per year by 2085—equivalent to 9.8 percent of the value of production of milk and meat from cattle in 2005. Under lower emission scenarios, losses could amount to nearly US$15 billion.
- Adaptation of livestock will require a combination of different interventions, some having to do with the animals themselves (breeding, pest management) and others about land management and the development of financial instruments to deal with climate risk.
- Although livestock is a key component of mixed crop-livestock systems, most climate change adaptation work has focused solely on the crop side. There is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa. The research base required

Photo: Kandukuru Nagarjun

for building climate-resilient livestock systems is underdeveloped and needs greater support.

- A few adaptation actions of direct relevance to livestock systems include implementing early warning systems and adaptive safety nets for farmers in climate risk hotspots and taking climate services to scale by connecting millions of farmers and agribusinesses to ICT-enabled bundled advisory services by 2030.

“

I believe that the Africa Adaptation Acceleration Program is an important part of the solution to make the food systems more resilient and to make them better placed to cope with the next drought, or the next flood, or the next plague. At the same time, we can create jobs for new generations, based on strengthening African value chains.”

Anne Beathe Tvinnereim
Minister of International Development of Norway

INTRODUCTION

Livestock plays a crucial role in the economic and social life of Africa, supplying meat and milk for food and commerce, generating a large part of household incomes, fulfilling many functions, and occupying a range of niches within both pastoral and mixed-crop systems. Livestock is especially crucial to smallholder farming and therefore deserve a special focus when it comes to adaptation.

This chapter is organized into five sections. After a description of the importance of the livestock sector for Africa in Section 1, Section 2 presents the impact of climate change on livestock. Section 3 describes some of the most promising technical interventions to strengthen adaptation and resilience in the livestock sector. Section 4 presents estimates of the cost of adaptation inaction and action in livestock. Section 5 concludes with some policy recommendations.

WHY LIVESTOCK MATTERS

This introductory section presents the role of livestock in food and nutritional security, the economic and social importance of livestock in Africa, and the specific livestock systems in North and Sub-Saharan Africa.

The Role of Livestock in Food and Nutritional Security

Livestock products are a valuable source of proteins and micronutrients and play a key role in providing a balanced and healthy diet. However, meat consumption in Africa is modest and particularly low in areas where there is widespread malnutrition. In Southern Africa, it is around 80 kg per person per year, compared to over 400 kg in the United States. In Central Africa, per capita consumption is just over 20 kg. In West Africa, it is approximately 35 kg.[1]

Between 1973 and 2013, per capita meat consumption in Sub-Saharan Africa rose from just 13.7 kg to 16.2 kg. But it is expected to increase over the next decades, driven by population growth, urbanization, and rising living standards.[2] One estimate suggests that the demand for meat in Africa will triple by 2050.[3] This will have significant implications for production and trade.

The Economic and Social Importance of Livestock

A 2009 review of case studies in Sub-Saharan Africa and South Asia found that livestock accounted for around 55 percent of total household income in pastoral systems and about one-third in mixed crop-livestock systems, which also use the animals for tasks such as plowing.[4] Livestock animals perform an essential function by converting plant biomass into nutrient-dense manure. They also play important cultural roles. For instance, sharing livestock can create or strengthen social relationships when used as a dowry or bride price.[5]

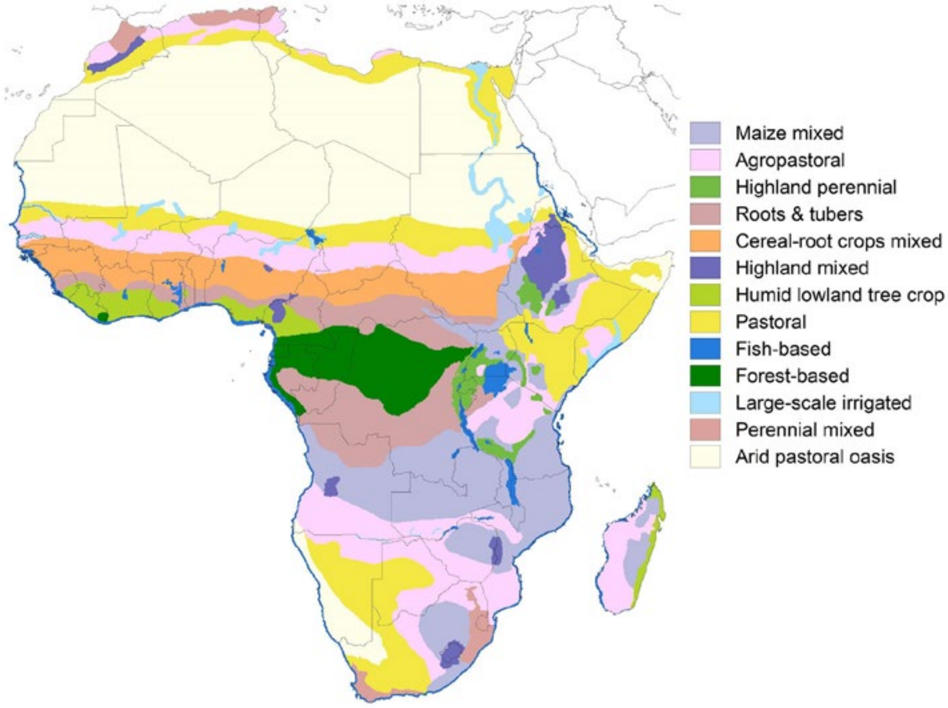
Over much of Africa livestock is one of the few assets that rural women can own.[6] However, even within the sector women find themselves at a significant disadvantage. They tend to keep fewer animals than men, which are likely to be poultry and small ruminants rather than cattle or camels. While men dominate the more important and lucrative roles of herding and marketing, women are often left with the tasks of milking, feeding, and looking after sick animals.[7]

Trade in livestock and livestock products in Africa is hampered by modest production levels, the failure to achieve global Secure Beef Supply (biosafety) standards, poor infrastructure, and low investment. In 2020, Africa's livestock imports were worth over US$10 billion, compared with US$3.2 billion in exports. Of the latter, US$1.3 billion of livestock products (mostly in the form of cattle, buffalo, and live animals) were traded within the continent, while US$1.8 billion of products (primarily sheep and cheese) were exported elsewhere.

Livestock Systems in North and Sub-Saharan Africa

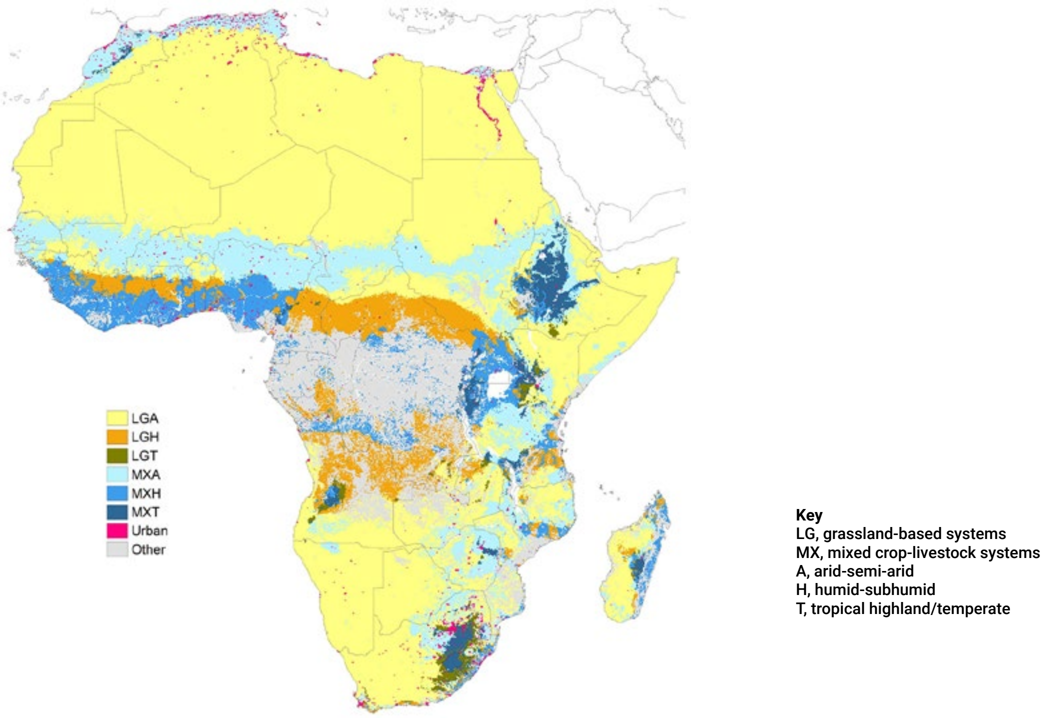
There are an estimated 46 million farms in Africa, the vast majority less than 2 hectares in size.[8] They support an agricultural population of some 580 million people. No other continent possesses such a diversity of farming systems as Africa. Figures 1 and 2 show two approaches to mapping and characterizing African farming systems. The first defines 13 major farming systems, based mostly on access to resources and services.[9] Livestock feature strongly in most of these farming systems. The second is a system of classification based on whether livestock is mostly kept in grassland-based systems or in mixed crop-livestock systems.[10]

Figure 1. Farming System Distribution in Africa



Source: Dixon et al., 2019[11]

Figure 2. Livestock Distribution in Africa



Source: Robinson et al., 2011[12]

The variety of agroecological zones in Africa is mirrored by the diversity of livestock breeds.[13] There are thought to be over 180 different breeds of cattle, each adapted to a particular environment and management system. Many local breeds are resistant to diseases that can otherwise cause huge economic losses. For example, N'Dama cattle do not suffer from trypanosomiasis. Most breeds of zebu cattle (*Bos indicus*) cope better with high temperatures than taurine cattle (*Bos taurus*) and exotic breeds. Unfortunately, poorly planned crossbreeding programs have led to genetic erosion and there is a serious risk that some breeds—and genes that favor, for example, heat tolerance and disease resistance—will be lost.

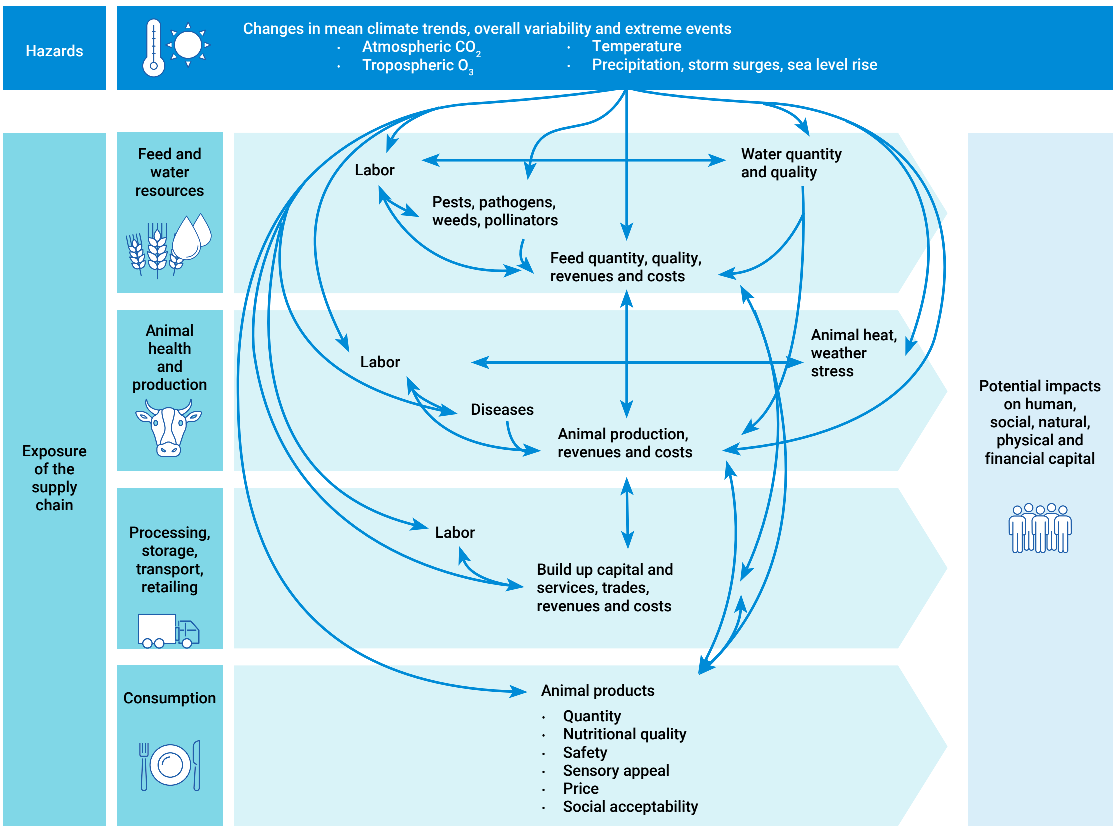
Livestock systems provide high levels of both formal and informal employment. A notable example of the former is the dairy sector in Kenya, which sustains some 3 million jobs, or 15 percent of the labor force.[14] In areas where the agricultural systems are focused entirely on livestock the rearing of cattle, camels and small ruminants often provides the main form of employment. About 40 percent of urban households in Africa are engaged in farming practice, often involving livestock.[15]

THE IMPACT OF CLIMATE CHANGE ON LIVESTOCK

The impact of climate change on livestock farming will have far-reaching consequences for national economies and the livelihoods and welfare of hundreds of millions of people in Africa. The impacts of climate change on livestock are presented in this section along five dimensions: heat stress, crops and grasslands, pests and diseases, food security, and household income.

Heat stress will have a major influence on productivity and changes in temperature, and rainfall will affect feed quantity and quality and the prevalence of livestock diseases. These disruptions will in turn have several knock-on effects, for example on gender differences in the way livestock and livestock products are owned and managed, or on the way mixed crop-livestock farming systems are run. Figure 3 summarizes the breadth of the impacts on livestock.

Figure 3. Potential Impacts of Climate Change on Livestock



Source: Godde et al., 2021[16]

Box 1. Livestock: Mitigation Co-Benefits of Adaptation

Photo: Boulenger Xavier/Shutterstock

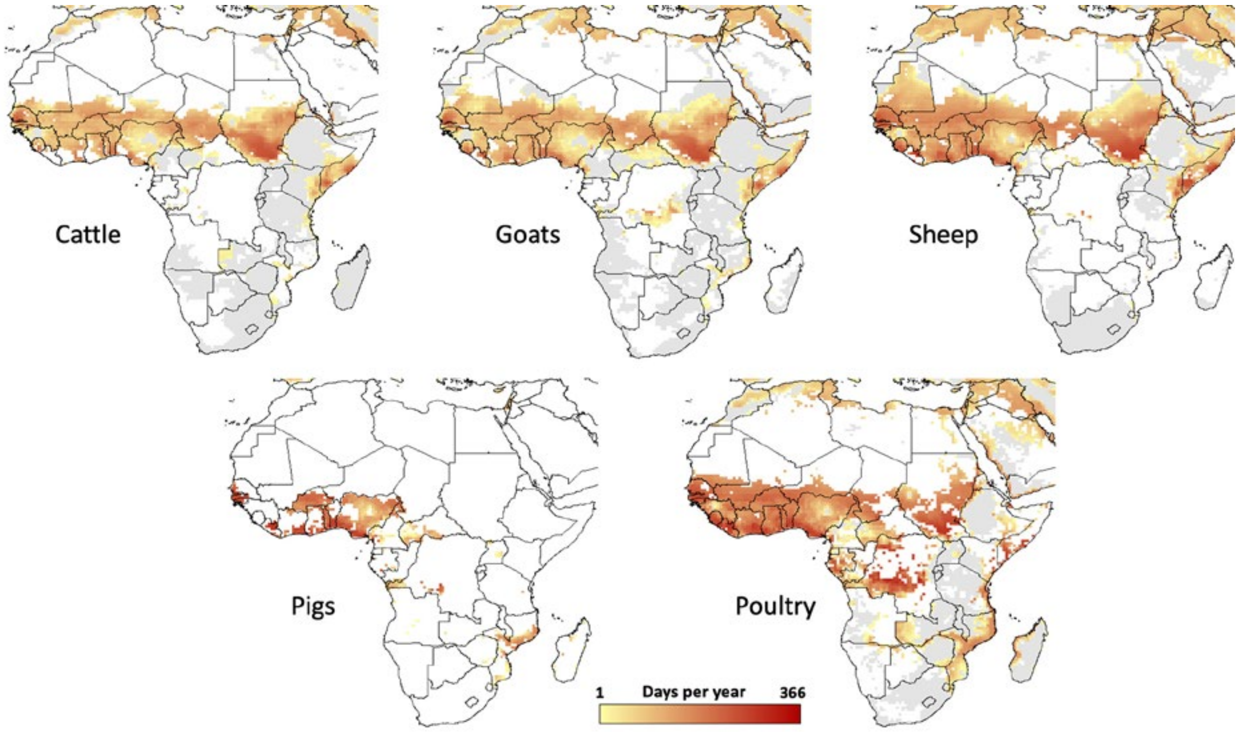
Mitigation as an issue preceded adaptation in the livestock sector, given northern donors' concern about greenhouse gas (GHG) emissions from livestock. This has slowed progress on adaptation to climate change for livestock production, as funding strategies for long-term adaptation in the sector have been slow to materialize. Critically, many countries have advanced targets for reducing GHG emissions but have very few specific targets for adapting their livestock sectors to climate change. As shown in this chapter, this bias toward mitigation actions poses major risks for the future of the livestock sector. A different way to look at the solution is to understand that most adaptation interventions have mitigation co-benefits. This is because adapting livestock production to climate change will improve productivity, and improvements in productivity reduce GHG emissions intensities. For example, improved feed baskets that are adapted to hotter conditions will also reduce GHG emissions intensities. Helping to adapt livestock to new disease patterns will also reduce emissions intensities by maintaining productivity.[17]

Heat Stress

The effects of heat stress include reduced productivity, compromised animal welfare, reduced fertility, increased susceptibility to disease, and in extreme cases higher mortality. Heat stress affects all domesticated species, although different animals respond in different ways, depending on factors such as species, breed, age, genetic potential, physiological status, nutritional status, animal size, and previous exposure.[18]

Recent projections of changes in the Temperature Humidity Index (THI), a widely used proxy for heat stress in livestock, are shown in Figure 4 for the five major domesticated livestock species.[19] Considerable increases are projected in the number of "extreme stress" days per year for cattle, chicken, goat, pig, and sheep populations in West and Central Africa. Projected changes in extreme stress in Southern Africa and substantial parts of East Africa are more muted. For North Africa, a large proportion of the cattle, goat and sheep populations will be affected by an increase in extreme heat stress.

Figure 4. Change in the Number of Days Per Year Above "Extreme Stress": Values from 2000 to the 2090s for SSP5-8.5



Source: Redrawn for Africa from Thornton et al., 2021.[20] Data mapped for each species' current global distribution from Gilbert et al., 2018.[21] Gray areas show no change from zero.

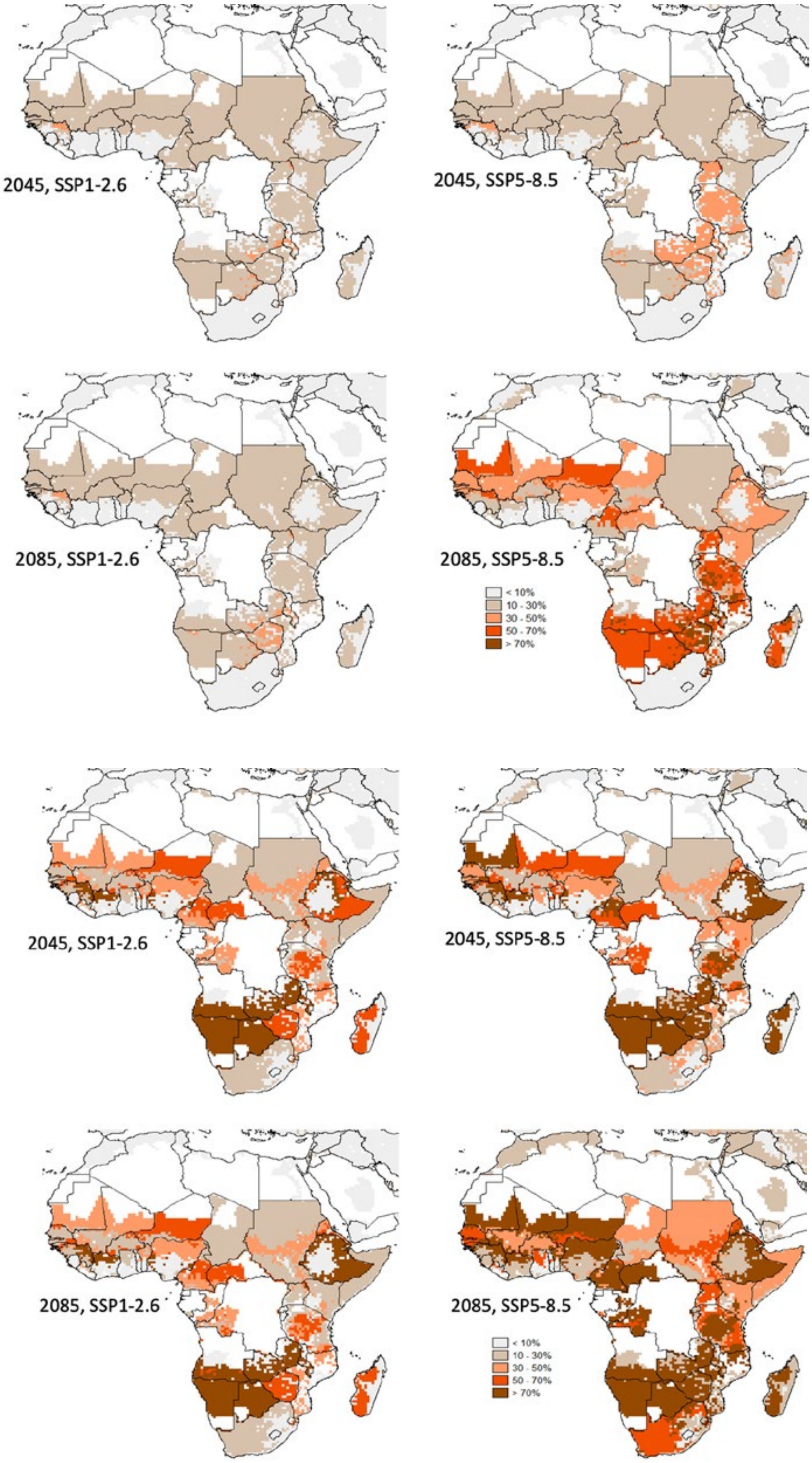
Possible economic losses in cattle meat and milk production in Africa are summarized in Table 1 and mapped in Figure 5. The losses projected for Africa are about four times those of the global averages (red numbers in Table 1).

Table 1. All-Africa Losses in Cattle Milk and Meat Production Due to Heat Stress Compared with 2005 Production

Scenario and year	Milk losses		Meat losses	
	US$ million	Percent	US$ million	Percent
SSP1-2.6, 2045	708	9.3	2,508	20.8
		1.7		5.3
SSP1-2.6, 2085	725	9.6	2,561	21.2
		1.7		5.4
SSP5-8.5, 2045	942	12.3	3,255	26.8
		2.2		7.1
SSP5-8.5, 2085	1,773	22.3	6,146	46.0
		4.7		14.4

Source: Thornton et al., 2022.[22]
Note: Costs are in constant 2005 USD. Percentages in red are the percentage of global losses.

Figure 5. African Country-by-System Value of Milk Production (left panel) and Meat Production (right panel): Loss Compared with 2005

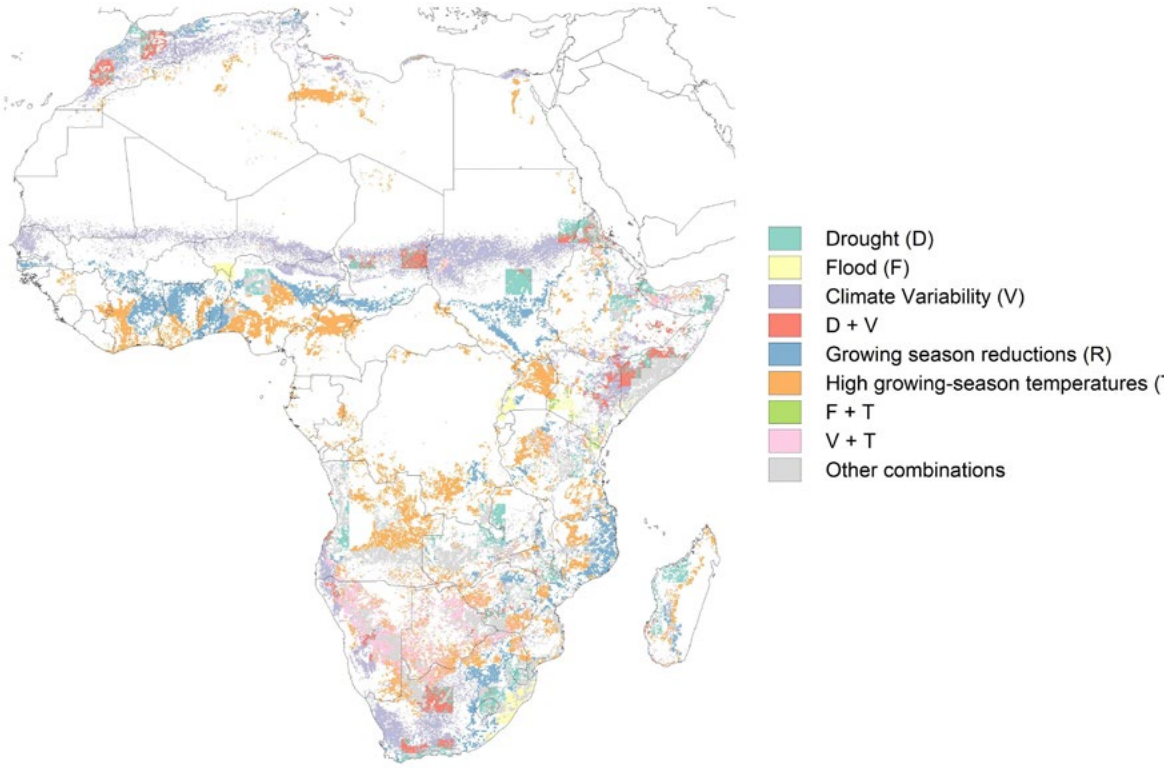


Source: Thornton et al., 2022.[23]

Crops and Grasslands

Over large parts of Africa, climate change is already having a profound impact on the distribution and quantity of rain, on the timing of wet and dry seasons, and on the frequency and severity of extreme events such as droughts and floods. The key climate hazards in Africa are shown in Figure 6.[24]

Figure 6. **Current and Future Climate Hazards in Africa**



Source: Redrawn for Africa from Jarvis et al., 2021[25]

Climate change is likely to have a significant impact on livestock feed availability through a range of mechanisms.[26] Higher concentrations of CO_2, in conjunction with increases in temperature and rainfall, may have a positive impact on productivity and could lengthen the growing season in temperate and tropical highland zones.[27] However, these positive effects are countered by climate change stresses such as increased temperature, and the increased scarcity of water during droughts and excess during floods. Because of the reliance of livestock on food crop by-products, such as straw and stovers, and on grains, the effects of climate change on livestock feed supply will largely mirror those for human food supply. In general, the direction of change for growing food and feed crops is likely to be positive in temperate regions and negative in tropical regions.[28]

As with food crops, the effect of climate change on grassland productivity relates to the balance between various competing factors. CO_2 fertilization could potentially enhance net primary productivity, but this will be countered by increasing aridity in some regions, including the Mediterranean and Sub-Saharan Africa. Grasslands are made up of diverse botanical assemblages and this lends them a degree of stability and resilience. Changing climatic conditions will doubtless influence their botanical composition, without necessarily causing a decline in productivity.

Ruminant systems are inherently seasonal, transferring nutrients from periods of scarcity to periods of abundance, either through conserving nutrients such as hay, straw, or silage, or by storing energy in livestock animals themselves through fat deposition.[29] The efficiency of these systems varies by region. Those with the greatest seasonality of feed supply, especially in the tropics, are likely to be most vulnerable to changes in rainfall patterns and an increase in the incidence of drought.

Droughts lead to a decrease in productivity and longer herd-recovery times, and there is a strong relationship between persistent drought and animal deaths. The impacts of increasing seasonality and intra-annual variability of rainfall on animal stocking rates have not been widely studied, but these may be considerably greater than those caused by changes in mean rainfall.[30] Extreme climate events are also likely to disrupt trade patterns and damage infrastructure and transport.

Pests and Diseases

Climate change will affect the prevalence and damage caused by pests and diseases of livestock. The effects are likely to be location-specific and they will vary over time as climate change becomes more pronounced.[31] Climate change is already having an impact. For example, changes in temperature and changing patterns of rainfall have increased the susceptibility of livestock to East Coast fever in the Northern and Eastern Cape of South Africa and in other areas south of the Democratic Republic of the Congo. Because of the links between Rift Valley fever outbreaks and El Niño–Southern Oscillation (ENSO) events, shifts are likely to occur in the range of outbreaks by mid-century as well as in its spread to new areas.

Climate change could have a significant impact on disease vectors such as the tsetse fly, mosquitoes, and midges, with changes in rainfall and temperature leading to a change in their abundance and distribution. For example, the geographical range of 50 percent of tick species in Africa could expand


Photo: GCA

in the future.[32] Climate change could also alter the transmission rate of diseases either directly, by affecting the survival of pathogens and parasites, or indirectly, by affecting transport and trade patterns.[33]

There is some concern that climate change could undermine existing biological control systems whereby one species helps to keep another at bay. The increase in extreme weather events could also have a significant impact. Recent outbreaks of the desert locust in East Africa were linked to a series of cyclones causing wet and warm conditions. The locusts destroyed some 200,000 ha of cropland in Ethiopia, leading to the loss of over 350,000 tonnes of grain. Their depredations also affected 1.5 million ha of pasture.[34]

Food Security

The negative impacts of climate change on livestock production will translate into significant food and nutritional security issues. The loss of animal source foods (ASF) in diets will affect vulnerable and malnourished groups across Africa. As women play a critical role in ensuring equitable household nutrition,[35] they must be engaged in the development of adaptive strategies. The existing literature on coping strategies in times of food insecurity suggests that these (e.g. skipping meals, selling off assets) are often detrimental to long-run outcomes.


Photo: DisobeyArt/Shutterstock

The quality of ASF may also decline with higher temperatures, as will overall food safety, as pathogens can multiply and food spoils more quickly.[36] Short-term solutions include more cold storage (although this is costly) and attention to good food hygiene practices by butchers and processors. Several authors also speculate that the price of ASF will increase if they become scarcer,[37] which will have implications for equity and access. The equity considerations that drive nutritional outcomes are considerable in this case, although there is not enough research on why inequity in food security persists, and how climate change may increase this unless deliberate attention is paid, for example, to securing women's economic independence.[38]

Household Income

The biggest challenge to household incomes will come from the absolute loss of income from livestock production, followed by the increased volatility in prices and market access. The volatility will be due to the greater temporal and spatial variability of production, meaning markets have a much less stable supply. The impacts will play out differently by production system, but the severity really depends on the adaptation options made available.

Although pastoral systems have evolved over centuries to manage climate variability, more recent trends such as land fragmentation and loss of tenure, coupled with severe recurrent droughts, have eroded traditional coping mechanisms. Solutions include insurance and other financial safety nets and restoring rangeland integrity and mobility. In the past decade, investors have promoted livestock market development and schemes to better orient pastoral production toward markets,[39] but their long-term impact on climate resilience is still poorly understood.

Although livestock is a key component of mixed crop-livestock systems, most climate change adaptation work has focused solely on the crop side.[40] While we know that the income from livestock is important in times of shock, there has not been enough research on mixed systems to understand how household incomes may adapt. Some households may turn to keeping more livestock; others may diversify into different crops; others will leave agriculture altogether.

Box 2. Will Climate Change Bring More Conflict to Dryland Systems?

Much has been written about the possibility that climate change will exacerbate conflict, as it increases weather shocks and extreme conditions.[41] There is particular concern about "fragile" dryland systems with ongoing conflict, such as areas in northern Mali, Chad, Somalia and Sudan, given that competition for resources is one driver of these conflicts.[42] However, the consensus of expert researchers is that climate change does not cause conflict directly, especially when assessed against other drivers such as the presence of arms and local and international political events.[43] However, climate events are a multiplier or exacerbator of stresses and conflict. It is therefore simplistic to assume that climate change will necessarily increase violent conflict across the board, as conflicts are too embedded in other processes.

ADAPTING TO CLIMATE CHANGE: TECHNICAL INTERVENTIONS

Rising temperatures, changing patterns of precipitation, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa's livestock farmers. This will not be achieved by a single strategy, but a combination of different interventions.[44] These will include developing breeds that are better adapted to high temperatures, new disease threats and other challenges; matching stocking rates with pasture production; improving the quality of diet; and changing management practices.[45]

This section presents adaptation solutions in seven categories: breeding, feed supply and seasonality, feed supply and demand, animal health and disease, rangeland management, climate information systems and financial solutions, and the critical role of women in adaptation solutions.

Breeding for the Future

Africa possesses a wealth of different agroecological zones, each directly influenced by climatic variation. Consequently, the livestock, with over 150 recognized local breeds of cattle, is highly diverse.[46] The genes responsible for traits such as heat tolerance, disease resistance, and an ability to cope with drought could play a key role in programs designed to develop breeds to cope with climate change.

These adaptation strategies could involve approaches like those used to establish disease resistance in dairy cattle, for example by crossing local zebu breeds resistant to trypanosomiasis with high-yielding exotic breeds. A good example of breeding for heat tolerance comes from the Caribbean, where the introduction of a "slick hair" gene from indigenous Senepol cattle into Holsteins increased heat tolerance and productivity.[47]

Breeding strategies need to consider how the environment will look in future to ensure that animals reproduce successfully under the new conditions. It will also be important to ensure that the breeds being promoted meet the needs and preferences of both women and men farmers. In some cases, breeding strategies will focus on general robustness, which can be defined as an animal's ability to carry on doing the various things it needs to do to favor the ability to reproduce, rather than any one particular trait.

Of the 4,000 breeds of domestic livestock recorded in the 20th century, around 16 percent were extinct by 2000. One estimate in 2007 suggested that 20 percent of breeds were at risk, with almost one breed becoming extinct each month.[48] This genetic erosion needs to be countered urgently to ensure that the genes which could help adapt to climate change are conserved for future breeding programs. The loss of genetic diversity has been primarily caused by the marginalization of traditional farming practices and breeds. Climate change is also having a negative impact on rare indigenous breeds.

Such is the speed of climate change that traditional breeding methods will frequently be too time-consuming to enable breeds to adapt to, for example, rising temperatures or new disease threats. We need to take advantage of new genetic and informatics technologies to become more agile and responsive. Research priorities include identifying the genomic basis of resilience, constructing novel genotypes, and developing innovative reproductive technologies using informatics and highly targeted interventions.

Increasing Feed Supply and Reducing Seasonality Issues

The supply of livestock feed will need to adjust to a changing climate. As it is inherently adaptable, options do exist. The major macronutrients required by livestock can come from a range of sources and the feed industry is accustomed to adjusting based on the availability of different commodities. Changes in the climate will inevitably make such adjustments more commonplace in future. For example, shifts from maize to dryland crops such as sorghum and millet will lead to differences in the mix of crop residues available for livestock.

Recent advances in precise phenotyping, genotyping and related molecular technologies have huge potential to improve the yield and nutritional quality of livestock feed, enhance disease resistance, and improve drought tolerance of forage species. However, they have been minimally applied to date.[49] Ongoing breeding efforts are already targeting resilience, and these will need to be intensified. For example, breeding programs will increasingly need to focus on drought tolerance.

Breeding for greater water use efficiency (WUE)—defined as the ratio of forage biomass produced per unit of water used, to cope with water-limited conditions—will be important. Trade-offs exist between WUE and biomass yield, and these will need to be considered. Breeding for pest and disease tolerance will also be important when it comes to maintaining and increasing the productivity of feed crops, not least because climate change is likely to lead to greater pest and disease pressure.

Livestock feeding systems that deliberately incorporate shade options are likely to become increasingly attractive.[50] Silvopastoral systems that combine pasture with trees are an obvious option. Trees provide shade and by reducing overall temperature also reduce the heat stress that can threaten the productivity and welfare of domestic livestock. Furthermore, deep-rooted trees can provide a source of fodder longer into dry spells than more shallow-rooted grasses and herbs.

Harvesting and managing rainwater can increase water availability and help to maintain feed and forage productivity during the dry season. Small-scale irrigation has enormous potential to smooth seasonal deficits in feed supply and increase overall feed availability in smallholder systems in tropical regions, provided such irrigation is managed sustainably.[51]


Photo: GCA

Matching Feed Supply with Feed Demand

The seasonal scarcity of feed supply already poses significant problems, particularly in tropical latitudes, and this is likely to intensify with the increasing incidence of drought and less certainty in growing seasons. To counter this, better feed conservation and storage methods are required, including better use of hay and silage. Creating denser feeds will facilitate storage and transport.[52]

Feed production potential varies both temporally and spatially. It is influenced by agro-ecological conditions such as temperature and rainfall and this can lead to feed being abundant in geographic zones where livestock production is unimportant. Obvious solutions to this mismatch include the transportation of feed, and its storage for use in periods of scarcity. However, this can be challenging in places where there are poorly developed livestock feed value chains, a lack of business skills, and a lack of mechanization for processing feed. Interventions to enhance feed business development could significantly improve the resilience of livestock production systems to the effects of climate change.

Animal Health and Disease

The most direct impacts of climate change can affect the capacity of animals to ward off infection. For example, heat-stressed animals are less productive and have weakened immune systems, although this varies by breed and species. With severe heat stress, mortality can increase. Heat stress can also decrease reproductive capacity and milk yields.[53] Simple interventions to keep animals cool include shelter from roofed sheds or trees; these can be easily incorporated into current mixed and extensive systems. Selective breeding to tolerate greater heat stress is a longer-term solution, as discussed above.

The distribution of disease vectors and pathogens will change significantly with new precipitation patterns and temperatures. Some geographical ranges will expand, and others decrease. Modeling these changes is extremely difficult and data-intensive, but investment in better prediction tools is critical. Disease surveillance systems are a "no-regret" option as early response is always more effective than interventions after disease outbreaks have occurred. Targeted responses are more effective and less costly. Some climate-sensitive diseases will occur in the same ecologies and so using vaccines or insecticides that respond to multiple vectors such as mosquitoes and ticks can be cost-effective. Selective breeding for disease resistance is a longer-term but ultimately necessary strategy, to reduce resistance to drugs.[54]

Rangeland Management

Pasture and water availability in African arid and semi-arid rangelands are highly sensitive to climatic events and conditions.[55] Managing this variability has been central to pastoral production for centuries. Climate change will increase the variability of precipitation,[56] with likely significant consequences for rangeland vegetation. Net primary productivity and biomass in many areas of African rangelands is projected to decrease by 2050 due to climate change.[57] This comes against more than two decades of loss of mobility and increased fragmentation of rangelands,[58] which already make rangeland management harder.

Interventions to manage the increased uncertainty in pasture and water availability include land use planning at community, local and national government levels. This nested approach[59] is effective in ensuring pastoralists have access to traditional dry-season grazing areas, but this should also enable coordinated management in response to future change. This planning will need to be accompanied by better seasonal predictions of vegetation patterns. Further, with changes in temperature and precipitation, species suitability will change; ideally more heat- and aridity-tolerant species can be introduced.

Enhanced species diversity in pastures can improve yield performance and stability relative to simpler grass systems or grass-legume systems, and at the


Photo: GCA

same time increase resilience to extreme weather events. Improved grazing management is also a promising option. For example, WUE in pastures planted with tropical forage grasses can be enhanced through moderate rotational grazing.

Climate Information Systems and Financial Solutions

Climate predictions such as seasonal forecasts have been employed by early warning systems for decades, with significant improvements in their quality and interpretability.[60] The rapid expansion of mobile phone use and networks has created intense interest in the possibilities of sharing climate information widely with farmers who formerly have had limited access to such information. Digital technologies overcome information problems that hinder market access for many smallholders and herders, increase knowledge through new ways of providing extension services, and provide novel ways for improving agricultural supply chain management.[61] Such technologies can catalytically improve agricultural efficiency and resilience to shocks by providing timely climate information to aid in decision-making, reducing financial and labor costs, decreasing losses, improving quality, supporting sustainable use of resources, and increasing productivity.[62]

Receiving information is helpful, but only if producers have access to inputs and financial services. Hence, several new projects funded by the World Bank and the OneCGIAR are exploring how to better combine climate information services with other inputs and information.[63]

There are also two decades of experiments with financial instruments for climate risk management, including insurance against drought. The Index-Based Livestock Insurance (IBLI) program has been implemented in East Africa for more than a decade. While the payouts have been shown to buffer against climate shocks,[64] as with climate information, these payouts are most beneficial if other services are bundled with them—for example, information about diseases, livestock prices, and feed markets.

Box 3. Climate Service Information Initiatives in West Africa

The International Livestock Research Institute (ILRI) has explored options for bundling climate service information with other types of information in livestock value chains in Senegal, Nigeria, and Burkina Faso. There are relevant experiences in each country. In Burkina Faso, the development organization SNV has been leading initiatives such as the Mobile Data for Moving Herds Management and Better Incomes (MODHEM). The MODHEM project aims to enhance household-level food security in the agro-pastoralist areas by improving access and use of geo-satellite data. Additionally, in partnership with the Ministry of Animal Fisheries Resources (MoAFR) and Orange Mobile, SNF launched the GARBAL in 2019 to facilitate access to information for pastoral herd migration mobility, agro-meteorological data, agricultural commodities, and livestock prices for decision-making.

In Senegal, an initiative of the United Nations Capital Development Fund (UNCDF) and the Mastercard Foundation has promoted digital solutions, including the mAgri platform. The mAgri platform has been set up to communicate information and send alerts to farmers in rural areas. The mAgri is a private platform, which aims to provide farmers with real-time information on market prices of agricultural products via SMS. In addition, Action Against Hunger (ACF) and Agronome et Vétérinaires sans Frontières (AVSF) have been providing information related to changes in pasture, functioning of the boreholes, market information and so on.

Box 4. Maladaptation Risks in Livestock Systems

Maladaptation is a significant concern. Simply put, this is when an intervention to adapt to climate change makes people more vulnerable.[65] There are many examples of how this could occur in livestock systems. For example, exotic breeds have often been promoted as a pathway to improve productivity, yet these animals lack the traits that are better at coping with heat stress. Extensive pastoral producers need freedom of mobility to have secure access to water and pasture; interventions to secure land for irrigated agriculture in drylands threatens this secure mobility and makes pastoral producers vulnerable to climate change.

Box 5. Markets, Trade, and Climate Change

Regional and global trade is a mechanism that countries rely on for both filling food gaps and increasing income. In countries with large livestock populations (e.g. Sudan, Ethiopia, Niger) regional and international trade in livestock contributes significantly to economic growth. Models suggest that livestock production and trade will increase in Sub-Saharan Africa through 2050, although shocks such as disease outbreaks will constrain this episodically.[66] Increasingly variable or severe climate shocks could have the same effects, and the long-term production declines from heat stress may depress economic growth. Some authors suggest that trade will accommodate partially for the availability gaps that climate change could increase,[67] but the impacts of this for African countries is not well understood. Economic models are yet to incorporate the type of downscaled climate information that this report has used.

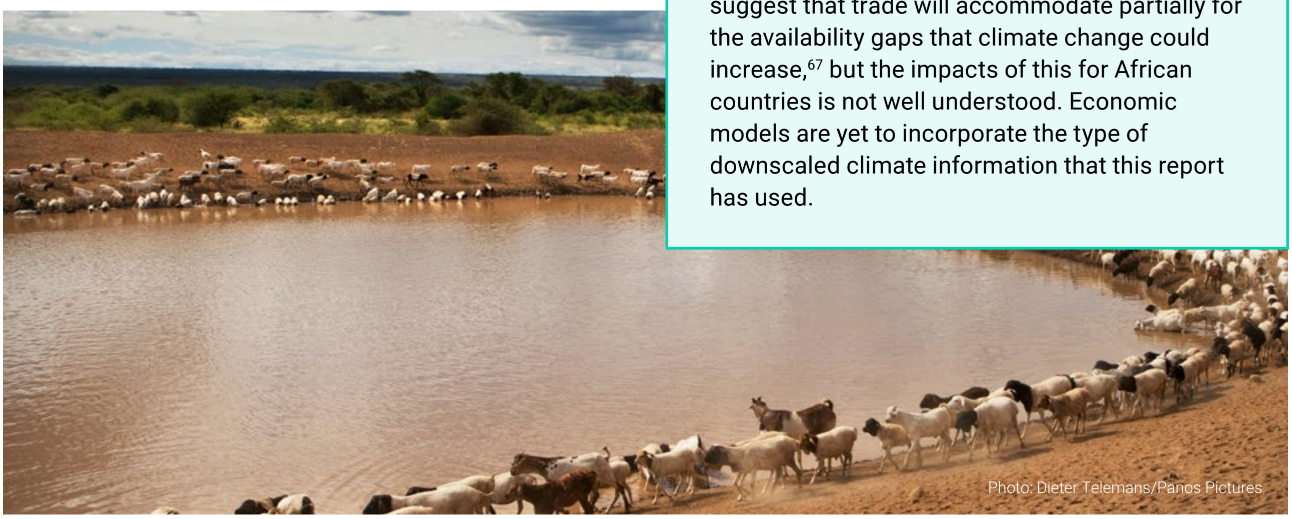


Photo: Dieter Telemans/Panos Pictures

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The Role of Women in Adaptation Solutions

The gender differences in women's and men's roles, participation, and benefits from livestock production mean that climate change will not affect genders in the same way, nor will men and women have the same choices regarding adaptation. Women have less adaptive capacity due to financial and other resource constraints, and less access to information and extension services.[68] Women are commonly perceived to be more vulnerable to climate shocks as a result.

Although we know that women are heavily involved in livestock management, their roles are often not recognized by researchers, extension workers, and NGOs seeking to improve livestock management.[69] This lack of attention has many unintended impacts. Many project interventions to improve farm management often increase women's labor burden.[70] Second, interventions that primarily focus on those who engage with formal markets will often disadvantage women: for example in the Kenyan dairy sector, most women sell in the informal, evening milk market.[71]

Despite their greater vulnerability and constraints, women can be agents of innovation in adapting to climate change with more deliberate policy and project support. With the recognition of the importance of women to livestock production and the urgent need to adapt to climate change, several manuals have been published that explain best practices for ensuring that women's needs are addressed.[72]

THE COSTS OF INACTION AND OF ACTION COMPARED

The Cost of Inaction

Climate change is already imposing serious costs on lives and livelihoods in Africa, both of which are closely tied to the stability and productivity of livestock. A portfolio of adaptation measures to counter the long-term effects of climate change will have significant costs, well in excess of the funds currently being made available for adaptation in Africa.

But as this section shows, these costs are far smaller than the estimated losses projected under different scenarios by modeling if no action is taken. Significantly, the costs of inaction only increase with time, meaning that immediate action and investment in adaptation is likely to be far more cost-effective, not to mention proactive and strategic, than piecemeal measures taken later in more challenging circumstances. This section gives the policy problem a quantitative dimension by setting out the projected costs of both inaction and action, while also noting the complexity of estimating costs for livestock adaptation, since many adaptation interventions in this realm also apply to agriculture in general. There is a need for more research on livestock-specific issues. Table 2 at the end of this section summarizes the costs of inaction analyzed.

Modeling studies suggest that under higher GHG emission scenarios, global cattle production losses from heat stress alone could amount to nearly US$40 billion per year by 2085—equivalent to 9.8 percent of the value of production of milk and meat from cattle in 2005 (Figure 5). Under lower emission scenarios, losses could amount to nearly US$15 billion.[73] For Africa, cattle meat and milk losses may amount to US$4.2 billion per year by 2085—equivalent to 22 and 46 percent, respectively, of Africa's milk and meat production.

Changes in grassland productivity are projected to lead to an overall decline in livestock numbers ranging from 7 to 10 percent, representing economic losses in the range of US$10–13 billion. Changes to African grassland productivity are likely to have substantial, negative impacts on the livelihoods of more than 180 million people.

Invasive alien species are already having an adverse effect on African countries. The estimated annual cost of indigenous alien species to agriculture in Africa is about US$66 billion.[74] Although just 0.26 percent of this is attributable to reductions in livestock income, livestock farmers also suffer from crop yield losses and the costs of weeding and management, which account for the rest of this estimate. The losses are modest in some countries—less than 1 percent of agricultural GDP in Algeria and Mauritania, for instance—but they account for over a quarter of agricultural GDP in many others, including Zambia, Niger, and Malawi. Climate change is likely to increase the spread and establishment of invasive alien species—in South Africa alone, 1,422 alien species have become naturalized—and in turn the costs of tackling them. Adapting to this possibility now, rather than waiting till it worsens, is therefore imperative.[75]

Higher temperatures resulting from climate change could also have an impact on labor and labor performance.[76] This will be particularly important in Sub-Saharan Africa, where smallholder farmers and herders rely on outside human labor. According to the International Labour Organisation, labor productivity begins to decline above 24–26°C. Once the temperature reaches 33–34°C there is a 50 percent decline in work capacity for moderate-intensity work tasks. Loss of labor capacity has critical implications for the livelihoods of households relying on subsistence farming and livestock. In rural populations exposed to temperature change, this capacity globally is estimated to have decreased by more than 5 percent from 2000 to 2016, but in large parts of West and Central Africa and coastal East Africa, observed losses were up to 30 percent more.[77] These losses will become greater and more widespread by mid-century, with increased morbidity and mortality and increased incidence of chronic kidney disease in agricultural populations. In hot regions, labor productivity could decline by 11 to 27 percent by 2080.

Finally, droughts, floods and storms regularly cause havoc in Africa, and they are likely to become more severe and more frequent in the coming decades. In general, the more severe a drought or flood, the greater the cost. For example, the estimated adverse impact of a 1-in-10-year drought in Malawi is 4 percent of annual GDP. This rises to 7 percent for a 1-in-15-year drought and 10 percent for a 1-in-25-year drought.[78] Nearly half of all the emergency multilateral food assistance to Africa is in response to disasters triggered by natural hazards.

Table 2. Estimates of the Costs of Adaptation Inaction in Livestock Systems in Africa

Element	Losses	Geography	Reference
Heat stress impacts on cattle milk and meat production	US$4.2 billion annually by 2085	Africa	38
Impact of reductions in grassland productivity on livestock populations	US$1.1 billion annually to 2050	Africa and Australia (most of the losses projected to be in Africa)	13
Loss of livestock income caused by invasive alien species	US$0.2 billion annually	Africa	39
Reduction in human physical work capacity in livestock systems caused by drought and flood	5% reduction by 2050 under RCP2.6 8% reduction by 2050 under RCP8.5	Africa	79
	Currently US$670 billion annually US$1,600 billion annually in a +2°C world	Global, all sectors	80
	Currently, mean US$0.8 billion per year	Africa, all sectors	43
Changes in pest and disease prevalence and severity	No data		

The Costs of Action

The size of the adaptation gap in general is both troubling and increasing. Adaptation finance for all sectors was about US$20 billion per year in 2019. Annual estimates for the total costs of adaptation vary enormously: from US$127 billion in 2030 and US$295 billion in 2050,[81] to 2–8 percent of GDP, or several trillion dollars each year.[82] It is noteworthy that these estimates are increasing in new studies. Agricultural adaptation is estimated to need 26 percent of the total.[83] For the recent round of Nationally Determined Contributions (NDCs) up to December 2020, in the East African region as an example, estimates of climate finance needs for the livestock sector and related systems have averaged about US$120 million per year. Most of this originates in the public sector and is directed to livestock system adaptation, with an emphasis on the most vulnerable populations.[84] Considering that the estimated cost of implementing the NDC of Ethiopia alone is US$295 billion to 2030, and of Kenya, US$62 billion, the finance currently available is clearly wholly inadequate—even with a doubling of adaptation finance, as outlined in a recent G7 statement.[85]

There is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa, at least as far as the levels of investment that are required. A recent Clim-Eat paper[86] estimated the cost of a few adaptation actions of direct relevance to livestock systems at the regional level, including:

- Implementing early-warning systems and adaptive safety nets for farmers in climate risk hotspots, US$3.4 billion per year for Sub-Saharan Africa.
- Taking climate services to scale by connecting millions of farmers and agribusinesses to ICT-enabled bundled advisory services by 2030, US$0.5 billion per year for SSA.

Other actions of indirect relevance to livestock systems were costed in the same study, such as climate-proofing investments in the agricultural sector and improving agricultural innovation systems, but these apply to agriculture in general rather than to just livestock.

The size of recent financial flows to the livestock sector directly are available for some countries.[87] For example, about US$230 million was mobilized for livestock adaptation in Mali over the period 2015 to 2022, most of which was public finance targeting adaptation options such as improved water and feed management, improved livestock marketing methods and coherent land use planning processes. In East Africa, climate finance for the livestock sector amounted to just under US$830 million between 2015 and 2022, again with most funds coming from the public sector and being targeted toward measures such as early-warning systems, feed and rangeland management, capacity development and marketing.

POLICY RECOMMENDATIONS

Some policy recommendations that emerge from the research synthesized and the analysis developed in this chapter are:

- Building climate-resilient livestock systems to cope with climate challenges requires concerted, coordinated action from investors and policymakers at the national and global levels. This will need to be informed by a solid research base,

which scientists have only started to assemble with the minimal funds allocated so far.[88]

- Researchers need to develop a toolbox of effective adaptation practices, technologies and policies that are robust across different scales, priorities, and climate futures. They must also work with funders and governments to prioritize investments in the livestock sector. It is not just technical inputs that are needed, but institutional change in the way that livestock is viewed by funders and governments. This will require a considerable evidence base.[89] And this evidence and technical support are also needed to enhance monitoring and reporting for national, regional, and continental planning.[90]
- Build capacity at national levels to understand how to prioritize interventions for the livestock sector across development and climate change planning.
- Develop policy to allow livestock development strategies that support rural development and contribute to a restoration economy, including the development of national policies and mechanisms to allow for carbon credit trading and benefit sharing for communities that implement rangeland restoration practices.[91]
- Design and update national and subnational animal feed strategic plans and strategic feed reserves; support predictive livestock early-warning systems and early-warning–early-action approaches, including for disease; establish feed inventories and feed stores; promote the establishment of intercommunity landscape-level grazing plans and natural resource management plans at community and farmer level.[92]

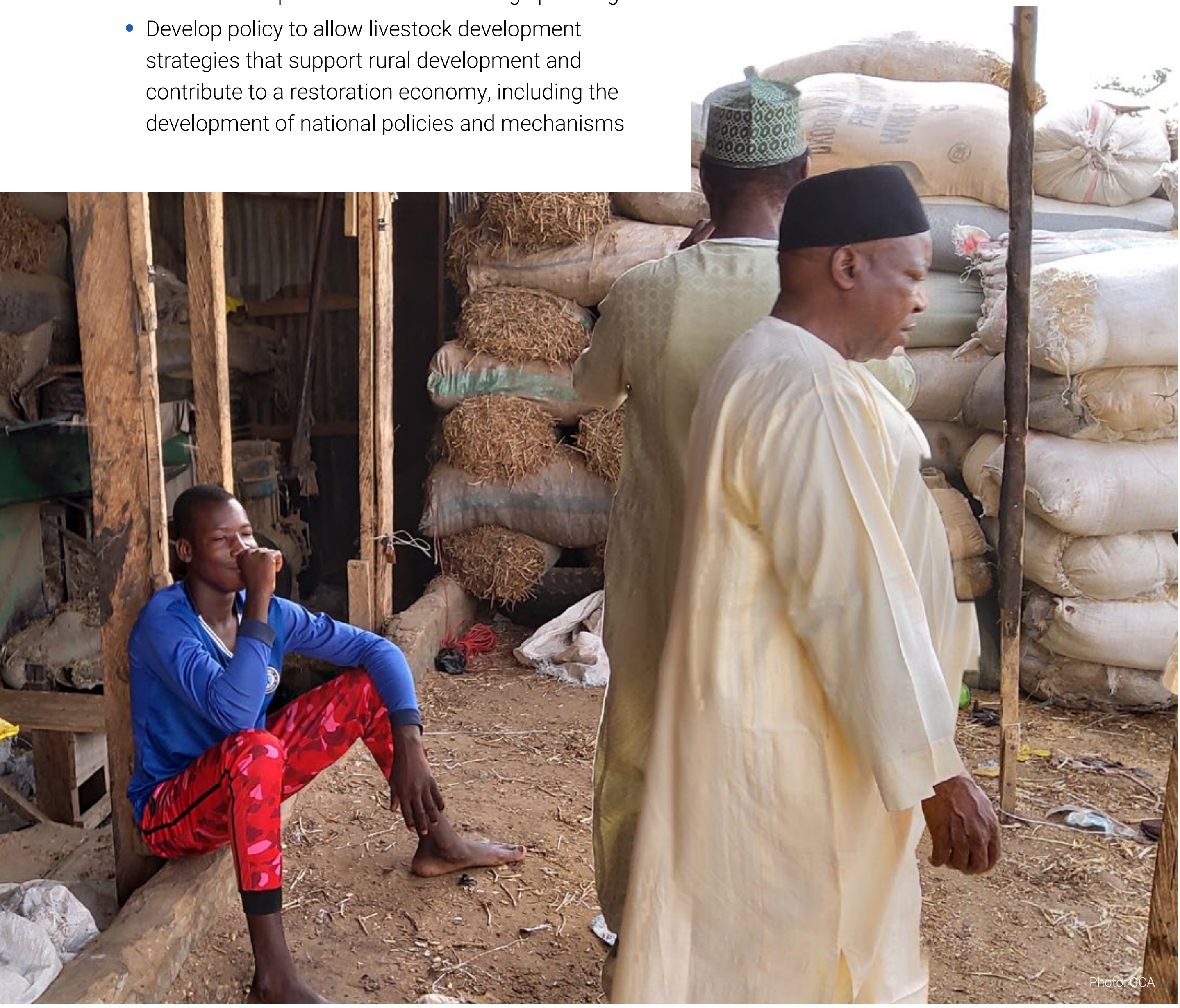


Photo: GCA

Innovation in Agriculture

Photo: Nora Castaneda-Alvarez/Crop Trust

KEY MESSAGES

- Agriculture and land-use changes contribute as much as 25 percent of heat-trapping greenhouse gas emissions. However, agriculture can also be part of the solution to climate change, with the potential to offset and sequester about 20 percent of annual emissions through improvements in soil management.
- The combination of changing consumer needs and demands coupled with climate and environmental challenges is accelerating the transition to a new way of thinking about agriculture. Meeting these needs and challenges will require a whole-system approach, involving the sustainable intensification of agriculture to increase productivity while minimizing environmental impacts through increased resource-use efficiency.
- Advances in breeding technologies and tool development are allowing improvements for multiple traits in the context of overall crop productivity. The extension of these tools to underserved crops that are climate-resilient will be key to meeting future climate adaptation goals.
- The wealth of genetic diversity available in public germplasm repositories, including CGIAR genebanks, can provide the basis for improving existing crops, as well as developing new crops, to meet specific and local climate adaptation needs. This will allow a move away from reliance on a few intensively farmed grain crops for food security to a broader collection of climate-resilient crops that includes a greater representation of legumes for smallholder farmers.

- Capacity building for climate-smart agricultural practices will require incentives and innovative finance mechanisms to lower the upfront cost barriers to adopting new practices and minimize the risk exposure—real and perceived—of smallholders as they adopt new production systems.
- The successful implementation of these strategies will require inclusive policies that benefit women (who make up a majority of smallholder farmers) and youth.

"The convergence of crises have made very clear that there is a link between climate shocks, food insecurity and poverty. 80% of the poor actually live in rural areas. When we talk about biodiversity, land, soil, sea life—these are the biggest assets for these poor rural small farm holders. Failure to conserve and to restore these assets will bring them into the brink of poverty. Small-scale producers, the rural poor community, need to be at the center of these adaptation efforts and of all our investments."

Alvaro Lario
President, International Fund for Agricultural Development

INTRODUCTION

Agriculture is the foundation of lives and livelihoods in Africa. More than 60 percent of Sub-Saharan Africans are smallholder farmers, and nearly a quarter of Africa's GDP comes from agriculture. The Global Center on Adaptation (GCA) State and Trends in Adaptation 2021[1] report (STA21) sets out several key messages for the future prospects of agriculture in Africa in the face of climate change. It shows that agriculture is already being impacted considerably by extreme weather events, and that the severity of future challenges depends on the warming trajectory. While a 1.5°C trajectory provides some options for adaptation of African food systems, this will still require urgent action. A 3°C warming trajectory, however, will cause catastrophic disruption within 30 years.

Since the release of the STA21 report, the challenges for agriculture in Africa have only become more onerous. The continuing COVID-19 pandemic has exacerbated climate-driven challenges in the agri-food sector. In addition, there are emerging impacts from the Russia–Ukraine conflict on grain markets and global food security, including the impacts that undisrupted markets are having on global agro-biosecurity systems, impacts on availability for food aid, and reduced fertilizer availability.[2] More than ever, whole-food-system approaches will be needed to tackle the current challenges as well as anticipate and prepare for impending ones.

As the world's population continues to grow, food production is being challenged by slowing crop yield increases in many parts of the world as well as degradation of natural resources such as soils, water, and biodiversity. According to a 2020 report by the Food and Agriculture Organization of the United Nations (FAO),[3] the world is not on track to achieve Zero Hunger by 2030 (Goal 2 of the UN's Sustainable Development Goals). Instead there are likely to be more than 840 million classified as hungry. By 2050, the world will need to produce about 70 percent more food than at present to feed an estimated population of nearly 10 billion people.

The combination of changing consumer needs and demands coupled with climate and environmental challenges is accelerating the transition to a new way of thinking about agriculture. Meeting these increasing food needs will require sustainable intensification of agriculture to increase productivity

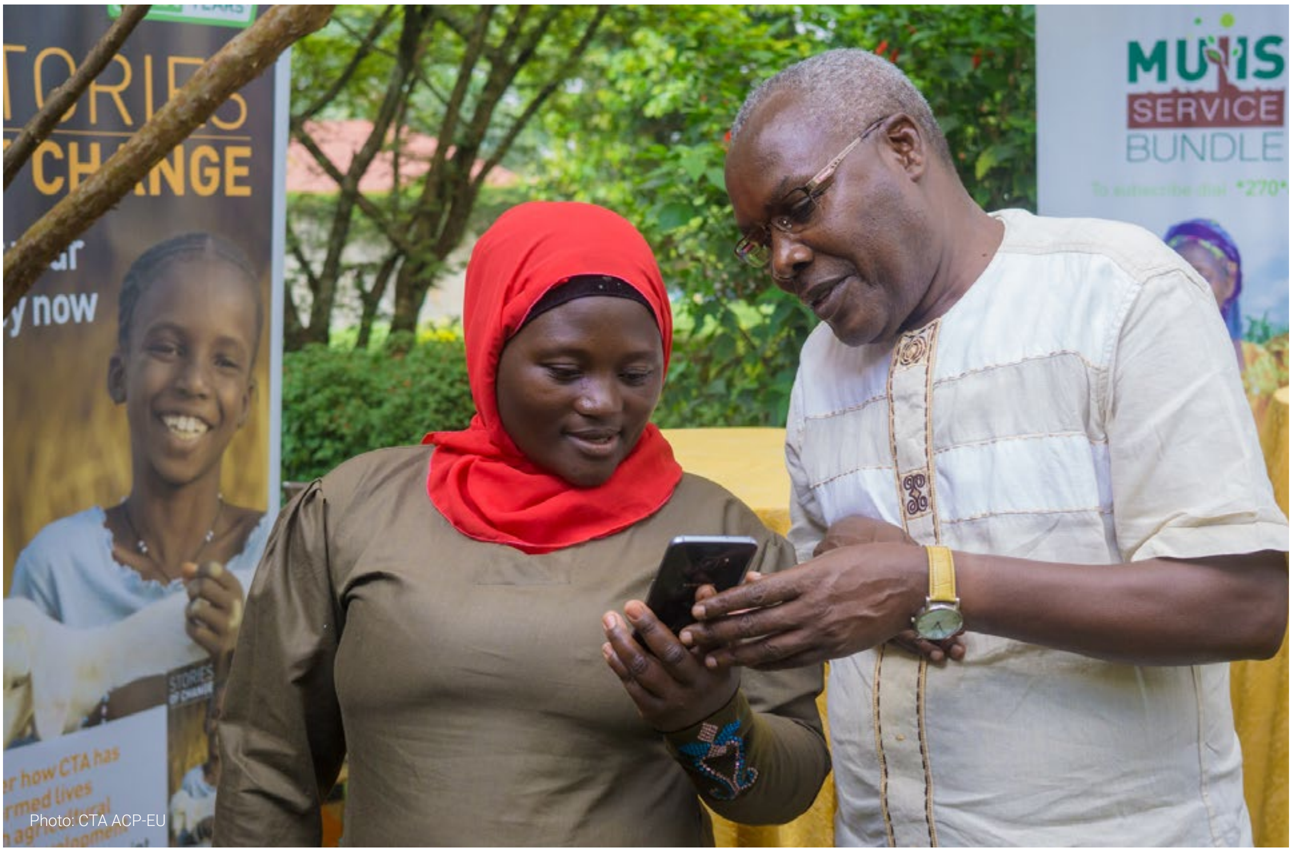


Photo: CTA ACP-EU

while minimizing environmental impacts through increased resource-use efficiency.

Financing agricultural adaptation is far more cost-effective than financing repeated crisis responses, disaster relief, and recovery efforts. Research synthesized in STA21 shows that for Sub-Saharan Africa, the cost of action on climate adaptation and food systems is less than a tenth of the cost of inaction: US$15 billion per annum compared with US$210 billion per annum.[4] Innovative approaches to climate change adaptation, however, will need to move beyond purely agricultural solutions into whole-food systems. Similarly, improvements to research and extension will need to be integrated into the whole agricultural chain. Innovation will also need to go together with use of local knowledge and systems as well as inclusive policies to achieve resilient and sustainable agricultural systems over the long term.

This chapter provides a detailed account of two trends in agriculture in Africa today that seek to drive the transformation required to enable agriculture and farmers in the continent to become more resilient in the face of climate change and its wide array of fallouts. The first is a timely convergence in thinking and policymaking about agriculture today, whether in the policy proposals of large multilateral institutions in the development or agricultural research space or in the agreements formulated at global forums like COP26, that emphasizes the need to take a holistic approach toward issues of agricultural productivity, sustainability, and technological innovation.

The second part of the chapter addresses a less widely disseminated subject, perhaps because it is more technical, but one that holds great potential for the future. This is the deployment of cutting-edge science in realms like plant breeding, genomic selection, pathogen resistance, and digital agriculture, often taking the form of collaborations between research organizations within and outside Africa. The goal is to devise and scale up innovative technological solutions to problems of soil health, crop productivity, genetic diversity, pest management, and lack of access to data and knowledge among smallholder farmers. Much of this work is highly specialized. But together, such solutions and emerging technologies can be combined into a very innovative and effective program of climate-smart agriculture (CSA) that addresses the challenges of the present and the coming decades.

CONVERGENCE ON THE CASE FOR A WHOLE-SYSTEM APPROACH

The need for an integrated approach to dealing with food security, climate change, and sustainability is a theme that connects several recent strategy documents, whether at global or regional levels. This section provides an overview of some of the most important of them.

In October 2015, the World Bank released the report "Future of Food: Shaping a Climate-Smart Global Food System," which examined ways to improve the productivity and resilience of the food system and to make agriculture part of the solution to climate change.[5] This report advocated for the widespread adoption of CSA to secure higher productivity, increased resilience to climate change, and lower greenhouse gas (GHG) emissions. The World Bank Group's "Climate Change Action Plan 2021–2025: Supporting Green, Resilient, and Inclusive Development"[6] recognized that building back from the COVID pandemic and the financial crisis will need to integrate climate and development strategies as well as align financial flows with the Paris Agreement.

The Koronivia Joint Work on Agriculture (KJWA), established at COP23, recognizes the unique potential for agriculture to tackle climate change and works to advance discussions on agriculture in the UNFCCC.[7] It addresses six inter-related topics: soil, livestock, nutrient use, and water management, as well as methods for assessing adaptation and the socioeconomic and food-security dimensions of climate change across agricultural sectors. The FAO supports its development and implementation. The COVID-19 pandemic has led to delays in implementation but its message of the need for climate adaptation and developing a wider network of partnerships is clear.

The FAO Strategic Framework 2022–2031,[8] released in October 2021, recognizes that food and agriculture hold the key to realizing the 2030 Agenda for Sustainable Development in an inclusive way that provides food security for all. CSA supports the plan for transformation of more efficient, inclusive, resilient, and sustainable agri-food systems to achieve the "four betters"—better production, better nutrition, a better environment, and a better life. The plan relies on innovative technological solutions to allow production of "more with less" and the implementation of systemic approaches across the whole food chain.

The COP26 Glasgow Climate Pact,[9] an output of COP26 in November 2021, focused on mitigation, adaptation, finance, and collaboration as a way to achieve its goal of keeping to the 1.5°C heating target set out in the COP21 Paris Agreement[10] in 2015. Notably, there was global agreement on an adaptation financing goal. While a substantial focus of these efforts was on the energy sector, it was also recognized that the natural environment will be an important part of the solution. For example, protecting and restoring ecosystems and managing land sustainably has the potential to reduce annual net GHG emissions by more than 7 gigatons by 2030. It was also recognized that while attention in the climate change space has been focused primarily on carbon dioxide emissions, methane is also a highly consequential GHG. Therefore, more than 100 countries signed up to the Global Methane Pledge at COP26 to reduce global methane emissions by 30 percent by 2030. Finally, COP26 also saw the launch of the Adaptation Research Alliance,[11] a global network of governments, businesses and local societies partnering to increase the resilience of vulnerable countries, placing indigenous knowledge and solutions at its core.

The Agricultural Innovation Mission (AIM) for Climate, a joint initiative led by the United States and the United Arab Emirates announced at COP26, focuses on enabling solutions at the intersection of agriculture and climate.[12] AIM for Climate seeks to address climate change and global hunger by uniting participants to significantly increase investment in, and other support for, CSA and food systems innovation over five years (2021–2025). At the heart of this initiative is the recognition that new technologies, products, and approaches will be needed to adapt vulnerable food systems. Increased investment is being attracted through "innovation sprints," aggregate self-financed investments from non-government partners to achieve an outcome in agriculture innovation and for CSA and food systems to be completed in an expedited timeframe.[13] The innovation sprints, which will be announced at COP27 in November 2022, focus on four key areas: Smallholder Farmers in Low- and Middle-Income Countries (LMICs); Methane Reduction; Emerging Technologies; and Agroecological Research.

The CGIAR 2030 Research and Innovation Strategy,[14] released in December 2021, refocuses CGIAR's efforts to achieve positive, measurable benefits across five interlinked impact areas, including climate adaptation and mitigation and environmental health and biodiversity. This strategy includes the transition to "One CGIAR" situating CGIAR in the evolving global context, which demands a systems transformation approach for food, land, and water systems. It aims to integrate CGIAR's assets and capabilities toward a new era of interconnected and partnership-driven research toward achieving the Sustainable Development Goals through a stronger, more relevant science agenda.[15] Its three action areas are systems transformation, resilient agri-food systems, and genetic innovation.

As the impacts of climate change increase, an increased alignment of different sectors on policy, financing, and strategy will be essential to successful implementation of CSA strategies to ensure the resilience of and sustainability of agricultural systems. The next section explains the nature and necessity of CSA in Africa today, and brings together a host of examples of such practice from the field today, collected under a series of broad themes, to give a sense of the possibilities of such an approach.

CLIMATE-SMART AGRICULTURE

CSA is an integrated approach to managing landscapes, including cropland, livestock, forests, and fisheries, that addresses the interlinked challenges of food security and climate change.[16] Agriculture and land-use changes contribute 25 percent of heat-trapping GHG emissions. Without interventions, this number will likely increase.[17] However, agriculture can also be part of the solution to climate change, with the potential to offset and sequester about 20 percent of annual emissions through improvements in soil management.[18] CSA aims to simultaneously increase agricultural productivity and enhance resilience while reducing GHG emissions. These improvements will require a full range of interventions, from innovations in crops and livestock to changes in management practices for soils, crops, water, livestock, forestry, and agroforestry, through systems approaches and enabling environments.[19] The World Bank Climate Change Action Plan 2021–2025 indicates that it will step up support for CSA across the entire agriculture and food value


Photo: CTA ACP-EU

chains, including the Blue Economy, via policy and technological interventions, using nature-based solutions where appropriate.[20] By taking an integrated approach, it is envisioned that productivity can be enhanced and resilience increased while reducing GHG emissions.

While the Green Revolution had positive impacts on food security, there were uneven outcomes for human nutrition, crop resilience, and the environment. As a consequence of the focus on staple grains and the adoption of expanded irrigation, the major benefits were in Asia, while Sub-Saharan Africa received fewer investments, particularly in orphan crops.[21] Going forward, achieving the necessary increases in plant productivity to meet growing food needs will require the development of climate-resilient crops tailored to local needs that can be grown sustainably. This will include leveraging naturally evolved traits as well as using new engineering strategies based on a mechanistic understanding. The efforts in research and development needed to effectively support agricultural adaptation to climate change are going to require not only an integrated approach across the whole food system, but the components will need to be tailored to local and regional preferences and needs, incorporate indigenous knowledge and practices, and be inclusive of women and youth. The focus of this chapter is on research and innovation with the potential for rapid scale-up and application for agriculture in Africa. Examples have been selected to illustrate specific regional issues, interventions, and drivers.

Genetic Strategies for Crop Adaptation

Genetic improvements have been a key component of the Green Revolution's success in increasing agricultural production, starting in the 1950s. Since then, there have been significant advances in the availability of basic biological information about potential targets for improvement and new sequence-based genomic tools that allow the acceleration of breeding strategies, as well as the modification of existing crop genes. These tools, including sequence-based trait mining and genomic selection, are allowing plant breeders to select and breed for specific traits in a more rapid and directed manner. Gene editing, using CRISPR-Cas9,[22] allows

Photo: Anne Wangalachi/CIMMYT

precise, targeted changes in genes within crops that might not be possible through traditional breeding approaches. The combination of these advances with the wealth of genetic resources contained within global genebanks opens up the possibility of using genetic diversity of crop germplasm for traits relevant to adaptation to abiotic stresses (drought, flooding, temperature stresses) and biotic stresses (pests, diseases) resulting from climate change.

One effort under way to address this critical topic, for example, is the AIM For Climate Innovation Sprint entitled "Fast Tracking Climate Solutions from Global Germplasm Banks."[23] This is a US$40 million initiative led by the CGIAR in partnership with the Foundation for Food & Agriculture Research and the Bill & Melinda Gates Foundation to unlock climate-resilient traits from CGIAR's global collections, expanding the utilization of high-value genetic diversity to benefit smallholder farmers. African "orphan" crops—those that have received little investment to date but are of local importance—may now be improved with respect to climate resilience as well as input use efficiency, yield, and nutritional content. These strategies will be most effective when used in conjunction with indigenous knowledge and expertise in growing and managing such crops in combination with new sensors and management techniques. Diversification of staple crops, use of indigenous knowledge, inclusion of women and youth, and integration into the whole value chain will be key to advancing CSA approaches toward more climate-resilient food production. The African Orphan Crops Consortium[24] is working to increase integration of orphan crops into African food systems through the development of sequence, genomics, and breeding resources for prioritized crop species. Intended outcomes of this strategy include providing quality planting material for farmers, improved nutritional content of crops, better value and remuneration for farmers, as well as new value chains, markets, and products.

Individual research initiatives as well as multinational collaborations have benefited from an expansion of the availability of web-based tools for plant breeders. The Breeding API (BrAPI) project[25] is an effort to enable plant-breeding databases to talk to each other. BrAPI is a web-based programming

Box 1. Online Breeding Tools and Resources

The goals of the CGIAR Excellence in Breeding (EIB) platform[28] is to empower breeding programs in the developing world to develop more resilient, nutritious crop varieties and livestock, faster and with greater relevance to local farmer communities. Its vision was developed by leaders and researchers from CGIAR in coordination with select National Agricultural Research Systems (NARS), funders, and private sector partners.

The Genomics Open-source Breeding Informatics Interface (GOBii),[29] funded by the Bill & Melinda Gates Foundation, is the first large-scale public-sector effort with the goal of systematically applying detailed mapping information to the breeding of staple crops in the developing world. The initial focus is on rice, wheat, maize, sorghum, and chickpea in South Asia and Sub-Saharan Africa. Its outputs will include decision-support tools for breeders. It collaborates with international partners, including the CGIAR (the International Maize and Wheat Improvement Center [CIMMYT], International Rice Research Institute [IRRI], and International Crops Research Institute for the Semi-Arid Tropics [ICRISAT]).

interface for communicating plant-breeding data that is open to anyone interested in plant-breeding data management. It covers a spectrum of data types including germplasm management, field trials, and genotyping, which can be used individually or in combination. It builds on established community data standards and can be used with any modern program language. Its partners are located worldwide and include Breedbase, CGIAR centers (IRRI, ICRISAT, International Center for Agriculture Research in the Dry Areas [ICARDA], International Potato Center [CIP], and CIMMYT), NextGen Cassava, AfricaYam, and DivSeek. This project is an essential building block connecting the use of germplasm collections to generate and test new varieties in the field and its architecture promotes collaboration. Its utility for African breeders would be expanded by internet availability in the field, bypassing the need to collect data and upload later when an internet connection is available.

A critical component of these breeding efforts focused on African crops will be the concomitant training of African breeders as well as provision of resources for them to be able to continue their work domestically and train others. The African Plant Breeding Academy[26] is a professional development course established by the University of California, Davis, in 2013 to teach the latest principles in plant breeding to Africa's top plant breeders. The courses are offered at the World Agroforestry Center (ICRAF) in Nairobi in partnership with The African Orphan Crops Consortium and the New Partnership for Africa's Development (NEPAD).[27] The course covers current approaches in plant breeding, quantitative genetics, statistics, and experimental design. It also includes accurate and precise trait evaluations, development of appropriate strategies to integrate genomics into breeding programs, and experience in identifying and utilizing genomic data and DNA-based markers in breeding programs.

Box 2. Genomic Selection Tools to Increase Maize and Wheat Yields

Researchers at CIMMYT are using genomic selection to increase the yield of maize and wheat varieties. In genomic selection, breeders use information about a plant's genetic makeup along with data on its visible and measurable traits, known as phenotypic data, to "train" a model to predict how a cross will turn out without having to plant seeds, wait for them to grow, and physically measure their traits. In this way, they save time and costs by reducing the number of selection cycles. The Accelerating Genetic Gain in Maize and Wheat for Improved Livelihoods (AGG) project, a partnership between Cornell University and CIMMYT, identified an optimal genomic selection strategy for maize using the EiB and GOBii. Over the last five years, CIMMYT's African maize breeding program has used genomic selection with the "test-half-and-predict-half" strategy, and has already reduced operational costs by 32 percent relative to traditional selection methods.[30]

Soil and Plant Health

Increasing basic knowledge about biological processes in plants, animals, and microbes, coupled with genome-scale analyses, is driving innovation in the development of biological solutions to CSA needs. Plants grow in a complex relationship with other living organisms as well as the environment around them. Advances in our understanding of the signals and receptors involved in communication across multiple organisms have enabled the development of new approaches to dealing with plant pathogens as well as fostering beneficial new associations. Biological approaches such as these can capitalize on and adapt existing pathways without many of the harmful environmental impacts brought about by chemical amendments, and they have the potential to avoid unintended consequences such as pathogen resistance. While some of these approaches are still at the proof-of-concept stage, they offer the possibility of sustainable long-term impact in Africa at scale, especially when used in concert with indigenous knowledge and advanced management approaches.

It has been estimated that 40 percent of the soils in Sub-Saharan Africa are low on nutrients.[31] Degraded soils do not just reduce the potential for food production but can also lead to desertification and erosion, while healthy soils contribute to resilience to flooding, nutrient cycling, and carbon sequestration.[32] Improving soil health requires both detailed knowledge of the specific regional issues as well as science-based management information.[33] The Alliance of Bioversity International and CIAT, the Plant and Soil Laboratory of University of Antwerp, and the Artificial Intelligence for Smart Agriculture Unit at the Leibniz Centre for Agricultural Landscape Research (ZALF) have synthesized more than one thousand primary studies to assess the impacts of different agricultural practices and climatic factors on soil health.[34] Their findings indicate that management practices, lack of diversity of crops grown, and the types of input applied can have negative impacts on the fungal components of soils.

Healthy soils comprise four major components: minerals, water, air, and organic matter. The living component of soils is a complex mixture of microscopic organisms such as bacteria, algae, and fungi, as well as nematodes, microarthropods, earthworms, and insects. These organisms play a critical role in soil fertility. Loss of, or alterations to, soil microbial communities can negatively impact soil health and consequently the productivity of crops it supports. Mutually beneficial associations ("symbioses") between flowering plant roots and a class of fungus (arbuscular mycorrhizal fungi) have been shown to be important for plant mineral uptake, including phosphorus.[35]

Another symbiosis important for plant nutrition and soil health is the association of legumes with nitrogen-fixing bacteria (for example, *Rhizobia* species). These symbioses lead to biological nitrogen fixation within the plant, which provides nutrition for the plant host and also enriches the surrounding soil. However, application of nitrogen fertilizers can decrease biological nitrogen fixation within legume crops, along with additional factors such as the crop cultivar, strain of nitrogen-fixing bacterium in the symbiosis, and additional environmental conditions. The N2Africa project,[36] a large-scale, science-based "research in development" project, has focused on putting nitrogen fixation to work for smallholder farmers in Africa. In this strategy, scientific research is linked with capacity building that engages actors along the whole chain, from farmers to traders, extension workers and NGOs, with an emphasis on training, women's empowerment, and input/output market access though public–private partnerships. The project, which is funded by the Bill & Melinda Gates Foundation, has been active in 11 African countries and focuses on common bean, chickpea, cowpea, fava bean, groundnut, and soybean. N2Africa optimizes plant genotypes, *Rhizobia* strains and management approaches and by testing with a wide range of farmers, it is tailoring and adapting legume technologies to specific sites and farmer needs. By 2017, N2Africa had already reached more than 600,000 smallholder farmers with improved technologies for grain legume production.

The reduction in biological nitrogen fixation efficiency in many grain legumes compared to wild relatives is likely to be, at least in part, a consequence of genetic changes that occurred during domestication. There is a wealth of legume genetic diversity in the world's plant diversity collections, including the CGIAR collections, that can serve as a source of useful traits, and analysis of wild relative genomes can allow restoration of genes required for establishment of robust symbioses as well as increased rates of biological nitrogen fixation. The transition to CSA would be greatly enhanced by reduction of, or removal of, the need for nitrogen and phosphorus fertilizers. While the use of organic management practices is one component of this strategy, its impacts could be significantly increased by transfer of the ability to form symbioses to enhance phosphorus and nitrogen availability in a wider range of plants. Recent advances in our mechanistic understanding of how these symbioses are established indicate that there are a relatively small number of genes necessary to confer biological nitrogen-fixing capabilities in non-legumes.[37] While this is almost certainly a longer-term approach, it would increase the options for African farmers to manage plant nutrition in a more sustainable and reliable way and reduce reliance on expensive and potentially environmentally harmful chemical fertilizers.[38] In the interim, management practices can accelerate the transition to sustainable practices. For example, a decade-long study shows that the management of placement and timing of nitrogen fertilizer on maize crops using conservation agriculture practices maintains productivity.[39]

There has been a movement toward using soil amendments such as biochars (charcoals) and microbial fertilizers and there is growing private-

Photo: S. Kilungu/CCAFS

sector activity in this area. However, there is a need to evaluate the interactions of these components with respect to different soils and environments so that treatments can be standardized and optimized.[40] Modern breeding tools have enhanced and accelerated the ability to breed and gene-edit crops with enhanced use efficiencies for water, phosphorus, and nitrogen. However, the complex interrelationships between plant processes, architecture and productivity will necessitate an integrated approach to developing climate-resilient crops rather than a gene-by-gene or trait-by-trait approach.[41]

Adaptation to Biotic Stresses

The impacts of plant pests—any species, strain or biotype of a plant, animal, or pathogenic agent injurious to plants—are already being exacerbated by climate change. Warming temperatures can expand the range of plant diseases as well as facilitate the establishment of new invasive species.

Plant disease resistance genes were early targets of breeding efforts, conferring race-specific resistance to adapted pathogens. However, while these genes are effective individually at conferring resistance, the resistance quickly breaks down under field conditions as the pathogen mutates into new resistant forms. Efforts to incorporate multiple resistance genes is time-consuming, technically more challenging, and can result in a reduction in yield because the plant has to divert resources to express the resistance pathways.[42] However, this approach is more durable in the field than single resistance genes and the 2Blades Foundation has been introducing between three and five resistance genes to confer wheat stem rust resistance.[43]

Advances in next-generation sequencing methods and the availability of high-density marker platforms have enabled mapping of quantitative trait loci (QTL) for broad-spectrum resistance to multiple variants of the same disease in crops where these resources are available. These broad-spectrum disease loci comprising major and minor contributing genes have been identified in several crops (such as sorghum[44] and rice[45]) but they have not yet been used extensively in crop production, perhaps because of associated reductions in yield.[46] The challenge for many African crops is that sequence and marker resources are often insufficient or unavailable. Where these are available, there has been significant progress in developing varieties with disease resistance that holds up under field conditions. The availability of sequence data and molecular tools for crop plants have enabled advances in understanding the basis of disease resistance and development of potential solutions. New multi-parent crop plant populations contain many of the desired traits sought by plant breeders, and they have attributes that make them suitable as a basis for breeding programs. Low-cost, sequence-based genotyping has become a highly cost-effective and efficient tool for a wide range of crops.[47]

Rice cultivation in Africa has increased significantly over the past two decades and during this time there has been a significant increase in rice bacterial blight caused by *Xanthomonas oryzae pv. Oryzae (Xoo)*. This disease is expanding to new rice production areas and results in losses of up to 50 percent, threatening food security. The most effective way to control the disease is through use of resistant germplasm.[48] New genetic populations have been used to map resistance loci for two major rice diseases, bacterial leaf streak and bacterial blight, caused by *X. oryzae* variants, some conferring resistance to multiple disease variants. Controlling these diseases is very important in Sub-Saharan Africa, where there are no sources of disease resistance in the lines that are currently deployed, and the new populations can serve as a source of new disease resistance loci in breeding programs.[49] Gene editing is an effective tool for creating resistance loci when there is knowledge of a pathway and potential targets. Cassava (*Manihot esculenta*) is believed to have been introduced to Sub-Saharan Africa by the Portuguese during the 16th century and is now a major source of calories in this area. Cassava's ease of vegetative propagation and resilience to abiotic stresses allows it to grow in a wide range of agroecological zones where many other crops cannot thrive.

However, as a staple crop, cassava has several drawbacks, including the poor protein content in tubers as well as low levels of vitamins A and E, iron, and zinc. Vegetative propagation under poor phytosanitary conditions also makes it susceptible to devastating viral diseases, including cassava mosaic disease (CMD) and cassava brown streak disease (CBSD), as well as additional viral and bacterial diseases.[50] CMD results in mottled and deformed leaves; infected plants are often stunted and produce few tubers. CMD resistance has been obtained using genetic approaches. In contrast to CMD, CBSD has few distinct leaf symptoms and can take a long time to become established, but it eventually results in necrosis of the tubers, making it difficult to screen plants for infection or resistance. There is no resistance against the viruses causing CBSD in African cassava varieties, and all of the common landraces and improved varieties eventually succumb.

However, there are sources of resistance in South American germplasm held at CIAT and these have been screened through the NextGen Cassava partnership using a new, fast-forward screening method developed to identify resistant crosses.[51] This strategy has resulted in identification of seedlings that carry both CMD and CBSD resistance and the CBSD resistance is a dominant trait.

Cassava is also susceptible to multiple bacterial diseases, including cassava bacterial blight (CBB). Four resistance genes have been isolated from cassava for the one strain and shown to mediate resistance in cassava, opening up the possibility for breeding strategies.[52] The cassava germplasm collections are likely to contain additional sources of resistance that could be introduced into breeding programs with the availability of the appropriate tools and resources.[53]

Box 3. NextGen Cassava

NextGen Cassava, funded by the Bill & Melinda Gates Foundation and the UK Foreign, Commonwealth and Development Office (FCDO), brings together 13 partners, including CGIAR, across eight countries on four continents. Its activities are organized around three primary divisions: breeding, research, and survey. Its breeding programs incorporate disease-resistant cassava germplasm from South America into the breeding populations and implement genomic selection strategies to accelerate the breeding cycle. The NextGen Cassava varieties are focused on quality traits including increased yield and improved disease resistance, traits identified through research surveys as of utility for smallholder farmers and cassava processors. Its work has been accelerated by development of a third generation HapMap for cassava, whole genome sequencing, a collection of 1,273 cassava clones, 20 million single nucleotide polymorphism (SNP) markers and genotyping of over 42,000 cassava accessions. Genomic selection approaches have shortened the breeding cycle time by more than half. NextGen Cassava also trains the next generation of cassava breeders and works closely with NARS.

One example of a new NextGen Cassava variety is Gamechanger, bred by IITA and the National Root Crops Research Institute in Nigeria.[54] Gamechanger cassava is resistant to CMD, cassava anthracnose disease (CAD) and cassava mealybug with moderate resistance to CBB, and tolerance for cassava green mite (CGM). It has improved processing qualities including high dry matter and yield and is suitable for making high-quality flour.


Photo: Nikada/istock

Photo: Ollivier Girard/CIFOR

Plant insect pests also pose increasing challenges as their ranges move with a changing climate and outbreaks become more frequent. Conventional genetic modification approaches are still yielding useful outcomes in the field; for example, in generating crops that are resistant to pests. *Maruca vitrata*, the Maruca pod borer, is a pantropical pest of legume crops, including pigeon pea, cowpea, mung bean, and soybean. In cowpea, there are no known resistance genes for this pest. Cowpea genetically modified with *Bacillus thuringiensis* (Bt) protein is resistant to *M. vitrata* and shows yield increases over non-Bt varieties.[55]

Parasitic nematodes are also devastating pests that kill the roots of susceptible plants, preventing the uptake of water and minerals. Impacted crops include potatoes, tomatoes, beans, bananas, and yams. There are over 4,100 species of plant-parasitic nematodes, which collectively cause an estimated US$80–125 billion in annual damage to crops.[56] The most economically significant of these species are those that target plant roots of major production crops, which make up about 15 percent of all known nematode species. For example, wheat, which is a staple food for 40 percent of the world's population, suffers significant reductions in yield when infected by the cereal cyst nematode (*Heterodera* spp.) Rice, another of the world's primary staples, also suffers from nematode infestations and approximately 10–25 percent of global annual yield loss in rice is attributed to the more than 100 species of nematodes. One of these species, *Meloidogyne graminicola*, may reduce yields in affected fields by up to 80 percent. Sweet potatoes, the world's sixth most important food crop and fifth most important in LMICs, are subject to approximately 10 percent annual yield loss due to plant-parasitic nematodes worldwide.

Unfortunately, chemical control of nematodes is expensive, environmentally damaging, and of limited utility. While genetic strategies have been successful in some cases, these do not necessarily transfer successfully to other hosts/nematode races. Basic studies of the signaling pathways that nematodes use to find plants has yielded a potential nature-based strategy. Plants release small molecules into the soil and nematodes have receptors that can detect these molecules and use them to locate potential hosts. Synthetic versions of these molecules could potentially be used to treat fields in place of older chemical treatments, which are deleterious to the environment.[57]

A number of companies have been established to develop biologically inspired pest and pathogen treatments. This type of strategy is consistent with sustainable agricultural practices and, with appropriate partnerships, could be extended to crops where genes for genetic resistance to nematodes are lacking.

Controlling the Impacts of Parasitic Weeds

Parasitic weeds in the family *Orobanchaceae*, and especially those in the genus *Striga*, are serious pathogens of cereals crops (corn, sorghum, rice, sugarcane) that are widespread across parts of Africa, Asia, Australia, and North America. *Striga*, also known as witchweed, is an obligate parasite and cannot complete its lifecycle without a living plant host to trigger germination and support the early stages of development. The impacts of *Striga* on subsistence farmers can be devastating because it causes serious yield reduction and symptoms include stunting, wilting, and chlorosis. *Striga* species are major constraints to agriculture throughout semi-arid Sub-Saharan Africa. Over 50 million hectares of arable farmland under cultivation with cereals and legumes are infested with one or more *Striga* species.[58] Many African countries, including Tanzania, Kenya, Malawi, Madagascar, Botswana, Zimbabwe, Gabon, Nigeria, Ethiopia, Niger, Togo, Benin, and Burkina Faso, have high levels of parasitic weed infestation.[59] In South Africa, *Striga* remains the single highest biological constraint to cereal grain production. In total, African smallholder farmers are losing more than half a million tonnes of rice a year because of *Striga*.[60] The FAO estimates more than US$7 billion is lost due to *Striga* across Africa every year, adversely affecting over 300 million people on 50 million hectares of *Striga*-infected croplands.[61]

Striga is particularly difficult to control because each plant can produce anywhere between 90,000 and 500,000 tiny seeds, which can remain viable in the soil for 10 years or longer. Germination is triggered by detection of chemicals (strigolactones) secreted by host plant roots. The parasitic seedling finds and attaches to the host roots. After a one-to-two-month development phase, the parasitic seedling flowers and produces seeds. Because the seeds are readily distributed by wind, water and in the soil as well as through human activity, and much of the lifecycle occurs underground, *Striga* is very difficult to control. Climate change will be likely to exacerbate the problem since crops grown under poor moisture and low-fertility conditions are especially susceptible, and plants that are growing under phosphorus-poor conditions release increased amounts of strigolactones.

Despite concerted efforts to develop methods of *Striga* control, to date there has been no single effective solution.[62] Control of *Striga* using chemical, biological and management strategies have met with limited success, in part because they are too expensive and/or too knowledge-intensive.[63] For smallholder farmers, this can mean having to abandon infected land, so new, sustainable solutions are urgently needed, especially as the impacts of climate change increase soil degradation and soil temperatures, creating more favorable conditions for the spread of *Striga*. Mapping [64] and modeling[65] are under way to understand the extent of potential impacts in different African regions.

Breeding of *Striga*-resistant varieties using crop genetic diversity is being explored to evaluate whether there are sources of resistance genes in major impacted crops.[66] *Striga* attachment host plant resistance traits, but these do not necessarily hold up against different *Striga* strains, and resistance has been found to break down in some cases.[67]

Another complementary strategy that has been used to generate *Striga* resistance is physical mutagenesis. A recently completed International Atomic Energy Agency Coordinated Project (D25005) enabled experts from 12 countries to identify novel sources of *Striga* resistance in cereals. A total of 64 induced mutants were identified with resistance and/or tolerance to two major *Striga* strains in sorghum, maize, and upland rice. At least three of the verified mutants for each crop were advanced to field evaluation for possible release in the participating countries (Burkina Faso, Madagascar, and Sudan) and capacity building provided in the form of training.[68]

The use of synthetic versions of strigolactones that mimic the growth signals *Striga* picks up from crops is being explored to pre-germinate and kill parasitic plant seeds prior to planting crops in the field.[69] The Japanese Institute for Transformative Bio-molecules (ITbM)[70] at Nagoya University has developed and is testing the efficacy of small molecules based on strigolactones.[71] These small molecules could be sprayed on a vacant field to germinate all the *Striga* seed, and once the plants had died off because they failed to find a host, the field could be potentially usable again for farming. This strategy is attractive because the small molecules are based on a biological understanding of the mechanism of strigolactone action, they are effective at low concentration, and would provide much-needed control strategies when genetic resources are not sufficient or available.

Adaptation to Abiotic Stresses

Climate change is already impacting African agriculture, causing reductions in maize and wheat yields in Sub-Saharan Africa and an estimated 34 percent reduction of agricultural production since 1961. The Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) sets out the irreversible consequences of global warming beyond 1.5°C for Africa, including shortened growing seasons and increased water stress.[72] The report flagged drought as a major driver for food insecurity and reduced crop yields.

Climate change exerts a range of impacts through multiple environmental changes, with downstream impacts on a range of crop attributes, including physiology, nutritional content, and yield.[73] An increase in average temperature during the growing season leads to greater energy use in plants for respiration and maintenance, and reduced growth. Reproductive cycles are shorter and yields lower, with accompanying impacts on nutritional content. Higher nighttime temperatures can impact seed set and yields of grain crops such as rice. Changes in the average amounts of rainfall, timing and intensity will work synergistically with temperature changes leading to increased moisture stress. These impacts will be severe for rainfed agricultural systems, and especially those with degraded soils. Shifting planting seasons and extreme weather events will make it difficult for farmers to determine the best times to plant.

Adaptation to the changes in plant growth ranges resulting from climate-induced changes in temperature and rainfall will necessitate better use of genetic resources, inputs, and management tools to continue to sustain crop production. At the same time, sustainable intensification will be needed to meet growing food needs while minimizing environmental impacts. Since the Green Revolution, mainstream agriculture has focused on a few key crops using controlled genetics alongside application of fertilizers and pesticides to maximize production.[74] The FAO “Save and Grow”[75] model for sustainable production and intensification calls for “greening” of the Green Revolution approach through the use of high-quality seed of diverse, well-adapted varieties with good agroecological practices to maintain soil health along with integrated pest management. Technological improvements can be part of building this kind of strategy when integrated into a whole-chain approach. Current efforts are focused on partnerships that integrate local knowledge, traditional practices, and new technologies to bring the needed innovations to the field.

Three of the Feed the Future Innovation Laboratory for Crop Improvement Centers funded by USAID are based in Africa: The East African Center of Innovation for Finger Millet and Sorghum (CIFMS) in Uganda, the Center for Innovation for Crop Improvement for East and Southern Africa (CICU-ESA) in Malawi, and Crop Innovation in West Africa (CIWA) in Senegal.[76] These

regional hubs, which represent partnerships between Cornell University in the US and African scientists on the ground, are working to accelerate improvement of crops essential for food security in a wide range of environments and cropping systems, with a focus on community needs. A goal of the hubs is to empower smallholder farmers, especially women and youth, to move from subsistence farming to food and nutritional security using interventions across the whole food chain. For example, CIFMS is breeding new varieties of sorghum and finger millet resilient to biotic and abiotic stresses as well as containing improved protein and micronutrient content, using gene and molecular marker discovery for novel traits.

The CGIAR system plays a central role in the development of genetic resources for African farmers with support from the platforms for Excellence in Breeding (EiB), genebanks, and Big Data for Agriculture. As part of the One CGIAR reform, the Global Science Group on Genetic Innovation will implement a crop breeding and seed system project for key crops, including groundnut and millet, across western and eastern African countries.[77]

This whole-chain system includes conservation of genetic resources in genebanks and facilitating and expanding their use by stakeholders, as well as accelerating crop improvement through precision genetic tools and enabling tools and technologies.

A new project led by CIMMYT under One CGIAR, called Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA),[78] will focus on increasing the productivity, profitability, resilience and marketability of grain, legume, and cereal crops. It will take a whole-system approach, strengthening networks to modernize crop breeding by CGIAR and national program partners and public–private partners to strengthen seed systems. The project is currently working in Burkina Faso, Ethiopia, Ghana, Mali, Nigeria, Uganda, and Tanzania. A CGIAR initiative entitled “Building Systemic Resilience Against Climate Variability and Extremes” (ClimBeR)[79] also takes a whole-food-systems approach to dealing with the poor climate adaptation preparedness of food and agricultural systems in low- and middle-income countries, including Kenya, Senegal, and Zambia. ClimBeR builds on prior investments, proposing clear pathways to improving the lives of 30 million smallholder farmers in six countries by 2030. It aims to transform the climate adaptation capacity of food, land, and water systems with the goal of increasing resilience of smallholder production systems to withstand climate impacts such as drought, flooding, and high temperatures. The focus

Photo: Cinoby/iStock

on adaptive transformation tackles the root causes rather than immediate causes of vulnerability, and the intended impacts extend beyond technology and solutions to integrate social equity, environmental quality and protection, and technical aspects, domains that are key to long-term success.

Livestock

Livestock is an important component of any climate-resilient agricultural strategy, accounting for 40 percent of the global value of agricultural output and directly supporting the livelihoods and nutritional security of 1.3 billion people.[80] More than 500 million pastoralists worldwide depend on livestock as a means of income, food security, and asset storage. These pastoralists are among the most vulnerable to climate change. Conversely, the livestock sector emits an estimated 7.1 gigatons of CO_2 equivalent per year, representing 14.5 percent of human-induced GHG emissions. Improving the efficiency and resilience of livestock supply chains is key to both limiting the growth of GHG emissions and protecting the food security and livelihoods for billions.

Many strategies exist to both minimize the climate impact of livestock and to improve climate adaptation of the livestock sector. Enteric methane produced by livestock is a significant source of GHG emissions. Work to mitigate the sector's emissions is under way through the development of technological solutions, developments in feed additives, and genetic efforts to develop lower methane-producing livestock breeds. Meanwhile, livestock animals are particularly at risk from pests and diseases whose ranges are expanding with climate change. Advances in vector control, vaccines and antimicrobials, and veterinary epidemiological monitoring systems are all under way to help mitigate these emerging threats.

Box 4. Bracharia, a Perennial Forage Grass for Soil Rehabilitation and Improved Livestock Feed

Arable land is being lost at an unprecedented 30–35 times the historical rate. Unsustainable management practices and intensive agriculture are eroding soils, having significant impact on the sustainability of food systems. Today about 25 percent of the world's soils are degraded and about 3.2 billion people are impacted by land degradation, especially rural communities and smallholder farmers. Sustainable, regenerative agricultural practices, including the use of more diverse crops, can instead allow agriculture to contribute to soil rehabilitation and land restoration. CGIAR is developing new crops as part of this effort.[81]


Photo: Vinicius Abe/Shutterstock

In Tanzania, Bracharia, a leafy perennial forage grass that originated in this area, is being used to increase soil carbon and reduce nitrous oxide emissions. Bracharia increases stable carbon storage through its deep roots and also releases a secondary compound into the soil than inhibits nitrification. Its tolerance of extreme climatic conditions as well as ability to grow in low-fertility soils make it a useful component of CSA systems.

In addition to its value for soil remediation and stable carbon capture, Bracharia is also valuable as an animal feedstock.[82] The Climate-Smart Bracharia program at the BecA ILRI Hub in Kenya provides technical support to NARS, non-governmental organizations, and the private sector on Bracharia grass production and forage biosciences.
Its research includes disease management, development of a Bracharia-legume cropping system for soil fertility management, African Bracharia seed production niches, and the use of plant-beneficial microbes to enhance resilience and production of Bracharia grass in Sub-Saharan Africa.

Tools and Data for Decision-Making

More than 60 percent of Sub-Saharan Africans are smallholder farmers, and nearly a quarter of Africa's GDP comes from agriculture.[83] However, most crops are not currently reaching full yield potentials and the impacts of climate change are only likely to reduce productivity further. For example, 50 percent of the droughts caused by anthropogenic climate change between 2001 and 2011 took place in Africa. The use of digital data for agriculture ("digital agriculture") and Artificial Intelligence (AI)–driven decision tools built on large data sets can enable farmers to better manage inputs such as water, fertilizer, and pesticides, as well as predict and manage the impacts of extreme weather events to improve and maintain productivity.[84]

A 2022 report from the FAO and the International Telecommunications Union (ITU)[85] reviewed the status of digital agriculture in 47 Sub-Saharan African countries. It is clear that different countries are at varying levels of digital transformation, but with almost 60 percent of the population under the age of 25, active engagement of youth in agriculture is essential, along with training for women and youth. A major barrier to expanding digital agriculture is the lack of investment in rural agricultural infrastructure as well as insufficient investment in research and development, agro-innovation (for example, in sensor development),[86] and agricultural entrepreneurship, which are essential drivers of digital agriculture transformation.

Expansion of broadband internet availability is needed to support data collection, forecasting, and dissemination of real-time information. In the short term, prioritization of connection of Sub-Saharan African countries to undersea cables is needed to improve broadband access for coastal and landlocked countries. These modalities could be complemented with available terrestrial backbones to link urban and rural areas.[87] In the longer term, satellite internet could have significant impacts on the coverage and speed of broadband access. A new range of low-power, sensor-to-satellite terminals and modules was recently announced that make it possible to connect agricultural sensors anywhere in the world, where there is no alternative coverage.[88]

A fourth agricultural revolution is under way, encompassing the application of smart technologies such as AI, biotechnology, the internet of things (IoT) linking sensors to the internet, big data, and robotics, to increase agricultural productivity and sustainability.[89] According to a 2019 report issued by the Technical Centre for Agricultural and Rural Cooperation,[90] more than 400 different digital agricultural solutions were reported to be in use in Africa among 33 million registered farmers across the Sub-Saharan region. More than a third of the participants said that they used at least one connected technology, such as field sensors, unmanned aerial vehicles (UAVs or "drones"), big data, or data analytics. Together these tools can assist farmers with data-driven management of irrigation and fertilization of their crops. Farmer advisory services are providing weather and planting information by SMS or smartphone, as well as market and supply chain information. These tools are already leading to yield improvements and accompanying increases in income for farmers. However, there are still significant gaps in uptake, particularly in young women who, according to the report comprise 40 percent of the agricultural labor force yet make up only one quarter of the registered users of digital services. Women have been reported to be 13 percent less likely to own a mobile phone.[91]

Digital services are being developed in both the public and private sectors. Africa Agriculture Watch (AAgWa)[92] developed by AKADEMIYA2063, an African non-profit organization, is a web-based platform that links to a technical model that uses machine learning and remote sensing data to predict agricultural yields and production of crops across Africa. African digital farming services are growing at nearly 45 percent per year, and Sub-Saharan Africa now has over 400 apps and platforms.[93] For example, Farmerline,[94] launched in Ghana in 2013, and the DigiFarm[95] app, which was launched in Kenya in 2017, provide access to business intelligence, quality inputs and access to financial services. AKILIMO,[96] an agronomic advisory service developed for and with smallholder farmers, is employing state-of-the-art analytics to provide site-specific recommendations that optimize productivity and profits. To date, its recommendations have been validated by more than 5,000 smallholder growers and used by over 200 partner organizations.

While the reach of digital services is growing quickly, more than half of the solutions are headquartered in East Africa and nearly two-thirds of registered farmers are based in East Africa, with the majority in Kenya.[97] Uptake of apps is limited by lack of internet access, as 3G networks only cover about 40 percent of Sub-Saharan Africa's rural areas, and half the region's population had no access to electricity as of 2020.[98] There are intermediate solutions—for example, the publicly funded apps PlantVillage Nuru[99] for disease diagnosis and CubicA[100] for weather and agricultural information, which do not require an internet connection. One critical area where digital tools can have a significant impact is in irrigation.[101] The majority of African farmland is rainfed, and the dependence on unpredictable rainfall makes food production seasonal and vulnerable to climate change. Irrigation can be costly and potentially detrimental to the environment and currently only 6 percent of cultivated African farmland is estimated to have access to reliable irrigation. In the private sector, SupPlant[102] is working with about half a million, mostly female smallholder maize farmers in Kenya using sensorless technology to gather hyperlocal climatic, plant, and irrigation data, while SunCulture[103] manufactures and distributes affordable solar-power irrigation solutions to meet smallholder irrigation needs.

Some of these digital solutions have led to the development of new tech start-up companies serving African agriculture. There are agri-tech companies covering almost every aspect of the agricultural chain, including financing, insurance, weather data, water and fertilizer inputs, disease tracking, cold storage, and market data. These solutions are critical for African farmers to be able to implement CSA in the face of technological constraints. An enabling business environment is fundamental to attracting investment to create a favorable business environment, especially start-ups.[104]

Box 5. PlantVillage Nuru

PlantVillage Nuru is a publicly developed and supported app that uses an AI-trained digital assistant to help farmers diagnose crop diseases in the field without an internet connection. For example, the app uses more than 200,000 annotated images of identifying and classifying diseases and uses these to train the digital assistant. The initial primary focus was cassava, although resources are now available for other crops, including rice and wheat. Partners include the CGIAR (CIP, CIAT, IITA, CIMMYT and IFPRI) as well as Penn State University, West African Virus Epidemiology for food security (WAVE), and the FAO. The project was a CGIAR Platform for Big Data in Agriculture Inspire Challenge 2017 pilot project and 2019 scale-up winner.[105]

Smartphone tools are also being developed to assist farmers with mechanization. The Hello Tractor app,[106] which won the 2021 Agtech IOT Platform of the Year award, connects farmers with tractors, matching supply and demand and maximizing profit and social outcomes. The app lets tractor owners rent their vehicles to smallholders in their area and allows farmers to pool efforts to rent a vehicle at affordable rates. Its innovative route optimization tool uses GPS data from the tractors to monitor supply locations and attributes, as well as weather forecasts to generate a monthly plan of activities. Hello Tractor, which operates in 13 countries, including Nigeria, Kenya, and Tanzania, has been described as "Uber for tractors." Since its launch in 2014, Hello Tractor has served more than half a million farmers and 55 percent of the customers were using the app for the first time.

The African Soil Information Service (AfSiS), funded by the Bill & Melinda Gates Foundation, provides detailed information that can be used to determine the best use of inputs such as fertilizers and other management practices.[107] Its activities are supported by close scientific, operational, and implementation partnerships with the Agriculture and Food Security Center (AgCenter)[108] and the Center for International Earth Science Information Network (CIESIN) at Columbia University in the United States,[109] ICRAF in Kenya, the International Food Policy Research Institute (IFPRI) in the United States,[110] ISRIC

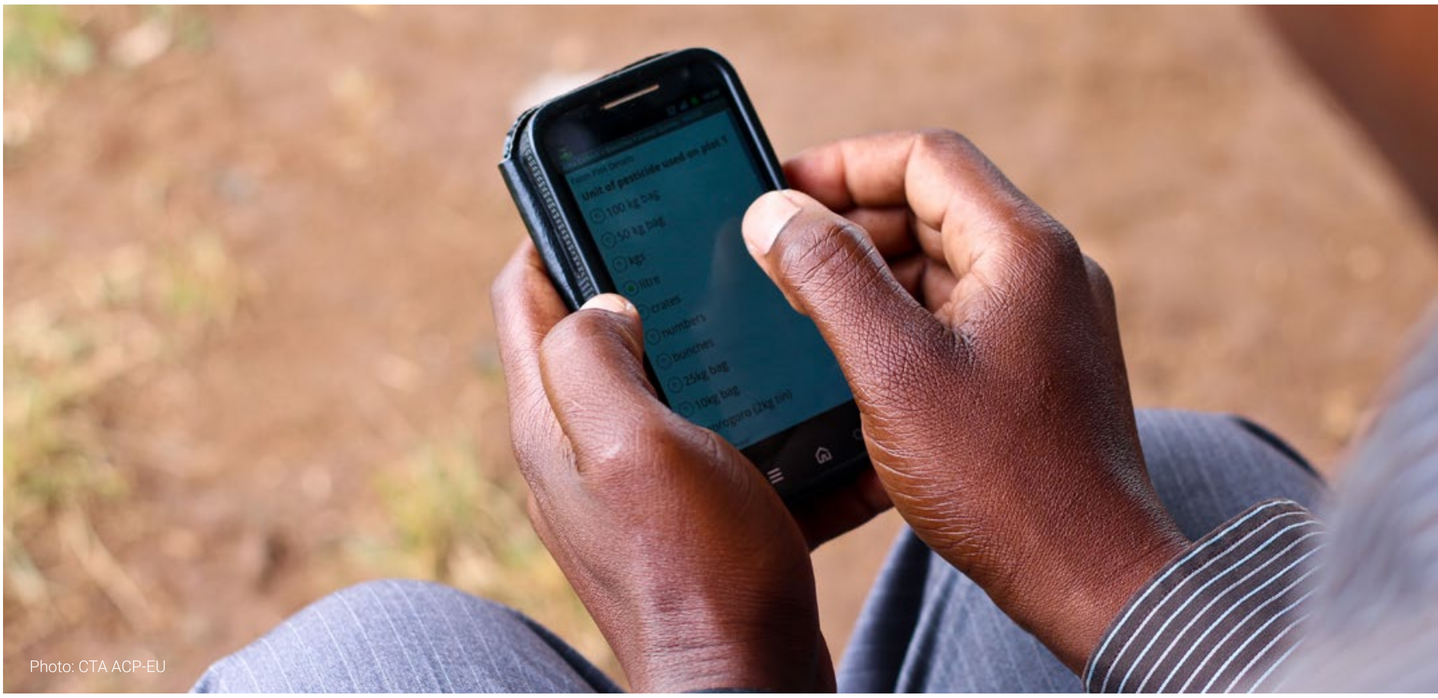


Photo: CTA ACP-EU

World Soil Information in the Netherlands,[111] and Rothamsted Research in the United Kingdom.[112]

Innovation in internet-linked sensor development could help to fill in gaps in forecasting and management data. For example, low-cost sensors built from off-the-shelf hardware can be used to measure and transmit diverse soil characteristics,[113] monitor environmental conditions,[114] as well as trap and identify insects.[115] Initially formed as a start-up company, ThirdEye[116] supports farmers in Mozambique and Kenya through its drones, which carry spatial sensors as well as sensors capable of detecting crop stresses before they are visible to the human eye.[117] These data allow farmers to make data-driven decisions about where and when to apply inputs (water, fertilizer, seed, and labor). This program was initially established using support from the Securing Water for Food program funded by USAID, the Swedish International Development Cooperation Agency (SIDA), and the Dutch Government Department of Foreign Affairs. iSDA Africa is investing in near-infrared handheld sensors to enable low-cost, farm-level measurement of soil properties, the nutritional content of crops, feeds and manures, and soil health diagnostics. iSDA partners with multiple organizations, including ICRAF and Rothamsted Research, and its soil data is hosted on the Amazon Web Services (AWS) registry of open data along with associated metadata. Where broadband internet access is not available, this kind of agronomic information is being made available through text messaging services. For example, Precision Agriculture for Development (PAD), a non-profit organization based in the United States, provides information to African farmers tailored to local soil, weather, and marketing conditions. In the private sector, Zenvus[118] and AgrCenta[119] provide similar kinds of services.

Open access to data will be important to sustaining the growth of digital resources for African farmers. The Global Open Data for Agriculture and Nutrition (GODAN)[120] is a partnership of more than 374 entities from national governments, non-governmental, international, and private-sector organizations that supports proactive sharing of open data to make information about agriculture and nutrition available, accessible, and usable. While there are existing policies for digital information and communication technologies, these are not aligned to existing agricultural policies, which hinders the process of digitization in the agricultural sector. The FAO/ITU report recommends the development of national strategies that support the digital transformation of agriculture. Digitization should encompass the entire value chain and be fostered at the government level. Increased collaboration among countries, international organizations and the private sector will be needed to create a set of public goods in agriculture that are sustainable and scalable.[121]

Box 6. Seeds for Needs

Climatic uncertainty means that smallholder farmers need to have more confidence in the seeds they use. Therefore, the CGIAR Research Program on Water, Land and Ecosystems (WLE) and The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) have launched a Seeds for Needs program targeting these farmers with a diverse range of seeds that are able to thrive in a changing climate.[122] Along with the seeds, they provide additional support to help farming communities adapt to climatic and other shocks, directly addressing their vulnerability to food insecurity. Seeds for Needs interventions include support for farmer selection of appropriate germplasm and cropping systems, as well as information about nutrition and conservation. The farmers are invited to be part of on-farm experimental trials of selected seed varieties. A Seeds for Needs program launched in 2011 by CGIAR in partnership with the Ethiopian Biodiversity Institute (EBI) with a focus on female farmers, has been implemented for wheat and barley in collaboration with local research institutes. The Seeds for Needs approach has also been used by other organizations in Ethiopia, including the Integrated Seed Sector Development Program (ISSD), which has distributed 280 varieties of 17 different crops to 20,000 farmers.


Photo: V. Atakos/CCAFS

RECOMMENDATIONS

As this chapter has demonstrated, capacity improvements are needed across the whole agricultural value chain if the challenges of climate change are to be met. However, there are some key intervention points that could have immediate impacts on existing strategies:

- Advances in breeding technologies and tool development are allowing improvements for multiple traits in the context of overall crop productivity. The availability of these tools needs to be expanded to underserved crops that are climate-resilient, including the diverse germplasm available in public genebanks.
- A major barrier to expanding digital agriculture is the lack of investment in rural agricultural infrastructure as well as insufficient investment in research and development, agro-innovation (for example, in sensor development)[123] and agricultural entrepreneurship. Expansion of broadband internet availability is needed to support data collection, forecasting, and dissemination of real-time information.
- Filling in gaps in digital data for areas like soils will be important for farmers to be able to access more precise forecasts and solutions to potential climate-related challenges.
- Bundling of digital services is needed so that farmers can receive information as well as possible courses of action, such as sources of seed, fertilizers, and funding.
- Improved networking is needed for stakeholders on the research side with downstream users, from extension agents to farmers. As climate-related challenges intensify, the existing tools will need to be adapted and improved to include the information that farmers need to make decisions about what to plant, when to plant it, and what inputs will be needed.
- There is a need for regional networks of scientists, (for example, plant breeders) to share knowledge, tools, and equipment, as well as innovative approaches for sharing resources.
- Increased alignment of different sectors on policy, financing, and strategy will be essential to successful implementation of CSA strategies to ensure the resilience of and sustainability of agricultural systems as the impacts of climate change increase.
- Incentives will be needed to promote adoption of new climate-resilient strategies. Fostering an enabling environment for the update of these strategies will prove to be a critical step, with a conscious effort needed to link climate-resilient policies, science, and food security within national agricultural implementation schemes.[124]
- Effective capacity building will also require a focused gender lens. Women account for about half of the world's smallholder farmers and grow 70 percent of Africa's food. As they are the majority food producers on the continent, research and innovation must keep women as the primary target audience. Any mechanism designed to improve capacity through climate-resilience practices and investments or through the wider enabling environment must prioritize their needs and preferences. Implementation efforts, likewise, must ensure gender-equitable access to new technologies and products to avoid exacerbating gender-based inequalities.
- Innovative finance mechanisms are another area for innovation to help farmers and businesses adopt climate-smart practices and technologies. Often the upfront costs, real and perceived, of new practices can prove a roadblock to adoption and implementation while risk mitigation remains a major concern both for businesses and farmers. Finance mechanisms, like innovative insurance or credit programs, that build onto existing financing arrangements with producers will aid in end-user adoption of climate-smart practices and tools.[125]
- Lastly, advisory services play a critical role in educating farmers and producers on use and adaptation of new technologies. As such, expanded capacity is needed among climate-smart advisory services as a key intervention to help farmers in their transition to more resilient practices and systems.[126] Effective capacity building among climate-smart advisory services in turn allows for the effective distribution of the climate-smart practices and technologies discussed above and is a requisite step in ensuring effective uptake of these innovations and practices by end users.

Urban Informality

Photo: Simon Townsley/Panos Pictures

KEY MESSAGES

- The intersection of rapid urbanization with informality in work and housing poses significant challenges for adapting to the impacts of climate change. Approximately 60 percent of urban residents in Sub-Saharan Africa live in slum areas, and the informal city is growing, not shrinking.
- Many of the policy challenges of adaptation in informal settlements have to do with the tension between formal governance mechanisms and the realities of the informal city and economy. For example, National Climate Change Adaptation Plans prepared by African governments tend to overlook the threats to the informal city.
- The scale and complexity of the climate-informality nexus means that many stakeholders have a role to play in adapting to climate change, from national and local governments to community associations, non-governmental organizations, and finally the residents themselves.
- A detailed case study of Accra in Ghana illustrates the challenges of inclusive planning for climate change adaptation within African cities. These range from the lack of capacity or funds in the local governments entrusted with implementing plans made at the national or regional level, to the push-and-pull of political economy dynamics

among a broad swathe of relevant stakeholders. This problem is replicated in other African cities, with variations dependent on the degree of decentralization of power and money.

- The reforms necessary for a comprehensive adaptation strategy in the informal city have to be considered as part of a medium- to long-term agenda. So it may be that the best policy measures in the short term involve minor, low-cost, in situ adaptation investments and increased coping measures. If done well, these actions could help build up the needed trust and political capital for more transformative reforms.

"In Africa, the main action for climate change that needs to be undertaken is for adaptation. Adaptation to climate change is a regional and women's issue. We believe that climate action has to be regionalized. And we want local territories and regions to be at the heart of adaptation measures to climate change in Africa. UCLG Africa proposes that we organize a forum of cities and territories for accelerating resilience and mobilizing climate financing."

Fatimetou Abdel Malick
President of United Cities and Local Governments Africa

INTRODUCTION

Sub-Saharan Africa is both the poorest region in the world,[1] and the one that is urbanizing most rapidly.[2] Urbanization usually has positive benefits for economic development as it is associated with structural transformation (which provides better jobs and higher incomes); economies of agglomeration (which promote better-functioning factor markets, exchange of information and technology transfer, and ultimately more rapid productivity gains); and better-quality public services, owing in part to a density effect on the cost of reaching people with services. Higher incomes and more accessible and higher-quality public services usually mean higher welfare. Research suggests that this is true for most large African cities because urban areas offer higher returns to human capital, resulting in an urban wage premium, and offer equal or better non-monetary amenities compared with rural areas.[3]

Yet Africa's rapid urbanization at low levels of national income, combined with insufficient structural transformation, has also brought major challenges. The populations of major cities, especially the capital cities, are expanding rapidly due to both migration (from smaller cities, towns, and rural areas) and natural population growth, which in most countries has been high in the last 20 years. Provision of water supply, sanitation, energy, transport, and other urban services has not kept up with population growth in larger African cities, nor has the supply of durable housing.

Migrants are overwhelmingly young and male, usually looking for work.[4] Steady jobs are in short supply, as lower income levels are associated with fewer high productivity wage–earning jobs. This results in more employment[5] in household farms and firms—the self-employment and contributing family worker activities commonly called the informal sector.

The intersection of rapid urbanization with informality poses significant challenges for adapting to the impacts of climate change. Within urban areas, individuals and households who work and live in informal conditions are particularly vulnerable to climate change risks such as flooding, excess heat, and drought.[6] They also lack the resources to finance needed adaptations for their households and within their communities. Although these issues are not unique to Africa, the region's rate of sea-level rise exceeds the global mean rate, extreme temperature events are becoming more frequent than they were a decade ago, and climate-related hazards are becoming a major driver of population displacement.

African cities already offer evidence of the exposure and vulnerability of urban residents. Although Africa made up only 17 percent of the world's population as of 2019, the World Meteorological Organization (WMO) has estimated that it accounted for 35 percent of deaths from extreme weather events from 1970 to 2019.[7] For example, cyclones Idai and Kenneth affected over 2 million people in Southern Africa in 2019, causing death, disease outbreaks, and displacement due to loss of housing and infrastructure.[8] The 2022 floods in Durban, South Africa, killed more than 400 people,[9] while a devastating flood in Greater Accra, Ghana, in 2015 killed about 200 people and affected the homes and other assets of more than 46,000.[10] A mudslide and flood on the edge of Freetown, Sierra Leone, in 2017 left more than 1,100 people dead or missing.[11] By mid-August 2022, floods had affected 17 countries in West and Central Africa, impacting more than 700,000 people and displacing more than 100,000.[12] At the same time, water scarcity is a growing problem in African cities, and several have regularly instituted mandatory water cuts and/or reduced hours of water supply in response to droughts. One of the best-known water crises occurred in 2017–18 in Cape Town, where the city warned that without severe restrictions, it would run out of water.[13]

In part, lack of services and poor quality of housing are a result of the urban population's low incomes, which limits the ability of national and subnational governments at all levels to collect taxes needed to fund these investments and also limits the capacity of urban households to pay for durable housing and service delivery. At the same time, political economy dynamics and insufficient state capacity remain binding constraints to adopting and implementing necessary adaptations to improve the livelihoods of those living and working in informal conditions.

Focusing on African cities, this chapter addresses these challenges at the intersection between informality in housing and employment, and climate change adaptation. Following a brief review of the economic and political forces perpetuating the informal city, the chapter presents a discussion of the threats that advancing climate change poses for communities of people living and working informally. A framework is articulated that illustrates the links between climate change threats and informality while also delineating the necessary interventions to address these threats. In doing so, the framework emphasizes that political economy (dis)incentives and limited state capacity impede countries in moving from statements of intent to implementing new policies that would create a more equitable and sustainable city for all.

The framework is illustrated with a case study of Accra, Ghana, which epitomizes the challenges of many of the region's urban agglomerations struggling to manage informality and climate change. Through literature review and interviews with national and city decision-makers, as well as with residents in informal communities, the chapter identifies the current state and trends in adaptation awareness and resources as well as the incentives and constraints to action. Although both the climate threats and the political economy of urban governance are context-specific, Accra well illustrates the challenge of inclusive planning for climate change adaptation within African cities, the oppositional incentives and lack of trust between formal and informal systems of governance, and the inertia within the current system that needs to be overcome to develop effective, affordable coping strategies and adaptation investments. The chapter concludes with some suggestions on next steps for Accra and similar Africa cities.

INFORMALITY IN URBAN AREAS: CAUSES AND CONSEQUENCES

While informality in employment and informality in housing have different causes and consequences, they are interlinked phenomena with a similar underlying origin—low income. Informality in this chapter refers to the informal sector, defined as production units owned by an individual or a family unit that are not constituted as separate legal entities independent of their owners. Typically, they operate with little organization and on a small scale. Earnings depend on income after costs of production; they are commonly called "nonwage earnings" or gross profits.[14] In Africa today, about 65 percent of total employment is in the informal sector.[15]

Production unit informality is closely related to economic transformation. In a very basic, subsistence economy where the household is the unit of production, everyone works in the informal sector. As an economy grows and specialization ensues, larger businesses are created that employ people in wage jobs. An expanding state creates legal structures that enshrine the rights and responsibilities of both companies and their shareholders, and the employees of these companies. The transition from an economy dominated by informal production units to one dominated by formal production units formally employing workers can take decades or centuries. Urbanization and the creation of formal firms usually go hand in hand.

Most African countries are in transition from a mostly informal to a mostly formal economy, but at a disappointing pace. Importantly, Africa's urbanization is not following the historical pattern of today's higher-income countries, where industrialization and the creation of larger formal firms in urban areas fueled urbanization by increasing demand for labor, pulling the working-age population from rural areas and towns into emerging cities. Most African countries have not been able to match the share of employment or value added from formal firms that today's high-income countries had at African levels of urbanization.

As a result, new wage jobs are not yet employing the majority of the labor force in African cities.[16] The reasons for the African pattern are complex, and include both the natural resource curse, which induces industrialization but does not create formal jobs outside the private sector,[17] and globalization and technology, which make it harder for late industrializers to develop a job-creating manufacturing sector.[18] As a result, both migrants from other parts of the country to Africa's larger cities as well as urban natives are forced to create their own employment by starting a business in the informal sector. Regardless of which factors dominate in a particular context, the important point is that the informal sector is not likely to disappear soon.

Informality as a household living standards outcome is commonly referred to as slum dwelling, because informal housing tends to be clustered within defined communities. Informal housing is defined by the absence of at least one of the following:[19]

- Durable housing of a permanent nature that protects against extreme climate conditions

- Sufficient living space, which means not more than three people sharing the same room
- Easy access to safe water in sufficient amounts at an affordable price
- Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people
- Security of tenure that prevents forced evictions

The first four conditions create substandard shelter, while the fifth refers to the conditions of occupancy, but is usually found alongside the first four.

Informal housing conditions are created by, and persist because of, an inadequate supply of adequate and affordable shelter. Limited development of urban sites for affordable housing, as well as the low incomes of both recent migrants and city natives, reduces demand for durable, higher-quality housing and has caused the growth of informal housing developments. These developments sprout and grow on unoccupied land that is often unsuitable for development owing to hilly or low-lying terrain, or at the periphery of the city. As of 2018, an estimated 56.2 percent of urban residents in Sub-Saharan Africa lived in slum households, more than twice the global average.[20]

A critical factor reducing the supply of informal housing in African cities is a lack of clear and uniform property rights and a well-functioning land market with low transaction costs. Insecurity of tenure, especially in slums that started out as squatter settlements, usually precludes the provision of public urban services such as utilities, garbage pick-up, roads, even safety.[21] Either the formal legal system or the policies of public utilities may prohibit service provision. But even if a slum is a legal development of an Indigenous community, it is often unfeasible for public utilities to provide services because roads and pathways within a slum are not wide enough or suitable for utility infrastructure.

Informality in employment and housing are thus two sides of the same coin of underdevelopment. Lack of employment opportunities for a growing urban workforce creates the need for an entrepreneurial and survivalist informal sector, earning modest income. Lack of affordable housing, as well as the income to purchase it, means that those who work in the informal sector have to live and often work in slums. Slums are hubs of informal economic activity, including the provision of basic services such as water supply, sanitation, transportation, energy, and education that the state refuses to supply (or supplies only at a low quality and with a lag). Whole informal developments exist where unregistered small-scale economic activity is conducted out of slum dwellings or by people living in unregistered, illegal or partially legal housing, all without any state protection of any rights.[22]

In such situations, informal economic and daily living activities compete directly with formal, state-sanctioned businesses and housing for access to urban land, especially if they operate side by side. An example is the street vendors who leave the slum every day to find customers in other parts of the city—in formal market structures built with public or private funds, or on public streets and transport hubs. Depending on their location, they may interact with representatives of the formal economic and administrative structures such as the police, tax collectors, or local business owners who supply them with goods to sell.[23] They then return home to their community of informality.

Slum communities establish their own rules governing the activities of their members and often establish member-based organizations for collective action. Communities may be organized by location and neighborhood, or by trade (street vendor, tailor, hairdresser, bar owner, etc.). Leaders of these organizations interact with formal political and economic authorities, including national and local governments and elected representatives to the political system, with each side sometimes courting the other and building trust and sometimes shunning or opposing the other, and using the other for their own gain where possible. These relationships can take on a formal and long-term character, such as the relationship between Ghanian informal sector organizations, trade unions, and the national Government.

Large-scale solutions to the conundrum of urban informality have not been found in Africa. The share of the labor force working in the informal sector is positively associated with labor force growth and negatively associated with economic growth.[24] One recent study estimated that it could take over 100 years to reduce the share of employment in the informal sector by 10 percent on average in Africa.[25]

Solutions to slum growth are equally difficult, despite increased attention from a range of external donors and advocacy organizations.[26] One solution often used is relocating the residents, demolishing existing structures, and rebuilding with more durable structures that have secure tenancy and access to urban services. This option is often sought by developers. However, the cost can be very high, with many costs not born by the developer, such as the cost of police and other agents of the state to enforce the eviction, the cost of new housing for the evicted, the negative effect on the livelihoods of slum dwellers who may depend on central city access or access to customers within their slum community, and the investment costs to provide the needed utility services (which could be borne by developers but more often are partially or completely shifted to the state).

An alternative is slum upgrading, involving legalizing or formalizing the land rights of residents in the existing settlement, state provision of some basic utility services (such as water supply or electricity), the delineation of land for transport services, and the provision of low-cost financing to allow residents to undertake housing improvements themselves. Slum upgrading requires the state to relinquish its own ownership rights and settle other outstanding claims to the land, policies that may be resisted by elites and the formal administration. Slum upgrading also risks further entrenching poor people on marginal land unsuitable for housing development (e.g. floodplains).

Meanwhile, the informal city is growing, not shrinking. The urban population continues to expand. With economic transformation, a growing share of the urban labor force is able to find wage jobs in factories, stores, warehouses, and offices, but the absolute size of the informal labor force continues to grow. Migrants help create new slums on peripheral land, previously used for farming, sometimes with the help of "brokers" who buy farmland from traditional leaders and then resell the land to migrants (without secure title), or to developers who create new suburbs. The city continues to sprawl.

THE INTERSECTION OF URBAN INFORMALITY AND CLIMATE CHANGE

Advancing climate change will impact the whole city via more extreme weather events—flooding, extreme heat, and drought—that threaten the assets, livelihoods, and welfare of Africa's urban population. Residents living in informal settlements and working in unsheltered locations within such cities are particularly vulnerable for four reasons:

1. **Increased days of high-intensity, heavy precipitation** are expected to flood houses and places of work, destroying household and business assets. Livelihoods will be disrupted. Flooding will also damage roads, blocking access to the rest of the city, including access to customers, suppliers, and services (e.g. healthcare). Power systems can be damaged by high winds or flooding causing a loss of service. Flooding also carries waste, including toxins, into the water supply, endangering health. Overall city storm drainage systems in Africa are poor or nonexistent, especially in informal settlements.[27] Standing water combined with poor sanitation facilities increases the likelihood of exposure to waterborne diseases such as cholera, dysentery, and typhoid, and creates a breeding ground for vector diseases like malaria.
2. **Days of excess heat** can contribute to the "urban heat island" effect, which occurs when temperatures exceed those in surrounding rural areas due to greater heat absorption by built-up surfaces and densely constructed buildings. Excess temperatures can cause heat stroke, rash, and edema in poorly ventilated homes and markets, endangering the health of urban residents and lowering productivity. Residents living in substandard housing or working out in the open will suffer the most. For instance, a study of excess heat in Nairobi's informal settlements revealed that poor ventilation contributed to high mortality for older adults and more respiratory illnesses for young children.[28]
3. **Increased drought** will create challenges for water supply, causing residents to pay more and/or travel longer distances for clean water. Drought may also raise fire risk in areas where slum residents cook over open fires. Drought also can reduce hydropower resources, exacerbating electricity shortages and costs for informal businesses. Drought in rural areas spurs migration to cities, placing additional burdens on infrastructure and competition for employment.
4. **Higher sea levels and higher tides** will increase flooding in Africa's low-elevation coastal zones

where population growth is expected to increase in the coming decade.[29] Higher sea levels could also compromise freshwater supply for urban areas through increased salinity.

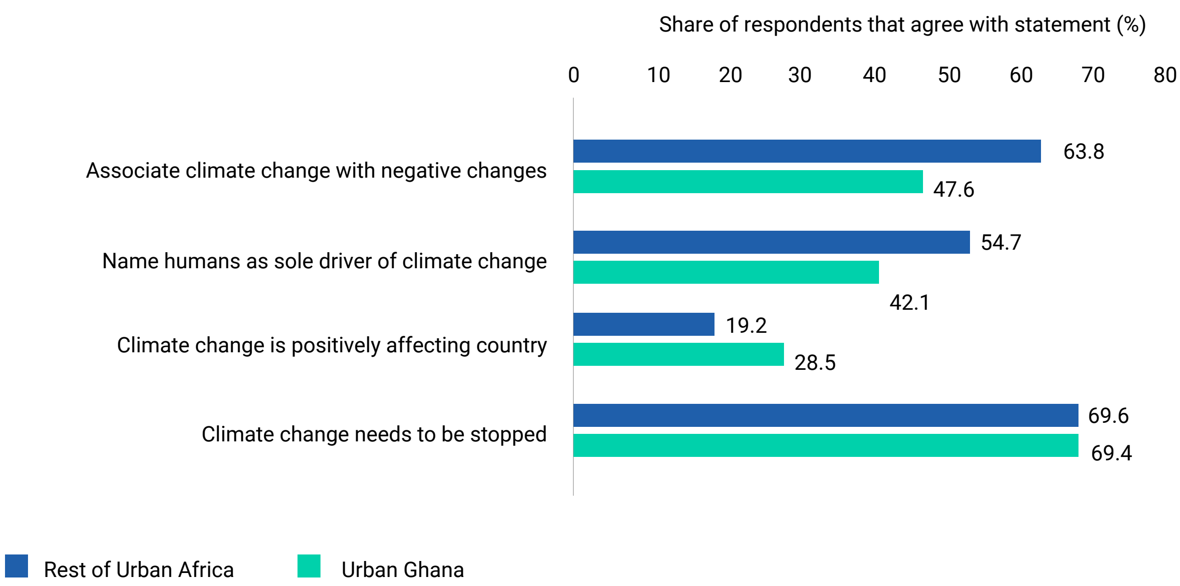
These shocks collectively exacerbate the vulnerabilities of the urban poor living in informal settlements and/or working in the informal sector. Beyond the impacts on livelihoods, assets, and physical health, the toll of such shocks on mental wellbeing is sizeable due to the trauma of loss, financial hardship, and uncertainty about the future.

Overall disaster preparedness in African cities (e.g. early-warning systems (EWS), emergency shelters, and other coping mechanisms) is quite low. In fact, the rate of implementing multi-hazard EWS is lower in Africa than any other region of the world.[30] This leaves residents, communities, and the public sector unprepared when shocks occur. Extant safety nets are largely informal, family- and community-based. Where public programs exist, the COVID-19 pandemic revealed that cash transfer safety net programs disproportionately favor the rural poor and ignore the millions coping in the urban informal sector.[31]

Even monitoring of the impacts of natural disasters such as heatwaves is limited.[32] National Climate Change Adaptation Plans prepared by African governments tend to overlook the threats to the informal city. For example, Ghana's 2015 plan focuses almost entirely on the challenges to the agricultural sector and rural areas. Ghana's more recent infrastructure adaptation plan covers the whole country, but once again does not discuss the plight of residents lacking infrastructure services when extreme weather events take place.

While the need for adaptation interventions is clear, the multifaceted nature of climate change threats creates complexities for informal communities. Public opinion polling of urban residents by Afrobarometer across 34 countries between 2016 and 2018 revealed that 63 percent had, on average, heard of climate change.[33] Among those urban residents who had heard of climate change, about two-thirds associated climate changes with negative changes in their lives, while 20 percent felt that climate change is positively affecting their country (Figure 1). This limits the capacity within the informal city to unify around short-to medium-term coping actions and advocate for medium- to long-term solutions.

Figure 1. Perceptions of Climate Change: Urban Africans and Urban Ghanaians



Source: Afrobarometer, Round 7.[34]

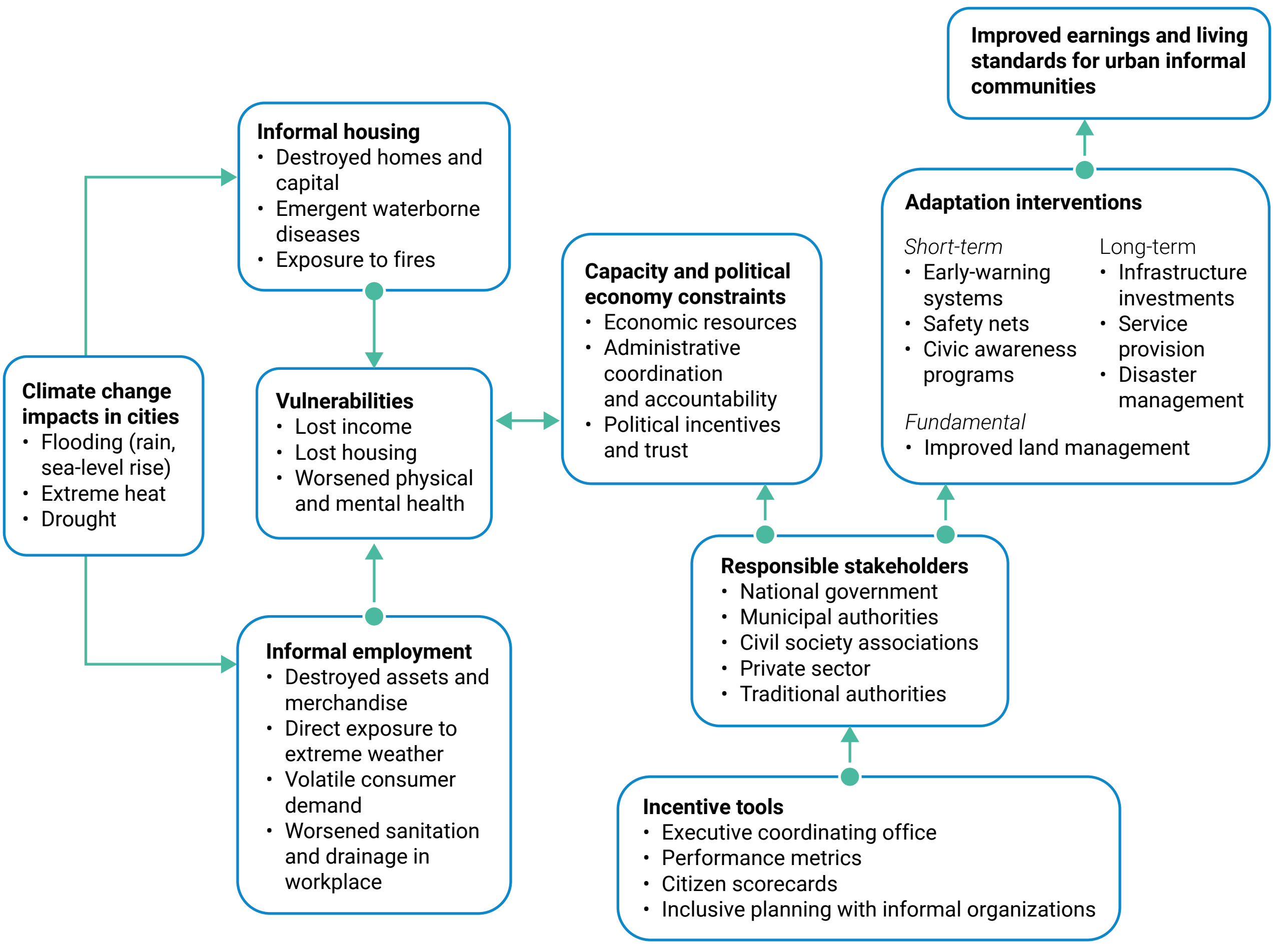
Note: The sample consists of 806 urban respondents in Ghana and 12,004 urban respondents from 33 other African countries. Samples exclude those who had not heard of climate change.

The required interventions are technically straightforward, and include:

- Threat assessments and development of disaster preparedness plans (including for post-disaster financial support)
- Education of the population on the growing climate threats and how these will impact their lives
- Public awareness campaigns for behavior change to reduce threats (e.g. proper waste management, fire dangers during droughts) and on what affected populations can do in case of a climate disaster emergency
- Financial and other support for improvements in existing structures, and new building codes to help ensure that new structures can withstand extreme weather (as well as the means to enforce them)
- Development and implementation of plans for needed new infrastructure investments such as durable roads, storm drainage systems, water supply and sanitation and solid waste disposal
- Strengthening of safety net programs

However, implementing these different interventions requires tackling a broad range of capacity shortfalls and political economy dynamics among a broad swathe of relevant stakeholders (Figure 2). Such stakeholders typically include various ministerial agencies, and, in more decentralized countries, municipal authorities, elected and appointed. City residents are important stakeholders, and can be represented by civil society organizations such as formal and informal business and housing associations, by traditional leaders, as well as by elected representatives. These associations may have overlapping, cross-cutting, and sometimes oppositional policy positions. The private sector, including the real estate and construction sectors,

Figure 2. Climate Change Adaptation and Informality in African Cities



as well as owners of businesses that make and sell goods and services, are also stakeholders, and exercise voice through their own associations and informal relationships with elected leaders. This range of stakeholders implies that capacity-strengthening efforts need to be multifaceted and tailored to a range of participants.

The complexity of the climate-informality nexus means that many stakeholders have a role to play. Vertical coordination is needed between municipal governments and their national counterparts, especially in areas where there are concurrent responsibilities or where local governments lack sufficient resources to meet their functional mandates. Since climate impacts often cross jurisdictional boundaries, particularly in metropolitan areas, horizontal coordination across subnational governments is also needed. Informal sector organizations may have trouble advocating for their interests within this maze of responsibilities and accountabilities, and could require targeted capacity strengthening to better understand current threats and viable adaptation interventions and thereby more effectively advocate their preferences to decision-makers.

Effective climate adaptation strategies require clarity and transparency around who has rights to occupy urban space under what conditions, and who is responsible for financing and investing in needed infrastructure and supplying necessary urban services to informal communities and places of work. This usually means improving land titling, registration, tenure arrangements, and administration, so that residences and workplaces are legally occupied and given the legal right to demand services. This may require a change in the mindset of elected and administrative authorities. Government authorities, both national and local, have often been more interested in attracting investment for tourism, business, and high-end housing, while having few incentives outside of electoral periods to provide goods and services to the informal city. This has led to land deals that displace the urban poor from their housing, communities, and places of work—including from informal markets, sidewalks, medians, and city parks, as well as designated locations where the informal sector traders aggregate to meet their customers and ply their trades (e.g. clusters of informal repair people). Traditional authorities, having

Photo: peeterv/iStock

lost land rights to the state and private developers, often choose to collude with developers for selective gains within a non-transparent land tenure and allocation system. In this environment, extending protections to the urban poor is a low priority for those holding power.

Community members also face conflicting incentives. Within informal settlements, members are also informal providers of services to their communities, including waste collection, water delivery, and toilet rentals; since they are earning money from the status quo, and uncertain of how upgrading of such settlements would affect their livelihoods, they often have minimal incentive to support needed reforms. These dynamics can contribute to high levels of mistrust of authorities that undermine efforts to address climate change. For instance, in Lagos, Nigeria, residents of informal settlements have in the past ignored government typhoon warnings and refused to evacuate because they feared the

government would use such evacuations as a pretext for demolishing their homes.[35] Public sector efforts to increase trust in government are essential for any climate interventions to work because communities will be less likely to register for safety net programs or agree to investments if they are skeptical of the public sector's intentions.

Facing up to the threat of climate change and developing and implementing effective climate adaptation plans therefore requires tackling these binding constraints through a range of incentive tools. Some of these include supervisory delivery units within the office of the executive (president, prime minister, governor, or mayor) or the creation of a distinct coordinating office or agency within one ministry, such as finance, environment, or urban development. In these cases, government actors should be compelled to collaborate on multisectoral issues and given distinct deliverables. Incentives to deliver can be bolstered through complementary public administrative tools, such as performance contracts whereby the performance of ministries is publicly disseminated, enhancing accountability. Bottom-up options, such as citizen scorecards, can rebuild trust when they are collaboratively developed between representatives of informal associations and public actors, the private sector, and traditional authorities. This can involve joint development of priority issues areas, delineation of who is responsible for delivering on each priority, and a collective mode of scoring progress that is tracked on a periodic basis and shared with the rest of the community.

Ultimately, extant laws on land and work need to be revisited and reformed, potentially recognizing in situ land rights in informal settlements hitherto considered illegal and reversing the penalization of certain types of informal work, such as street vending, that are common in much of Africa. While the need for these reforms is recognized, political economy dynamics reduce decision-makers' appetite for actually implementing this type of reform. Instead, an inertia among many stakeholders has been bred, and a potentially unstable and unsustainable status quo perpetuates. In such an environment, the most likely next steps in adaptation are reactive, short-term coping measures to help the informal city when disaster strikes or climate stresses emerge. Less extensive or expensive pre-disaster adaptation measures might be feasible as well, such as expanded weather tracking and information provision by the national authorities together with community-based EWS, or individual and community measures to reduce the impact of climate stress on households such as painting roofs with solar-reflective white paint to reduce heat retention. If done well, these actions could help build up the needed trust and political capital for more transformative reforms, recognizing that the reforms necessary for a more comprehensive adaptation strategy have to be considered a medium- to long-term agenda.

In the next section, we examine the case of Accra, Ghana. We use this framework of vulnerabilities, stakeholders, and the incentives and constraints to action to delineate the issues and challenges the informal city within Accra faces as extreme weather events become more common.

Photo: Delali Adogla-Bessa/Shutterstock

CASE STUDY: Accra, Ghana

Ghana is a lower-middle-income country that has experienced substantial economic growth and urbanization over the last several decades. Prior to the onset of the COVID-19–induced recession, annual per capita GDP growth was consistently positive since 1984, averaging 2.8 percent, and an estimated 57.3 percent of the population lived in urban areas as of 2020, compared with 31.2 percent in 1980.[36] Along with natural population growth, much of this urbanization is driven by migration from the poorer northern regions to cities in the Greater Accra and Ashanti regions, exacerbated by drought conditions in the Northern Savannah zone. Ghana's growth has not translated into enough structural transformation,[37] resulting in a lack of productive formal employment.

Well recognized as one of Africa's most robust democracies, Ghana has a vibrant civil society environment, replete with organizations representing the interests of the urban poor and informal workers. Among others, such organizations include the Ghana's Federation of the Urban and Rural Poor, the People's Dialogue on Human Settlements, Slum Dwellers International, the Informal Hawkers and Vendors Association, and the Union of Informal Workers Associations. At the same time, electoral competition between the two main parties, the National Democratic Congress (NDC) and New Patriotic Party (NPP), has contributed to the persistence of political clientelism and the selective allocation of goods and services.[38] Weak state capacity likewise frequently is identified as a major challenge in Ghana for implementing strategic plans and policies, including those that could facilitate structural transformation.[39]

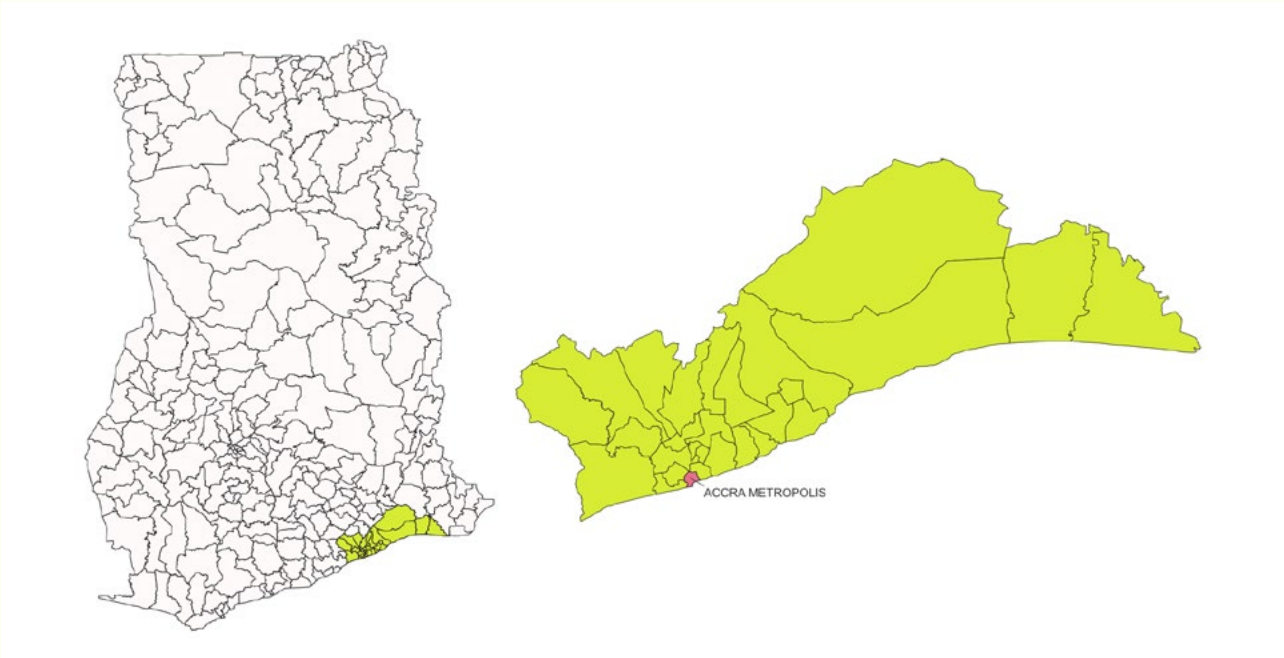
These political and capacity dynamics have direct implications for addressing climate change threats facing the country. Ghana is typical of other littoral countries in the region that are increasingly affected by the impacts of climate change, including more volatile shifts in rainfall and heat. The number of flood incidents has increased notably since the country's independence, with the Emergency Events Data (EM-DAT) recording 23 flooding disasters in the last 20 years compared with only four during the 1981–2000 period.[40] Qualitative interviews with residents in different parts of Ghana also indicate strong, subjective perceptions of increased flooding during the annual June to September rainy season.[41] However, as seen earlier in Figure 1, overall awareness of the causes and effects of climate change is lower in urban Ghana than in urban Africa as a whole.

The capital city of Accra—commonly called the Accra Metropolitan Assembly (AMA)—is one of Ghana's 261 Metropolitan, Municipal, and District Assemblies (MMDAs), which are the administrative unit of local government.[42] As shown in Figure 3, the AMA, with a 2022 population of 2.6 million, is part of the larger Greater Accra Metropolitan Area (GAMA), which has a regional population of almost 5 million, or about 15 percent of the total population of Ghana. As Ghana's economic powerhouse, the AMA has expanded tremendously in recent decades. Approximately 2 million people from GAMA and beyond commute into the city every day.

In response to rapid population growth, the administrative units of Ghana have been continuously divided, leading to a somewhat fragmented municipal governance. In 2019, the AMA was divided into three sub-metros—Ablekuma South, Ashiedu Keteke, and Okaikoi South—each of which has its own chairperson.[43] Collectively, there are 20 electoral areas within the AMA for the purposes of electing assembly representatives, and three parliamentary constituencies. The GAMA contains an additional 24 MMDAs. All MMDAs are managed by a head appointed by the President (called a Metropolitan Chief Executive or MCE in metro areas). Legislative power rests with the assembly members, 70 percent of whom are elected on a non-partisan basis in local elections, while a further 30 percent are appointed by the President. Members of Parliament representing the constituencies in each district are ex officio members of the MMDAs legislative body. Given the strong role of the President and the national government within Ghana's political system, Accra's MCE (the mayor) as well as the heads of neighboring municipalities enjoy considerable power, while elected assembly representatives have limited authority to shape and guide local adaptation strategies.

Accra's low-lying elevation, at –4 to 130 meters above mean sea level, makes it increasingly vulnerable to climate change-related weather patterns. In addition to flooding caused by increased rainfall, Accra receives water runoff flowing downwards from other municipalities. The city is also affected by fluvial floods—those caused when excessive rain causes

Figure 3. Map of MMDAs comprising Greater Accra Metropolitan Area



Source: Authors' layer created from ArcGIS Hub. Original layer of districts created on October 9, 2019 inundation of the Odaw River, the Korle Lagoon, and the Onyasia River—as well as pluvial foods caused by the growth in impervious surface areas (i.e. pavements and buildings), insufficient drainage, and construction on waterways due to increased population density. As one member of the Adabraka Odawna Market Women and Traders' Association noted, "Even when it's not raining, we have to be on guard and on the lookout because the Odaw River rapidly swells up with upstream flood water which can suddenly flow into our home and the market without warning."[44] Due to insufficient waste collection and prevailing attitudes about disposal among residents, trash is often dumped in drains and water streams, complicating rainwater management during periods of heavy rain.

More than half of the flooding incidents since 2001 have affected Accra or Greater Accra. While the floods of June 2015 garnered the most media attention due to their devastating toll, claiming 150 lives, the collective impacts on health and productivity from flooding become more pervasive each year. Foot rot and electrocutions from hanging wires in standing water have been reported as common challenges faced by communities in Accra's informal settlements.[45] Studies of the impacts of the 2015 floods on those living in informal communities are telling; two years after that incident, one-third of informal households reported they had not yet recovered economically.[46]

The non-farm informal sector is the most important source of employment for Accra's labor force, followed closely by wage employment of all types, although about one-fourth of wage employment is informal (Table 1). Nearly 20 percent of Accra's labor force reports performing agricultural work on their own land; this is mostly young people who may be going to school part-time.[47] Women and older people are more likely to work in the informal sector while men and younger people are more able to secure wage employment (Table 2). While wage workers tend to report a regular 40-hour work week, people operating informal businesses may work fewer hours or they may report a substantially longer work week (Figure 4).

Table 1. **Structure of Employment in Accra Metropolitan Assembly**

Sector of work	Share
Employment in the informal sector	**42.1**
Non-agric self-employed with employees	6.8
Non-agric self-employed without employees	32.5
Non-agric contributing family worker	2.8
Wage employment*	**39.7**
Paid employee	31.6
Casual worker	5.3
Apprentice	2.6
Other	0.3
Agricultural employment**	**18.3**
Total	100

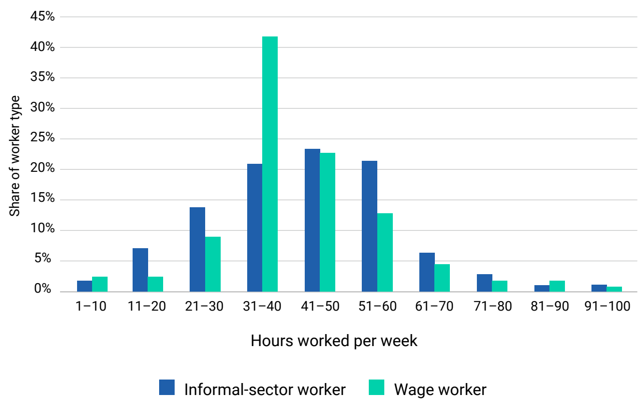
Source: Data from GLSS7, 2017. Notes: *Most paid employment is likely to be formal; all other wage employment is informal. **Consists mostly of youth and women tending to household gardens. Some sell surplus production in the market or to wholesalers.

Table 2. **Structure of Employment in AMA by Gender and Average Age**

Category	Share that is female (%)	Average age (years)
Informal sector	69.8	41.6
Wage employment	34.7	36
Agricultural employment	48.4	19.6
Total	**52.0**	**35.4**

Source: Data from GLSS7, 2017

Figure 4. **Distribution of Hours Worked by Employment Type**



Over 60 percent of the city's households live in substandard, informal housing (Table 3).[48] There are approximately 78 slums within GAMA,[49] and it is the residents in these slums whose wellbeing is most directly affected by climate change adaptation options. People living in informal housing are not more likely to work in the informal sector (Table 4), in part because wage employment includes casual wage workers and apprentices, whose income may be even lower than those owning an informal business. Also, almost one-fourth of households contain both people who engage in wage work and people working in the informal sector. About two-thirds of households in informal housing have at least one member who works in the informal sector, indicating a high level of vulnerability in this group.

About 30 percent of people working in informal sector businesses do so from their own home, making them most vulnerable to extreme weather events, as a flood could destroy their inventory and assets (Table 5). Of these, about half live in informal dwellings, which are the least resistant to flooding (Table 6). Another one-fourth do business on the street, either from a fixed location or from wherever they can. This group is vulnerable to extreme heat from heat islands as well as to loss of inventory and customers from flash floods. Since they store their inventory and tools at home, those who live in informal dwellings are among the most vulnerable in this group as well. During droughts, they can also be susceptible to price inflation by "water mafias"—the tanker suppliers and sachet water retailers—who provide water to those unconnected to the pipelines of Ghana's water utility company.

As in much of Africa, the persistence of slums in Accra reflects a dualistic housing market that favors affluent residents and reflects longstanding practices of land mismanagement and overlapping tenure claims. High-end, gated communities and apartment complexes have expanded in Accra, but such housing is unaffordable to most residents. Most of this housing is built by private developers on either state land or customary land that was acquired by the state.[50] Lack of affordable housing pushes many of the urban poor into dense settlements, some of which appeal to migrants from specific parts of the country.[51]

Table 3. Distribution of Households by Type of Dwelling

	Share (%)
Formal dwelling	36.7
Informal dwelling	63.3
Total	**100.0**

Source: Data from GLSS7, 2017

Table 4. Type of Employment by Type of Dwelling (non-agricultural employment only)

	Wage employment share (%)	Informal sector share (%)	Total share (%)
Formal dwelling	40.6	41.3	40.9
Informal dwelling	59.4	58.7	59.1
Total	**100**	**100**	**100**

Table 5. Where Informal Activity Takes Place in Accra

Work location	Share (%)
Home	29.5
Store/shop	17.9
Street not at a fixed location	14.6
Market	13.4
Street at a fixed location	10.8
Workshop	3.8
Construction site	2.4
Lorry park	2.1
Other	5
Total	**100**

Table 6. Work Location by Dwelling Type (non-farm informal sector employment only)

	Formal dwelling share (%)	Informal dwelling share (%)	Total share (%)
Work from home	13.4	15.6	29
Street	9.7	15.8	25.5
Market	5.3	8.1	13.4
Other	13	19.2	32.2
Total	**40.9**	**59.9**	**100**

The settlements though vary immensely in terms of the degree of land tenure security.[52] Specifically, some of these slums are illegal/extralegal, meaning that the residents lack the right to live and work in the community. Old Fadama is an example of an extralegal settlement on state land, sitting on the wetlands of the Korle Lagoon with little private value. Others are considered Indigenous settlements where customary tenure remains, the landlords are Indigenous leaders, and residents are therefore not under threat of eviction. But residents usually do not have secure land titles. In Accra, there are several settlements of the Indigenous Ga community that fall into this category (e.g. Jamestown). A third category of settlements are those on land purchased from either customary leaders or the state (e.g. Nima).

Any climate change adaptation interventions aimed at improving the resilience of Accra's most vulnerable communities require engaging with at least three sets of distinct relationships: within communities, between communities and the AMA, and between the AMA, the GAMA and national Government. More specifically, within informal settlements, residents' access to land and services, as well as protection from eviction, depends heavily on complex forms of transaction and loyalty with traditional authorities, local power brokers, and politicians from the main political parties.[53] As in other parts of the world,[54] party politicians may encourage "forbearance"—refraining from enforcing the law—in extralegal settlements where they obtain votes, or they may criticize the bureaucrats from the AMA for pursuing evictions or "decongestion" campaigns that remove vendors from the streets.[55] There are also dense linkages among community members who rely on each other for services and protection, including kaya bolas (informal waste collectors) who remove trash from settlements and markets, sometimes by dumping it into waterways and drains.

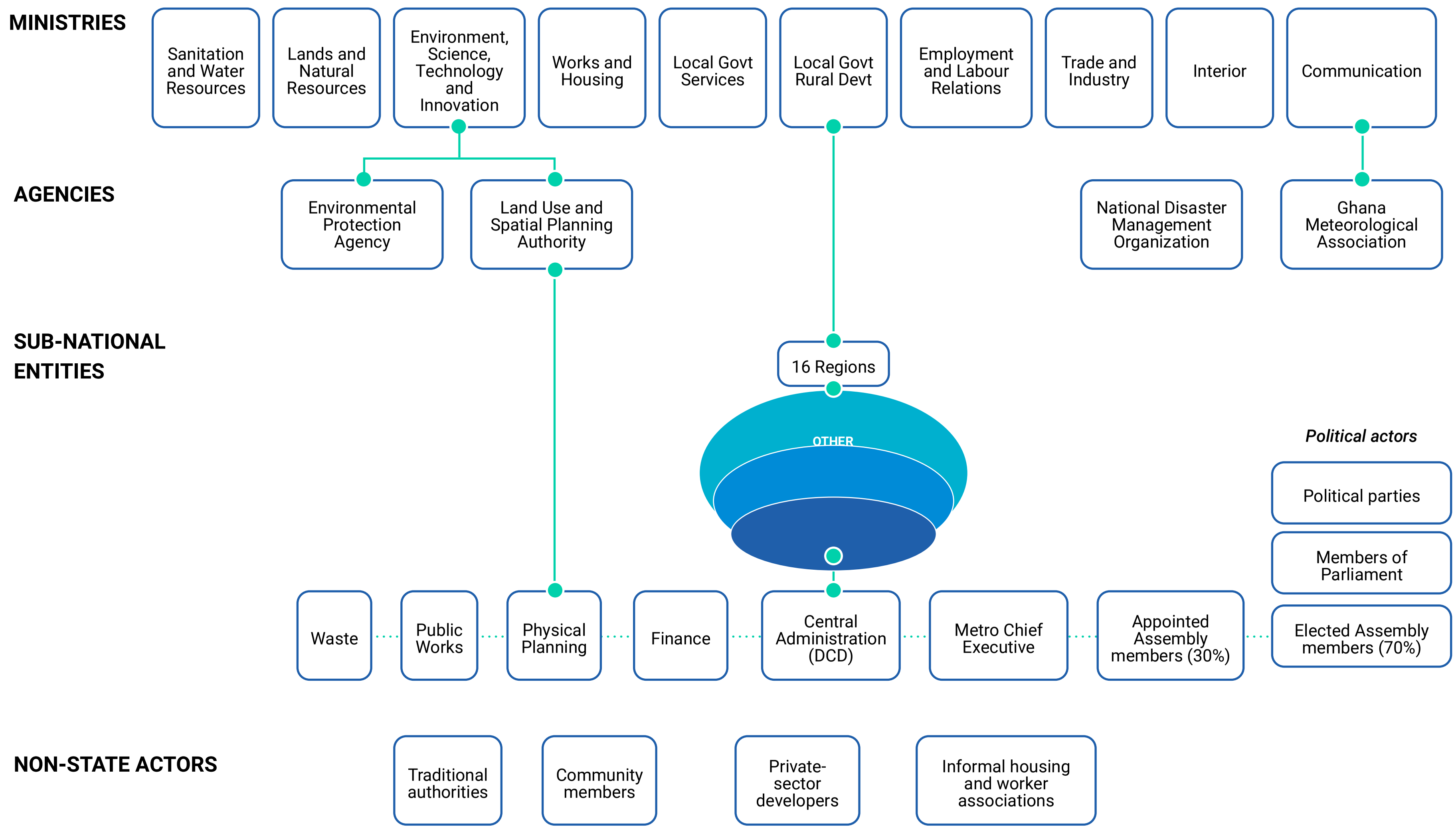
The relationship between informal communities and the AMA is also critical. Due to Ghana's extensive decentralization processes, the MMDAs have functional autonomy over many areas relevant to the livelihoods of the urban poor and for addressing climate change adaptation. According to the Local Governance Act of 2016, these areas include pursuing public works and basic infrastructure; developing, improving and managing human settlements; maintaining the MMDA's environment; and effectively mobilizing resources needed for the development of the MMDA. Because MMDA chief executives (mayors) are appointed by the President, they have little downward accountability to citizens, and several of Accra's mayors have pursued eviction campaigns of extralegal settlements as well as "decongestion" campaigns against informal workers, especially street vendors,[56] executed by the Accra police force counter to the wishes of elected AMA elected representatives. In other cases, however, the bureaucrats within the AMA lack the resources, logistics, or workforce to enforce their by-laws, or face interference by politicians. This can allow unplanned development to proceed.[57] Perhaps because of these dynamics, surveys by Afrobarometer repeatedly show that Ghanaians perceive their MMDA administrations to be unresponsive to their concerns and have low levels of trust in them.[58]

In addition, as noted above, there is a complex institutional setting whereby the AMA is embedded within the GAMA and the Greater Accra Region but is also divided into sub-metro authorities. This institutional setting means that there are clear issues of coordination that emerge when dealing with interjurisdictional development challenges, such as those created by climate change. Finally, several types of interventions require guidance and support from national-level actors, including the Lands Commission, the Ministry of Housing, the Ministry of Sanitation and Water Resources, the National Disaster Management Organization, and many others. For example, even if an international finance institution is financing a project in the AMA or GAMA, because it is a sovereign loan or credit, the national ministries would necessarily be involved. Figure 5 provides a stakeholder mapping of these top-down, bottom-up, and horizontal relationships.

Climate Adaptation in Accra

The threat of climate change has not gone unnoticed by Ghana's policymakers. Ghana has had several different urban planning and climate adaptation plans over the years, many of which recognize that the urban poor and those in informal communities are most at risk. These include Ghana's National Urban Plan (2012), which advocated in situ upgrading instead of evictions of extralegal settlements, the National Environmental Policy (2014), and the National Housing Policy (2015). These were

Figure 5. Stakeholder Mapping of Actors and Institutions for Climate Adaptation in Informal Settlements



formulated, however, under the NDC government. When the NPP administration came to office in 2016 (it was reelected in 2020), new plans were developed, including the Accra Resilience Strategy, supported by the 100 Resilient Cities initiative. This strategy also has a strong emphasis on working with informal-sector organizations.[59]

In 2018, under the leadership of the Environmental Protection Agency, with support from the Ministry of Finance and the National Planning Development Commission, the national Government published a framework for the production of a new National Adaptation Plan (NAP).[60] The intention was to lay out a new, bottom-up approach to the NAP process and provide a reference point for bringing together various adaptation planning efforts from different sectors, subnational structures, and scales of decision-making. The framework attempts to align the NAP process with existing policies, strategies, programs and adaptation research, while serving as a basis for stakeholder engagement.

Photo: Slum Dwellers International

Nonetheless, there are various concerns about the political will and institutional capacity to implement such goals. Drawing on interviews with Government representatives and focus group discussions with informal-sector organizations, this section highlights extant approaches to climate adaptation and informality in Accra and explains why a more holistic and proactive set of actions is needed.

Extant Approaches to Adaptation

With guidance from the Land Use and Spatial Planning Authority, MMDAs have the primary mandate to engage in development planning. Efforts to train the AMA on flood risk assessment to inform planning decisions has been affected by insufficient funding and a lack of demand by the local authorities. Future efforts to train MMDA planners to integrate climate risk assessments into their land-use assessments need to also involve MCEs and district coordinating directors (Figure 5) since these are ultimately the main decision-makers at the local level.

Thus far, infrastructure investments have tended to dominate the Government's response to adaptation. These include paving alleyways within informal settlements and markets to reduce flash flooding as well as improving primary and secondary drains. Under the Greater Accra Resilient and Integrated (GARI) Development Project, supported with US$200 million in financing from the World Bank, rehabilitating infrastructure to improve the management of the Odaw River is a priority. Drainage investments, though, are medium-term solutions since they require at least three to four years to complete.

Planning duplication is also problematic as other ministries, particularly the Ministry of Works and Housing, also have slum upgrading strategies. The Ministry of Works and Housing is interested in expanding access to more energy-efficient materials to deal with excess heat. Key among these include replacing sandcrete (a mixture of cement and sand) with interlocking bricks (a mixture of laterite and cement) that retain cool air better, as well as micro-roofing tiles that improve ventilation much more than the zinc or aluminum roofs currently used. While there are aspirations to increase access to such materials as part of slum upgrading projects, no settlements currently use these, and some means of subsidizing access to such materials would be needed for poor households.

Such investments are necessary but not sufficient, and proactive planning remains a major gap. The National Disaster Management Organization (NDMO) under the Ministry of the Interior (Figure 5) plays a critical role in flood and other emergency rescue operations but does not engage in prospective assessments of potential risk scenarios. Within the settlements, there are few officially designated safe havens for flood victims except for a religious building or school that the community has chosen to use. Addressing how to help those in the informal sector appears to be a notable gap in the policy discussions around climate adaptation. Current donor-funded "green jobs" projects focus on activities and jobs that are primarily in the formal sector.

Coordinating Mechanisms and Financing

Most ministries now have designated units to focus on climate, environment, and/or flooding. To improve coordination, a bill has even been tabled in Parliament to create an institution that solely deals with flooding. The coordinating councils of the country's 16 regions also help with managing climate plans across multiple MMDAs, while within the MMDAs, the district coordinating division helps facilitate integration of climate-related plans across departments.

Ministerial volatility is, however, one challenge for implementation. For instance, after an extensive study on slum upgrading completed in 2015, the Ministry of Local Government had prepared a slum upgrading strategy. Yet, momentum was derailed when this was allocated to the newly created Ministry of Inner-Cities and Zongo development in 2017. The abolition of the latter ministry in 2021 further affected project implementation, including of the World Bank-financed GARI project noted above.

Within the MMDAs, another challenge is insufficient financing, which further derails holistic planning processes. Funding from either the intergovernmental District Assemblies Common Fund (DACF) or from internally generated revenue is typically allocated to one-off, visible investments in communities, such as toilets, streetlights, or clinics, which can be easily quantified in annual performance reports.

Land Rights and Community Trust in Government

In Ga Mashie, which encompasses several Indigenous settlements of the Ga people that include Ussher Town and Jamestown, slum upgrading has been pursued since 2015 under UN-Habitat's Participatory Slum Upgrading Program (PSUP). The existence of the Ga Mashie Development Agency (GAMADA), which was established as a quasi-local government agency in 2006 and integrated into the AMA in 2010, facilitated such upgrading. In addition, the fact that the land is owned by the Ga and their families meant that there was less concern about the Government's motivations, and disputes over tenure are less common. The upgrading project involved first interviewing residents to ensure a sound understanding of their needs and priorities.

By contrast, upgrades to deal with climate shocks have been much more challenging in the extralegal settlement of Old Fadama. There, residents note they have received assistance from the People's Dialogue on Human Settlements. Mistrust of the AMA, though, is high, undermining any Government attempts to address flooding. In fact, respondents have been reluctant to speak about flooding out of fear of eviction. Such fears are not entirely misplaced; the AMA has several times tried to resettle parts of the community into a new area called New Fadama, but residents often return or new ones take their place. The attraction of Old Fadama remains its strong link to employment opportunities; one of Accra's biggest markets, Agbogbloshie Market, is close by, and it is the center of "bulk breaking activities" where food comes in from around the country and is then broken down into smaller quantities to be sold throughout the city. As a traditional authority that is a member of the Old Fadama Informal Housing Neighborhood Association conveyed, "This community is here to stay. See how extensive this place is and how brisk business and commercial activities thrive here, especially for the women traders and cooked food sellers."[61] Efforts at resettlement that fail to account for the need of residents to be proximate to employment opportunities are rarely successful. Politicians from both the NPP and NDC have been maligned for promising to protect the residents during campaign periods only to abandon them after elections take place.

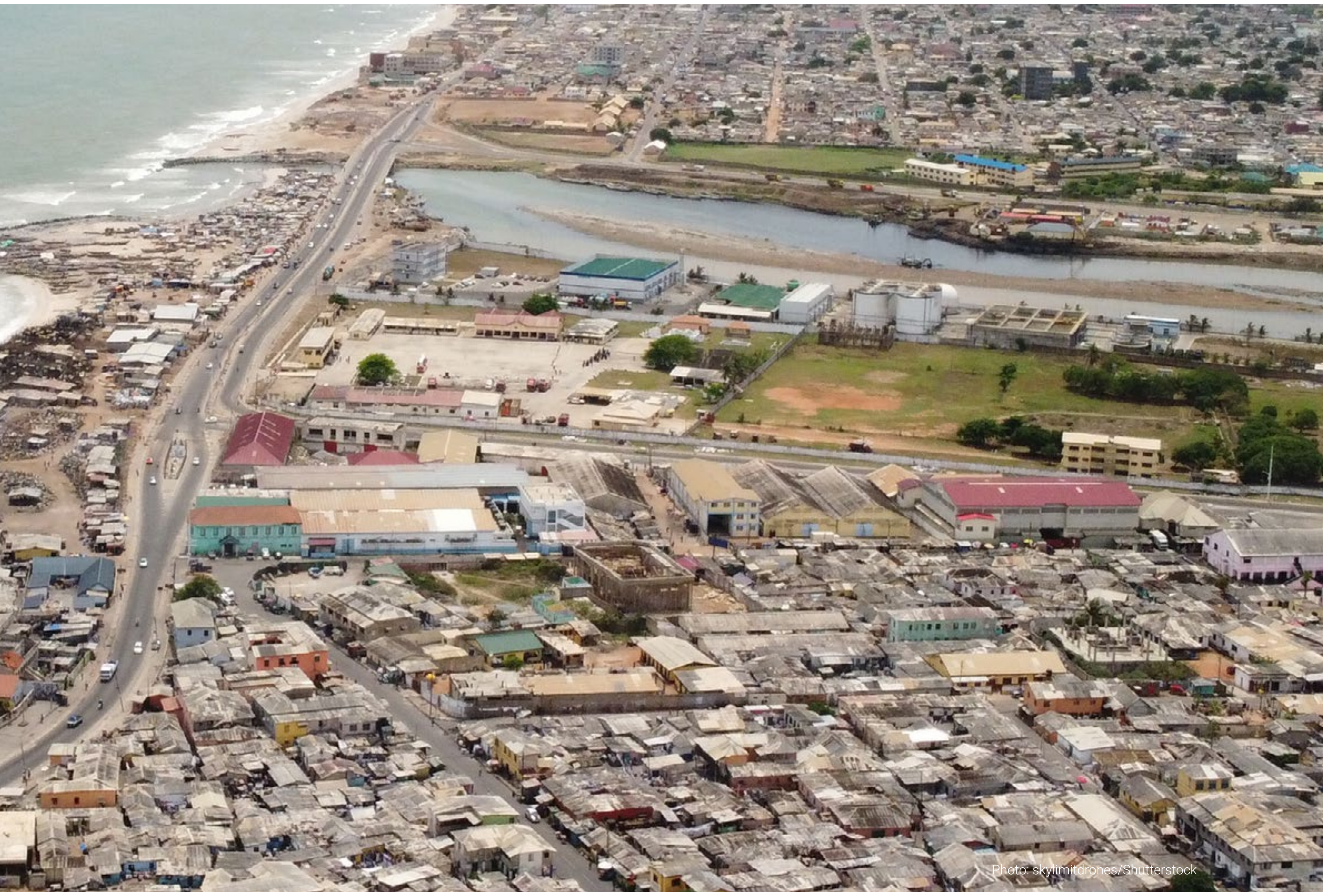
Building trust requires continuous communication between citizens and the Government, which can be facilitated through community associations. Within Old Fadama, there is an association consisting of 16 representatives of recognized tribes who convey community preferences to the AMA, opposition leaders, and Government officials who visit the community. This coordinating association works with local NGOs (such as the People's Dialogue), INGOs, and donors for technical assistance and to try to obtain funds for slum upgrading and to help coordinate and integrate donor projects. Other options for building trust include citizen scorecards (Figure 2) that are based on performance indicators agreed on through a consensus between communities and their local governments. Such indicators can be tracked over time and shared in regular community meetings as both a way of ensuring accountability and to mitigate volatility in decision-making that often occurs as governments change and politicians forget previous promises to their constituents.

"Extreme weather and rapid changes to Ghana's climate present a profound risk to key sectors of Ghana's socioeconomic development. Infrastructure in these sectors are the bedrock of the country's economic growth and development."

Dr. Kwaku Afriyie
Minister of Environment, Science, Technology and Innovation, Ghana

CONCLUSIONS

Climate change scholars highlight the need for transformational change within urban areas to meet the coming climate challenges, and to avoid locking in unsustainable practices. In cities such as Accra, with overlapping mandates for action but weak accountability structures, envisaging the planning, financing, and implementation process for transformational change is difficult. Some climate adaptation plans, such as Accra's Resilience Strategy, do articulate objectives and intentions toward the transformational, and recognize the needs and rights of the informal city. However, actual inclusive, transformational change seems improbable as long as informality is seen as illegal, the land on which informal settlements are located is contested, and alternatives to informality



are largely unavailable. Moreover, a deteriorating fiscal environment in Ghana and many other African countries limits financing for needed public investments in urban services, further constraining implementation of NAPs.

Local governments such as the AMA are closer to their citizens' needs. The AMA and other MMDAs have been assigned many of the responsibilities for the planning, project development, and implementation that effective adaptation strategies involve. Yet these entities often lack both the funds and the capacity to undertake these responsibilities. Thus, plans and frameworks articulated by the national or regional government mostly represent unachievable intentions. This problem is replicated in other African cities, with variations dependent on the degree of decentralization of power and money.

Consequently, the most inclusive approaches in the short to medium term likely will involve minor, low-cost, in situ adaptation investments, and increased coping measures. As the example of Accra shows, simply advancing proactive climate change–induced disaster planning could benefit city residents living in communities of informal housing who work on the street or at home. Partnerships between a leading national ministry, the regional coordinating council, the AMA, and community groups for the purpose of effective disaster management could produce results if they were focused on a limited set of coping outcomes.

More broadly, recognizing land rights in slums and the right of the informal sector to occupy urban spaces in order to work would itself be transformational, even if it is only step one on a long path toward adaptation. The problem for African cities such as Accra is that the time clock on climate change is advancing, and therefore the cost of the current inertia is rising.

City Resilience

Photo: Nyani Quarmyne/Panos Pictures

KEY MESSAGES

- Today, as many as 79 African cities rank among the 100 fastest-growing cities in the world, but also fall within the "extreme risk" category of climate hazards. The Rapid Climate Risk Assessment (RCRA) is an approach for urban climate risk assessment developed by the Global Center on Adaptation (GCA) building off a similar approach for climate risk assessment developed by the C40 Cities Climate Leadership Group.
- An RCRA gathers key information on climate hazard and risk, development context, infrastructure bottlenecks, past and current initiatives as well as relevant policies and institutions. To keep costs down and to better ensure time efficiency, the approach relies heavily on globally available free data.
- In its first round, GCA has implemented RCRAs in Antananarivo, Madagascar; Bizerte, Tunisia; Conakry, Guinea; Dodoma, Tanzania; and Libreville, Gabon. These cities were selected in partnership with the African Development Bank (AfDB).
- Although not meant to be exhaustive, RCRA can often serve as a codified document summarizing

the overall state of climate adaptation within a city, providing a basis for collaborative governance, integration of different knowledge domains across sectors, as well as a consensus-building tool among various interests in a city.

- The GCA RCRA methodology has been further fine-tuned based upon implementation experience shared by both the supervision team and firms. These changes will be reflected in the implementation of GCA RCRA methodology in a second batch of African cities.

“

Doing nothing is not an option. In fact, doing nothing means you lose. Why? Because these new steps in adaptation will lead to the new economies and will lead to the new jobs. And I see that day by day in my port, where 150,000 people are working every day.”

Ahmed Aboutaleb
Mayor of Rotterdam, the Netherlands

INTRODUCTION

Underpinning all climate adaptation solutions—from climate-adaptive planning and infrastructure investment to service delivery, community development, land management, and nature-based solutions (NBS)—is a solid sense of the current climate risk context. Cities, especially, are where this downscaled knowledge is needed—to inform the prioritization, design, implementation and operations and maintenance (O&M) of localized action. It is in this context that the Global Center on Adaptation (GCA) has developed and implemented its Rapid Climate Risk Assessment (RCRA) methodology, in response to the strong need and demand in Africa's rapidly urbanizing cities.

The vulnerability of African countries to climate change, relative to their readiness to adapt, ranks them among the lowest on the Notre Dame Global Adaptation Index (ND-GAIN): 16 of the 20 countries ranking lowest in the Index are in Africa.[1] Germanwatch's most recent Global Climate Risk Index shows that in 2019, five of the 10 most affected countries by extreme weather events were African: Mozambique (No. 1), Zimbabwe (No. 2), Malawi (No. 5), South Sudan (No. 8), and Niger (No. 9).[2] And African nations' climate risk is increasingly being concentrated in cities, where rapidly growing proportions of people, assets and economic activity are becoming exposed to climate hazards.

According to the Climate Change Vulnerability Index (CCVI), 79 African cities rank among the 100 fastest-growing cities in the world, but also fall within the "extreme risk" category. A total of 15 African capitals, and many of the continent's key commercial hubs, have significant combined risk factors stemming from rapid population and economic growth and climate risk. Among the most at risk are Addis Ababa (Ethiopia), Luanda (Angola), Dar es Salaam (Tanzania), Kampala (Uganda), and Abuja and Lagos (Nigeria).[3]

These risks take different forms. Flood risk is most prevalent in southwest Africa and countries with large rivers in West Africa, fueled by increasingly extreme hydrometeorological activity and by deforestation and urban encroachment into flood plains. Sea-level rise is of particular concern in low-lying coastal areas, increasing flood frequency and the risk of storm surges. This is of especial concern given that half of the African settlements with 1–5 million inhabitants are located in low-elevation coastal zones, with some estimates projecting that Africa's populations in low-elevation coastal zones (LECZ) will rise at more than double the world's average.[4] The impact of drought is particularly acute in African cities as it manifests itself in reduced water supply, which in turn creates difficult water management issues as urban water utilities often source their water upstream in watersheds that go beyond their municipal jurisdiction. Extreme heat is another pressing concern, as the cities in Africa are often being built without consideration for green space, leading to an increased heat island effect. Tropical cyclones, whereby one singular event can have a globally catastrophic impact, are also of concern. For example, the impacts of Cyclone Idai in March 2019 alone propelled Mozambique, Zimbabwe and Malawi to the Germanwatch top 10 list, due to catastrophic damage and a subsequent humanitarian crisis.[5]

These impacts are experienced most especially among the urban poor, who have the least amount of access to formal means of withstanding the impacts of climate change. A combination of high levels of social vulnerability among Africa's rapidly growing urban poor, coupled with the increasingly recurrent impacts of extreme weather events, is creating an urgent need for adaptation responses.[6]

THE OPPORTUNITY

While climate risks and vulnerabilities abound in African cities, there nevertheless remains a unique opportunity to get things right, as much of Sub-Saharan Africa (approximately 40 percent) is still in the early stages of urbanization. Climate risk assessments can help decision-makers understand the climate risks associated with current and future urban development, and identify, prioritize, and implement low-cost actions to avoid repeating mistakes made by other regions of the world and locking in risks. Thankfully, working toward resilience is not cost-prohibitive. Some estimates suggest designing more resilient assets in the energy, water and sanitation, and transportation sectors in low- and middle-income countries would amount to an additional 3 percent in costs.

As noted in this State and Trends in Adaptation report 2022, up-to-date knowledge of current and future risks, based on cost-effective data collection, among other elements, is critical in significantly reducing the impact of climate change in African cities. The prioritization of investments based on climate risks and bottlenecks requires an understanding of the general landscape of climate hazard, risk and resilience opportunities. However, given the limited resources of African cities, doing so can be cost-prohibitive if not done in a way that is strategic.

The RCRA is an approach developed by GCA, building off a similar approach for climate risk assessment developed by the C40 Cities Climate Leadership Group, a global network of mayors collaborating to reduce emissions in their cities. An RCRA gathers key information on climate hazard and risk, development context, infrastructure bottlenecks, past and current initiatives as well as relevant policies and institutions. To keep costs down and to better ensure time efficiency, the approach relies heavily on globally available free data. While RCRAs are by no means meant to serve as all-encompassing studies, they provide the basis upon which more detailed studies for project feasibility, preparation and design can be made. Thus, RCRAs can serve as a critical first step in a longer-term climate resilience—building journey for cities across the continent—by first understanding the current state of climate adaptation locally.

OBJECTIVE AND METHODOLOGY OF CITY RESILIENCE ASSESSMENTS

As a first step in the engagement of cities, GCA implements RCRAs to identify key climate risks and vulnerabilities, and to scope expected impacts in selected cities. The RCRAs also work further to gain a more solid understanding of past and current initiatives in the urban climate adaptation and resilience domain, to help inform a future course of action. For GCA, improved urban climate adaptation and resilience outcomes are characterized by:

- strengthened urban climate risk management in cities and their hinterlands;[7]

Photo: Goedele Monnens/iStock

- improved climate-adaptive spatial planning at the municipal and regional levels;[8]
- enhanced urban water resources management for more equitable access to ecosystem benefits;[9]
- enhanced resilience, consistency, inclusiveness and integration of urban drinking water, sanitation and solid waste management services;[10] and,
- improved urban livability and public health from climate risks stemming from heat stress and disease.

An RCRA consists of three parts to be implemented in each city:

Part A: City Scan provides a rapid review of what has been done in the respective city regarding climate hazard and risk assessments, as well as more locally focused assessments of vulnerability and adaptive capacity. It provides a clearer picture of the city's urban climate adaptation and resilience ambitions, strategies, plans and specific priorities.

Part B: Rapid Climate Risk Assessment provides an overview of the key climate hazards and associated risks that a city faces and is intended to inform the decision on whether an in-depth climate risk assessment is required. This part of the RCRA largely builds off the C40 Cities Climate Leadership Group approach for climate risk assessment. Box 1 outlines the differences between the two approaches.

Part C: City Scoping provides insight into past and current initiatives relevant for adaptation and resilience building, identifying key stakeholders and relevant initiatives. This provides the basis for early identification of potential no-regrets climate adaptation measures a city can consider for further analysis.

Box 1. A Comparison of Approaches to Assessing Climate Risk

The C40 Climate Action Planning Framework includes guidance for conducting both climate hazard assessment and climate hazard impact assessment. The former identifies the probability, intensity and timescale of key climate hazards (i.e. short- or long-term meteorological, climatological, hydrological events) in a city. This is done by accounting for historic climate trends and the current situation of a city as well as future climate scenarios derived from available scientific evidence through to 2050 (and beyond, where possible). The latter draws on the former and looks at the potential impact of extreme climate events on people, assets, and service delivery within a city. In addition to identifying (a) potential climate impacts on people and systems (e.g. number of individuals impacted, cost of damages and economic losses due to service delivery disruption), it also provides guidance on how to assess (b) the capacity of an area's population and systems to adapt in the face of climate hazards, and importantly (c) consideration of vulnerable groups within the population, relevant systems, and service sectors (e.g. water, transport, energy, solid waste management). GCA's RCRA methodology—in particular, for Part B: largely aims to achieve the same objectives.

However, the GCA RCRA approach diverges from the C40 approach in its exclusive focus on climate adaptation. Spanning both the climate adaptation and mitigation sides of the climate spectrum can result in an assessment not so different from a general sustainable development assessment of a city, for example. Concentrating on the adaptation side of the climate spectrum can enable a quicker process resulting from a more focused identification of and discussion with government counterparts when conducting GCA RCRA's Part A: City Scan. For example, experience has shown that in all contexts (regardless of level of development), climate change adaptation and mitigation concepts are often confused with each other, resulting in disjointed problem articulation, assumptions and recommendations. In addition, when it comes to identification of no-regrets measures under Part C: City Scoping, a focus on adaptation enables more concrete recommendations on how to strengthen a city's resilience to climate hazards. While actions that demonstrate both adaptation and mitigation co-benefits certainly exist (e.g. effective upstream watershed management can both reduce downstream flood risk and confer greening benefits by increasing absorption of CO_2), this list of actions is relatively limited. Thus, having an adaptation focus may result in a wider menu of actionable options—be it for investment or policy reform.

In all, RCRAs largely consist of the following key elements:

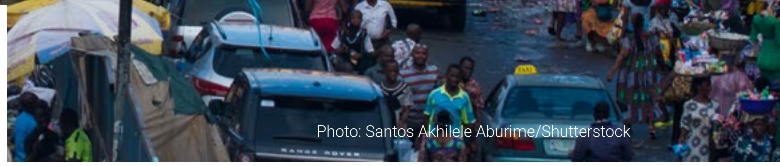


Photo: Santos Akhilele Aburime/Shutterstock

Figure 1. Key Elements of an RCRA

Introduction: A general overview of the RCRA, including a context section highlighting key development indicators related to urbanization, poverty, and informality.

Governance Structure: A detailed survey of municipal and national policies and institutions relevant to climate adaptation within the city.

Hazard, Impact, and Risk Assessments: Based upon existing data, information and analysis (including freely available global data sets), they assess the climate hazard, impact and risk context of the city. When available, these assessments include existing hazard, impact, and risk maps. While often these maps do not exist due to a lack of localized data, identifying specific neighborhoods and districts that have recently experienced high-impact climate events (including disasters) can provide a rough picture of the climate context within a city, with specifications for further analysis in future investigation, whether in the identification and prioritization of specific infrastructure interventions and/or to inform the planning process.

Past and Planned Investments: A survey of past, current and planned climate adaptation investments within the city, to shed light on the climate adaptation landscape and identify gaps that can be filled in future investment activities.

No-Regrets Measures: Identification of no-regrets climate adaptation measures that can be implemented and result in high impact in strengthening the climate resilience of the municipality. These are items that can be considered by the municipal and national authorities—as well as potential financiers—for future potential project finance, and serve as a first step for more in-depth, future scoping activities.

The key to this approach is the rapid nature in which the climate risk assessment is carried out. In essence, RCRAs are meant to put the finger on the pulse so as to support decision-making of municipal and national authorities for where further, more in-depth investigation is necessary (which requires more resources and time). And, in an effort to understand the needs of the most vulnerable, the RCRAs aim to understand the informal sector as much as possible, often having to rely on primary information gathering as well as identification of areas for further investigation.

Box 2 offers a comparison of RCRAs with a more detailed climate-risk assessment conducted by GCA in Accra, Ghana.

Box 2. Why Choose an RCRA?

Two kinds of climate-risk assessment are possible: rapid or in-depth. Any assessment that is more comprehensive is obviously more ideal, but the more in-depth the analysis (meaning the inclusion of new quantitative analysis and mapping), the higher the cost involved and the longer the time required to implement it. Determining the level of detail of an assessment, therefore, is contingent on the available budget as well as other factors, such as availability of other assessments or capability, and political will of a city in achieving its climate adaptation ambitions. Table 1 provides an outline of the pros and cons of a rapid versus in-depth climate-risk assessment based upon GCA's experience in implementing both kinds of assessments: RCRAs in five African cities and in-depth assessments in Accra.

While in-depth assessments in every context would be ideal, RCRAs may prove most feasible given that they are relatively quick, cheap and easily deployable—especially when generation of new hazard and exposure data is required, but time- or cost-prohibitive.

In such a situation, even if the end result of an assessment is not as comprehensive as needed, an RCRA can serve as the preliminary legwork that would have still been required for determining the parameters of a more in-depth analysis. An RCRA can serve, then, as a strategic first step in engaging city and country authorities on the importance of considering climate adaptation options, while building the necessary political will needed for embarking on a long-term climate adaptation journey that requires both investment and meaningful policy change.

Table 1. Rapid Versus In-Depth Climate Risk Assessment

Factor	Rapid		In-Depth	
	Advantages	Disadvantages	Advantages	Disadvantages
Methodology	Simple, modular and easily deployable	Limited, particularly the depth of new quantitative analysis	Results in detailed picture of climate risk landscape of a city	Highly specific to local context, requiring preliminary reconnaissance of existing analysis in the city and technical staff to provide quality assurance of outputs (even when fully outsourced)
Cost	Relatively low-cost			Relatively high-cost, especially in data-poor environments
Technology	At a minimum, can be relatively low-tech and deployable in data-poor environments	Likely to result in a broad-brush assessment and mapping of hazard and risk. Unlikely to identify and prioritize specific climate-adaptation investments	Likely to result in a detailed picture of hazard and vulnerability hotspots of a city, resulting in a critical reference when identifying and prioritizing climate-adaptation investments	Highly technical, likely requiring contracting of external analytical (quantitative) expertise
Time Duration	Quick (3–4 months average)			Time-intensive (9–12 months minimum)

Box 3. The Benefits of Batch Procurement Case Study

Batching together the RCRAs into two separate contracts provides a number of benefits.

First, the efficiency gains stemming from batch procurement saves time in recruitment and contracting. Procuring the consultant services of a firm can further offer efficiency gains by placing the onus of hiring multiple expertise on the firm—which can often be quicker in the private sector. This is especially important when considering the diverse expertise required to be deployed in a rapid manner with the RCRA, ranging from climate change, urban development, hazard and risk analysis, social development, and economics. This, in addition to the need to hire local consultants with local knowledge and access to the local communities, institutions and data, has proven especially critical in enabling a quick turnaround.

Second, a significant benefit stems from the opportunity to employ a diversity of approaches and to learn from each other's approaches—in a context where there is no single way of conducting an RCRA, even when the questions are clearly laid out. As a plethora of assessment approaches exist, and ways in which to overcome commonly experienced challenges, peer-to-peer exchange among firms proved to be successful in sharing experiences and overcoming common implementation challenges. Enabling this exchange is something in which the contract holder (GCA) can play a strategic role.

Third, having two firms also offers the opportunity to standardize methodologies. While initially seeming to be counter intuitive in having two firms (as opposed to one), the batching of cities ensures that the firm develops a modular approach that can be applied to more than one city, rather than having a methodology focused on the minutiae of each individual city. By implementing an RCRA in two or more cities, a firm focuses on developing and delivering on a standardized approach, and moves the climate-risk assessment dialogue closer to a more streamlined methodology globally.

That said, the enabling factor of success in implementing batch procurement is the time taken to design detailed Terms of Reference (TOR) and being as specific as possible in detailing the questions that should be answered by the RCRA. This provides guidance to the firms, but also helps ensure some level of comparability between the two firms' outputs. Going through an open competitive process, with sufficient time dedicated to advertising a Request for Expressions of Interest and Request for Proposal, helps ensure the most appropriate firms are aware of this opportunity. Lastly, a competitive process between two firms helps ensure that certain performance-based standards are met—in particular, the rapidity of delivery. Importantly still, having two firms further helps the contract holder understand whether certain requests detailed in a TOR cannot be met, which is normally made apparent when both firms express the same challenges—allowing the contract holder to collectively brainstorm and decide with the firms on how to modify the requirements.

By gaining a general sense of the current climate landscape in a city offered by an RCRA, decision-makers have a more informed view of where further investigation is needed, such as with conducting more detailed hazard and risk mapping or conducting more in-depth analysis in identifying, prioritizing, siting and designing climate-adaptation investments. This is particularly important given the linkage with the Africa Adaptation Acceleration Program (AAAP), which aims to mobilize US$25 billion in climate adaptation investment in Africa.

Importantly, by bidding the effort out to private firms, the RCRAs leverage the unique expertise and ability to deliver of the private sector.

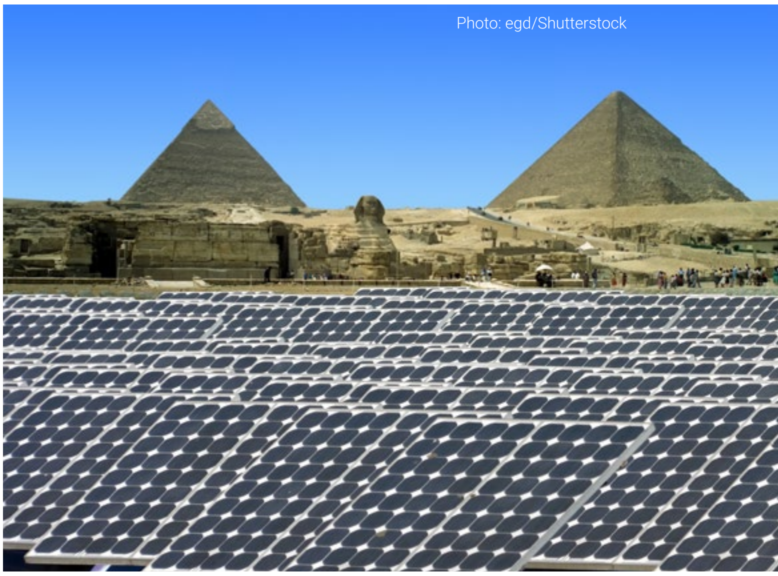


Photo: egd/Shutterstock

A SUMMARY OF RESILIENCE ASSESSMENTS IN FIVE CITIES

In its first round, GCA has implemented RCRAs in (a) Antananarivo, Madagascar; (b) Bizerte, Tunisia; (c) Conakry, Guinea; (d) Dodoma, Tanzania; and (e) Libreville, Gabon. These cities were selected in partnership with the African Development Bank (AfDB). Often, the RCRA represents the first step in a long-term engagement with cities in their climate resilience–building journey. Not only does it assess the climate hazards and risks and identify past, current and planned climate adaptation initiatives, it also provides the premise for forming institutional linkages and connections required for any long-term climate adaptation engagement.

RCRAs are meant to develop an overall picture of the city, including background information of the city and country relevant to expected climate change and its impacts and risks; and they provide a rapid insight into what has been done in the city regarding climate hazard and risk assessments as well as more locally focused assessments of vulnerability and adaptive capacity. They should also provide an overview of the city's urban climate adaptation and resilience ambitions, strategies and plans. They also provide insight into the most significant climate risks across the city and support the identification and preparation of subsequent investment projects. Often, this is where a development partner such as an international financial institution (IFI) or a donor is likely to take the torch, after a general sense of the climate landscape is established by the RCRA, and vulnerable hotspots and in-demand no-regrets measures are identified. A development partner—with project finance—can finance follow-on studies needed for the identification, design, preparation and implementation of climate-adaptation investments (be it a concrete project or policy reform). RCRAs provide the preliminary legwork required for detailed studies to be conducted, as well as help identify cities where there is strong local institutional support and political will to embark on a long-term climate adaptation journey.

The most noteworthy findings from each city resilience assessment, with key takeaways, are summarized in Table 2.

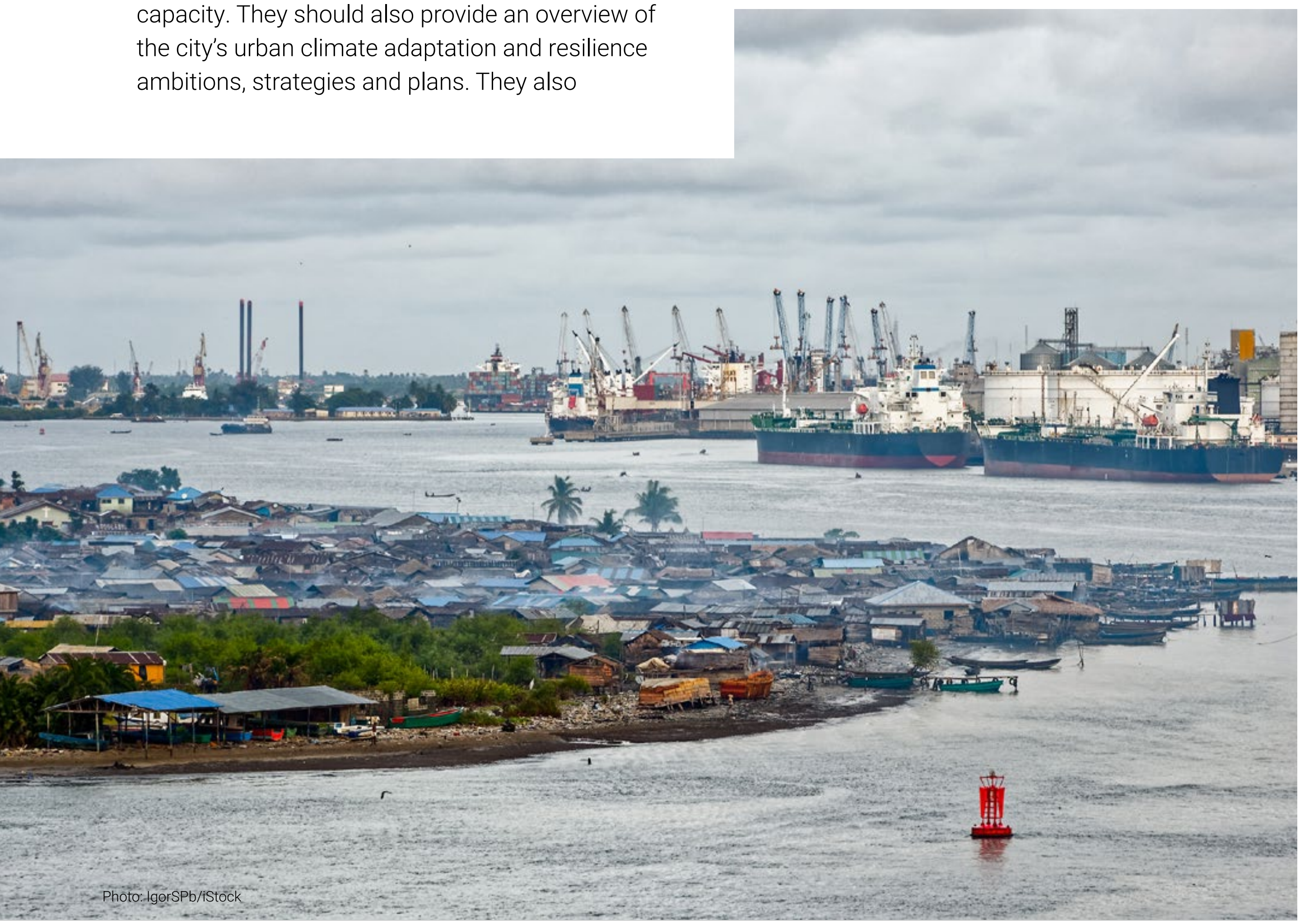


Photo: IgorSPb/iStock

Table 2. Summary Comparison of Five African Cities

Factors	Antananarivo	Bizerte	Conakry	Dodoma	Libreville
Population	~3–4 million inhabitants	~150,000 inhabitants	~1.6 million inhabitants	~580,000 inhabitants	~850,000 inhabitants
Key Attributes	Capital city; swampy plain bordered by hillsides	Secondary city; coastal city with extensive shoreline	Capital city; coastal city situated on low-lying wetland peninsula	Capital city; low density; semi-arid plain with highly impermeable soils	Capital city; coastal hilly city with developments in marshy valleys
Informal Sector	~70%	Unknown	~67%	~67%	~80%
Key Hazards	Floods; landslides; increasingly frequent droughts and cyclones	Floods; sea-level rise; coastal erosion; wildfire; drought; water scarcity and salination; extreme heat	Floods; sea-level rise; coastal erosion; cyclones; water scarcity	Extreme heat; drought; water scarcity; floods	Extreme rainfall; floods; sea-level rise and coastal erosion
Key Risks	Displacement and loss of lives; food insecurity; damage to buildings and infrastructure; negative health; increased rural-to-urban migration	Loss of economic assets and activity (e.g. beaches and tourism, fishing); damage to buildings and infrastructure; adverse health outcomes	Loss of economic assets (e.g. land, beaches); increased water scarcity; destruction of ecosystems and fisheries; adverse health outcomes	Loss of agricultural productivity, soil fertility and incomes; increased water-borne disease; adverse health outcomes; food shortages	Damage to infrastructure; displacement; post-flood disease; adverse health outcomes
No-regrets Measures Identified	Strengthening adaptive capacity; disaster evacuation planning; climate-resilient water and sanitation infrastructure; nature-based flood risk reduction	Stormwater drainage management; rainwater-harvesting; resilient urban planning; resilient mobility; sustainable forest management	Climate-resilient urban and land-use planning; nature-based solutions; stormwater drainage management; improved sewerage and solid waste management; water management; coastal protection	Climate-resilient farming and water management; improved solid waste management; urban greening; climate-resilient infrastructure; flood defenses	Flood prevention; improved solid waste management; climate-resilient water and sanitation infrastructure; urban greening
Institutional Mandates for Climate Adaptation	Strong	Medium	Limited	Medium	Limited

Antananarivo, Madagascar—Increasing Flood Risk in a Fast-Growing City

Rapid population growth (from about 3 million in 2018 to a projected 5.2 million by 2030)[11] is expected to exacerbate social and economic challenges in the capital city of Antananarivo. Almost three-quarters of the Malagasy people lived on less than US$1.90 per day in 2019, and the pandemic devastated urban areas in particular, deepening poverty.[12] Uncontrolled growth in the swampy Betsimitatatra plain, in low-lying areas along three rivers that traverse the city, and into the hills bordering the south and east of the current urban footprint has led to an increased concentration of people and assets in hazard-prone areas. More frequent high-intensity rainfall events fueled by climate change, coupled with deforestation upstream, have increased the flood and landslide risk to urban residents downstream. Currently, nearly one-third of the city consists of flood-prone areas.

Urban population growth and expansion have largely outpaced the capacity of existing infrastructure—largely dating from the colonial period, which ended in the 1950s. Water supply, sewerage and drainage


Photo: Tommy Trenchard/Panos Pictures

infrastructures have not been designed to account for current flooding events. Insufficient solid waste management further exacerbates the occurrence of flooding. Catastrophic floods in Greater Antananarivo in January 2015 affected almost 100,000 people, displacing 40,000, and caused damage equivalent to 1.1 percent of GDP.[13]. The majority of those affected are the poorest, who moved into marginal areas that are most exposed to flooding hazard and have least access to urban services. And with 70 percent of the urban workforce employed in low-paying informal sector jobs, there is often little margin to cope with disruptions in urban service delivery. This became particularly apparent during the most recent floods in January 2022 (which occurred during the implementation of the RCRA), in which more than 62,000 people were affected and 6,800 houses were underwater and at risk of flooding or collapsing. More than 35,000 people were forced to take shelter in more than 60 evacuation centers.

To this end, a number of no-regrets measures have been identified to increase the climate-adaptive capacity of Antananarivo and include strengthening disaster evacuation planning, investing in climate resilience of water and sanitation infrastructure, expanding NBS to reduce flood risk and urban heat island effect—all of which are in line with the Antananarivo 2040 action plan. These efforts would complement recent initiatives, which include (a) Integrated Urban Development and Resilience Project (PRODUIRE) (IDA, US$75 million); (b) PIAA-SDAA Urban and Sanitation Master Plan for Antananarivo (AFD and EU, €28 million); (c) Adapt'Action: setting up a national climate adaptation policy and governance framework (AFD, €30 million); (d) SUNREF: mobilizing the financial sector to invest into climate change adaptation (European donors and EIB, €33 million); and (e) Antananarivo Vision 2040 (2025–2040) (AfDB, 2021).

Bizerte, Tunisia—Rising Temperatures and Sea Levels along the Mediterranean Coast

Over the past three decades, the urban built environment has doubled in size in Bizerte. Over the past five decades, average temperatures have steadily increased by 4°C, with projected increases of 4.4°C by 2070; average daily maximum temperature is expected to increase to 43.8°C. By the same token, there have been noticeable decreases in average annual precipitation, with an expected decrease from 365 mm per year to 288 mm per year by 2070. A combination of drought, water scarcity and heatwaves are of concern, having adverse impacts on public health due to the urban heat island effect, water shortages (the Sidi Salem Dam currently functions at 30 percent capacity) and increases in

Figure 2. Bizerte Hazard Map

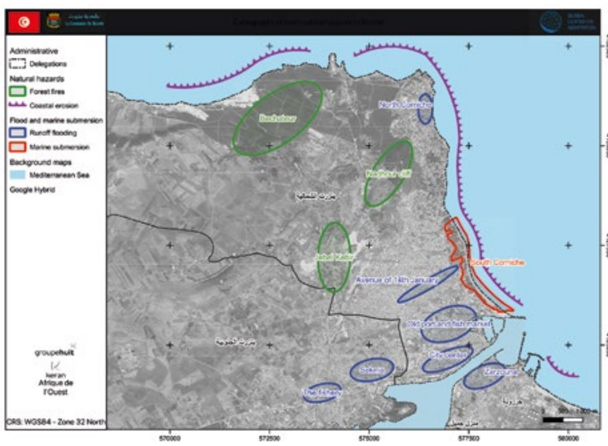
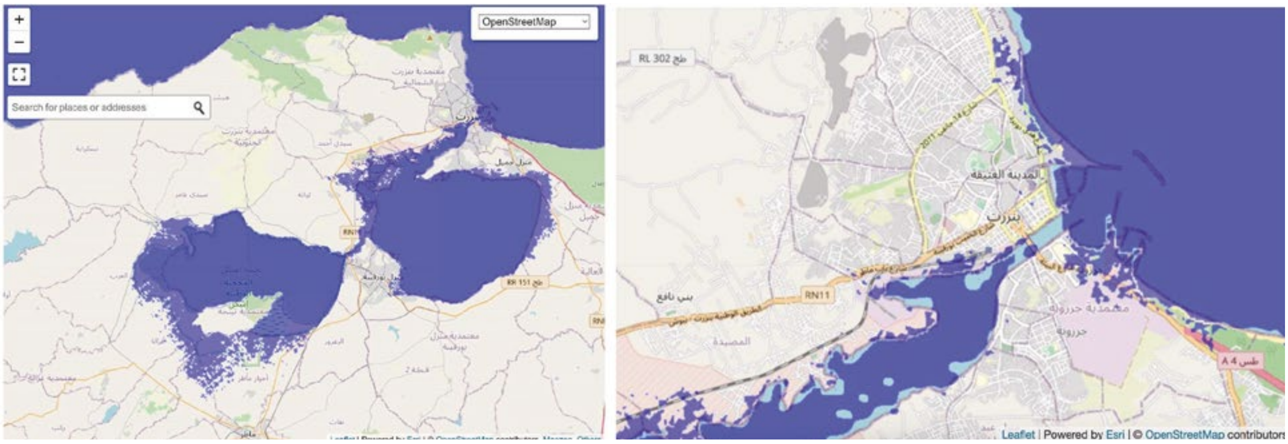


Figure 3. Areas Anticipated to be Submerged with Sea-Level Rise In Bizerte, Largely Limited to Areas around Lake Bizerte and Lake Ichkeul



forest fires. Projected sea-level rise is expected to increase by 0.42 m by 2070 and 0.78 m by 2100, raising concerns of coastal erosion and flooding of low-lying coastal areas (in particular areas built on landfill) as well as salinization of aquifers. The main areas expected to experience impacts include urban economic activities and tourism along the coastline and city center due to coastal inundation and flooding respectively; agriculture due to lower precipitation, salinization of water resources and drought; fisheries due to increased water temperatures; and industrial activities impacted by water shortages and urban floods.

Key physical challenges identified include (a) lack of a properly designed drainage network and hydraulic bottlenecks; (b) expected loss of land, in particular beaches and landfill sites, which are critical for tourism and coastal development. Key institutional challenges identified include (a) lack of knowledge of climate risks and lack of hazard and risk data to guide urban planning practice (e.g. maps of high-risk flood areas); (b) lack of enforcement capacity and ability to ensure risk-sensitive development; (c) lack of municipal-level financial and human resources to manage drainage infrastructure. A new Urban Development Plan (PAU) is currently under development and will guide future urban growth by creating a new urbanization area, but will need to account for climate risk as current planning documents do not.

Current climate adaptation initiatives include (a) Tunisian Coastal Areas Protection Program (Programme de Protection du Littoral Tunisien —PPLT) managed by the Agency for Protection and Planning of the Coastline (Agence pour la Protection et l'Aménagement du Littoral—APAL) to include measures to protect and recreate 7 km of Bizerte coastline, including seawalls and beach renourishment (KfW and other sources, €32 million); (b) Tunisia Disaster Resilience Program-for-Results (P4R), under which Bizerte is one of six municipalities participating in reducing flood risk and enhancing disaster preparedness, among other activities; and (c) new dam construction in south Bizerte slated to be completed by 2023.

Conakry, Guinea—Too Much and Too Little Water Exacerbating Climate Change Vulnerability

Located on a peninsula, Conakry suffers the hydrological challenge of too much salt water and too little consistent freshwater—a challenge further exacerbated by climate change and vulnerability. The projected increase in sea level is expected to be 0.4 m by 2070, which will mean greatly increased coastal flooding. This is intensified by poor waste management, lack of correctly designed drainage, as well as informal construction in flood-prone areas. Coastal recession is reaching 85 cm per year in some places, fueled by increasingly intense storm events

Figure 4. River Flooding and Coastal Erosion/Flooding Hazard Map of Conakry

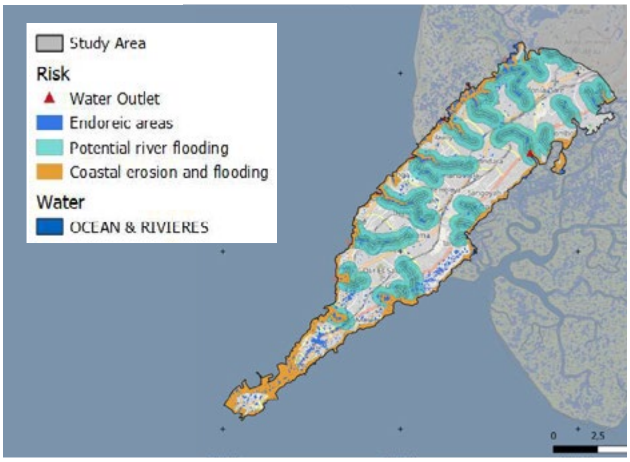
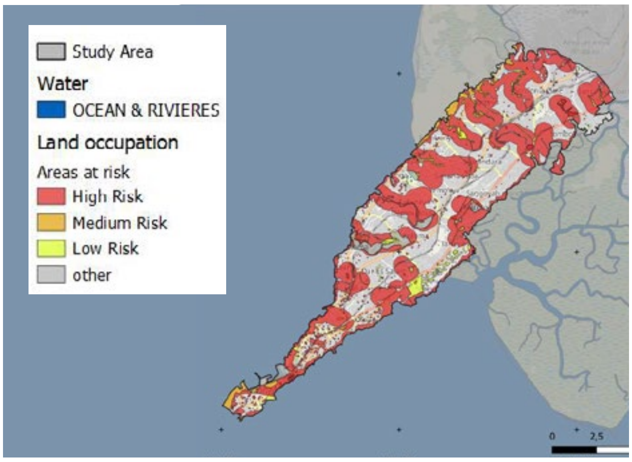


Figure 5. Flood Risk Map of Conakry



and sea-level rise. This is exacerbated by uncontrolled coastal development and destruction of mangroves.

The urban built environment within the city's borders has increased from 89 km^2 in 1990 to 116 km^2 in 2018 (30 percent). Between 1990 and today, the city has lost almost all its natural spaces, which have been replaced by built-up areas (green spaces currently represent 4 percent of the total area, down from 40 percent in 1990). Roughly 30 percent of the urban population in Conakry live below the poverty line, and more than two-thirds live in precariously built housing, greatly vulnerable to climate hazards. People's incomes are vulnerable to climate impacts on economic activities (fishery, agriculture, industries). Drinking water availability is a significant issue for a large part of the population.

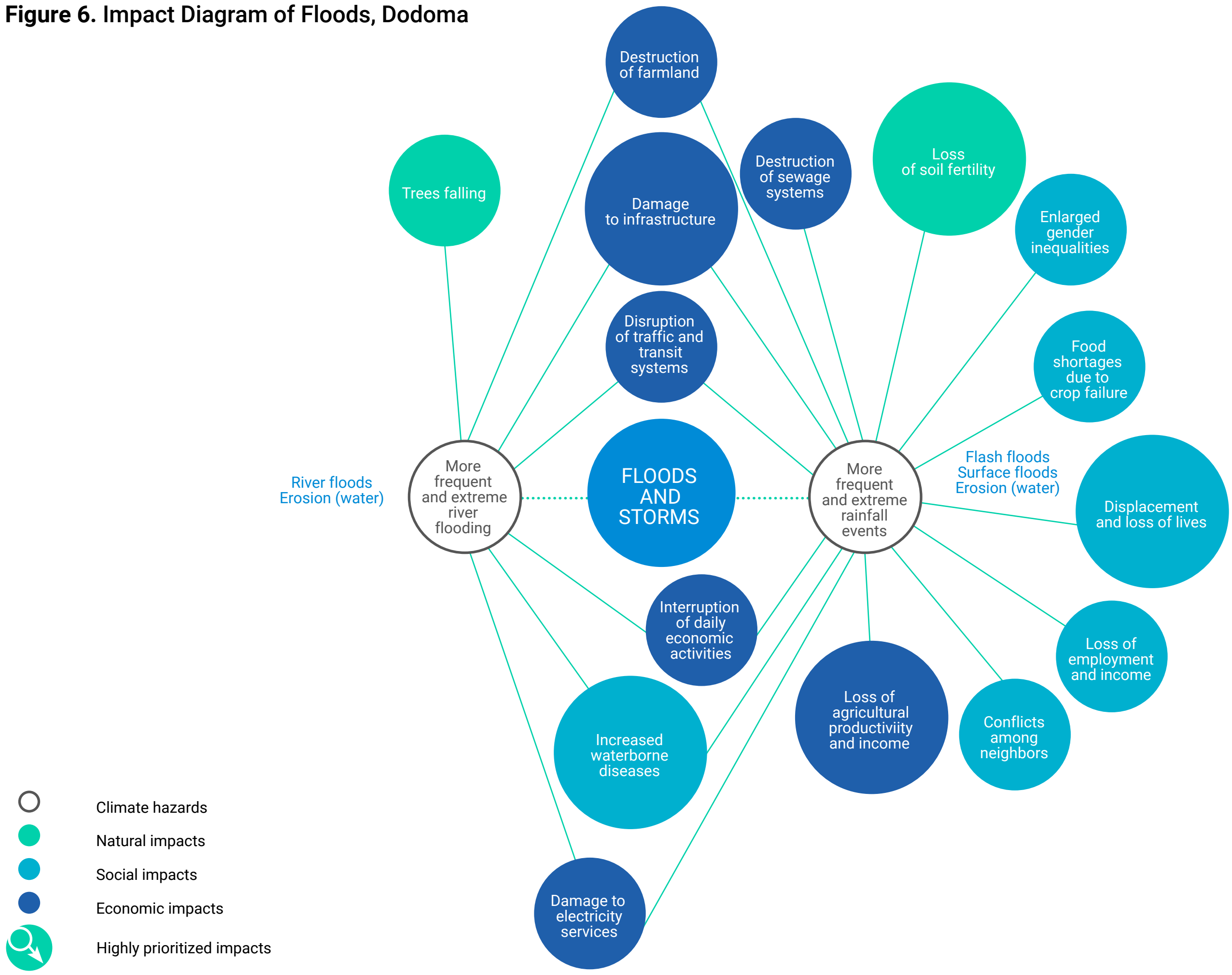
From an institutional perspective, the current urban regulatory framework is not sufficient to address climate change: there is a lack of urban planning and lack of enforcement of existing rules. There is spontaneous urbanization in flood-prone areas, for instance on riverbanks. Earth-filling in wetlands for urban development projects is blocking the natural catchment area of surplus water in case of heavy rainfall. Other activities such as mangrove wood exploitation (only one-fourth of the population are connected to the electricity network, the rest use firewood) and uncontrolled drilling of groundwater are contributing to water scarcity and hazardous conditions (e.g. increased coastal and soil erosion, resulting in increased flooding).

No-regrets measures identified include implementing NBS to reduce floods, heatwaves, erosion, and water-scarcity hazards; improving stormwater management infrastructure; integrating solid waste management and sewerage infrastructure; and limiting the impacts of coastal erosion through beach nourishment and coastal defense infrastructure. While a handful of plans and strategies exist that touch on climate adaptation, there is no project that specifically addresses urban climate adaptation issues, with the exception of the Guinea Urban Water Project (World Bank, US$30 million), which includes (a) expansion of water supply capacity at Grandes Chutes Dam; (b) rehabilitation of distribution network; (c) updated urban water supply masterplan, baseline and hydraulic modeling for Greater Conakry for the 2030 horizon; and (d) strengthening public-sector capacity for water resources management.

Dodoma, Tanzania—Heating Up in the Nation's Young Capital

Serving as the country's official capital since 1996, Dodoma is a relatively small city (approximately 580,000 residents) with low population density. Nearly 54 percent of the city's territory comprises scattered settlements and farming land as well as open space set aside for nature reserves and recreation. The City Master Plan of 2019 proposes a 20-year zoning and development plan to guide future urban development to accommodate a population that is expected to nearly triple (1.7 million residents) by 2040. Agriculture represents an estimated 39 percent of economic activity, followed by consumer services (29 percent) largely provided by the informal sector (food stalls, beauty salons, tailoring,

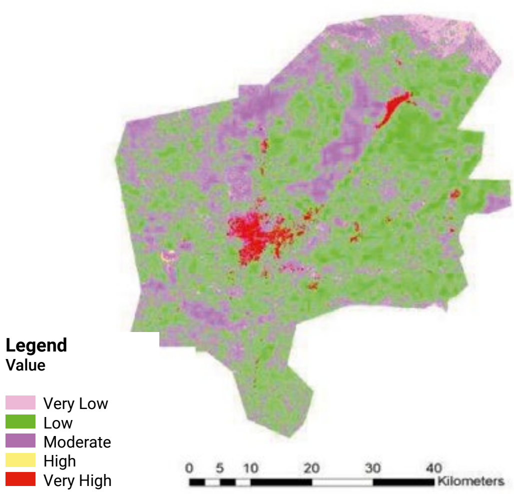
Figure 6. Impact Diagram of Floods, Dodoma



automobile repair) and industry (wood, foodstuffs, household consumer goods).

Located on high-elevation, semi-arid plains, with poor soil permeability of surface water, Dodoma is increasingly affected by heat, drought and water scarcity. This is particularly concerning given the high proportion of the population dependent on agriculture. To a lesser extent, floods and storms are an issue. By current estimates, average maximum temperature is expected to increase by 1.3–1.8°C by 2050, with an almost nine-fold increase in total number of very hot days (>35°C), from 9 days currently to 87 days in 2050. This is particularly concerning as the city's economic production is heavily reliant on agriculture; this will also significantly impact water availability. Within the city as well, increases in very hot days are likely to result in an urban heat island effect, which is expected to impact the poor and most vulnerable living in informal

Figure 7. Flood Hazard Map, Dodoma



Source: Drainage and Sanitation Development Plan, Dodomo City, 2019 settlements and possessing the least financial means of being able to afford cooling equipment.

A series of no-regrets measures identified include promotion of climate-resilient farming practices (including drought-tolerant seed varieties and technologies), increasing large-scale water storage capacity to relieve pressure on dwindling groundwater resources, and promoting city greening initiatives to reduce heat island effect. These efforts would complement recent initiatives that include (a) Eco-Village Adaptation to Climate Change in Central Tanzania—Dodoma (European Commission, US$2.2 million); and (b) various sub-projects implemented under the Tanzania Strategic Cities Project (TSCP) involving climate-resilient drainage and sewerage infrastructure, solid waste management (World Bank, ~US$11 million); (c) construction of a new Farkwa dam to augment water supply (AfDB); and (d) an urban greening initiative, Make Dodoma Green, to reduce urban heat island effect and improve urban livability and public health (City of Dodoma resources).

Figure 8. Libreville Hazard Map

Libreville, Gabon—Assessing Climate Risk in a Young but Data-Poor City

With more than a third of the country's population living in Libreville (and nearly 80 percent of the population living in the top four cities), Gabon maintains one of the highest urbanization rates in Africa. Much of this urban growth is recent, with Libreville's population increasing 20-fold since Gabon's independence in 1960 to nearly 900,000 in 2022. With this rapid growth came a change in demographics, landscape and governance structure. Currently, more than half the city is under the age of 25, with nearly 87 percent below the age of 50 years. 80 percent of urban inhabitants live in "under-integrated districts," which are characterized by informality, uncertain tenure and insufficient urban service delivery. Green cover has reduced from 75 percent of Libreville city center to 5 percent in 1996. Most of the municipal budget is dedicated toward staffing, leaving little left for future investment or even maintenance of existing infrastructure.

There is hilly terrain in the city's center, and flat plains in the city's north and northeast. Wealthier neighborhoods are concentrated on the hilltops and the oceanfront, while lower-income neighborhoods are concentrated in the valley. Flood risk affects more than 37 percent of the population and more than 42 percent of the city's surface area, exacerbated by insufficient solid waste management and high


Photo: Nguema Ellangmane Adrim Derrick

prevalence of littering and dumping. And while a national statute stipulates that municipalities are responsible for management of sanitation and drainage, transfer of powers and responsibilities has yet to take place, resulting in national ministries (Ministry of Public Works, Equipment and Infrastructure; Ministry of Energy and Hydraulic Resources) being still responsible for the provision of such services. Land is managed under a combination of civil land law and customary law. Such traditional governance is particularly prevalent in the old Libreville districts as well as informal communities.

Given these challenges, the RCRA relied heavily on primary research and field surveys of public perception in the city's first, third and fifth districts, to make up for the relative dearth of urban information. (For example, there is only one meteorological station in Libreville at the airport—one of only three in the entire country). Rainfall stations date from 1974, and are currently out of service. Existing projections are largely at the national scale from global models, with virtually no downscaled information available for the local level. In inquiring about flood and storm risk to the city, the primary impacts are felt in the destruction of urban infrastructure and housing, public health, access to drinking water and jobs. Given the high degree of informal development in Libreville, many of the no-regrets measures identified align closely with sustainable urban development that is climate-resilient and include improving solid waste management, land-use planning, roads, drainage and flood defense as well as water supply. Planned climate-adaptation projects include (a) stormwater drainage construction project (Development Bank of the Central African States, ~US$115 million); (b) stormwater management and sanitation infrastructure under Local Infrastructure Development Project—Phase II (World Bank, US$100 million).

RECOMMENDATIONS

This section offers common recommendations and lessons learned from implementing the RCRAs across five cities, followed by next steps.

1. **Recognize the value of qualitative data:** Often, when we think of climate risk assessments, we think of hazard and risk mapping. Without doubt this is a critical aspect of an assessment, but it does not always have to be quantitative. Since RCRAs are meant to be quick and cost-effective, there often is not enough time or resources to develop a full quantitative picture of a situation on the ground. Qualitative information has its value as well, especially in environments that are data-poor. And when seeking to address the needs encountered among informal communities and the poor, qualitative mapping and information can sometimes be equally, if not more, informative and cost-effective. This is true especially where the predominance of the informal market in cities means that there is likely to be no quantitative data at all—whether regarding service delivery and provision or land and housing markets. Employing field surveys to gain perception data can be a start that will inform future quantitative work, as was done in Libreville.

   RCRAs acknowledge and recognize that generating any kind of data is better than no data at all. Using an RCRA opportunity to ask consultants/firms to gather as much qualitative data as possible can be useful to help provide more context to inform existing and future quantitative work. The efficiency resulting in doing a desk review further ensures that future analytical work builds on what is already there. Thus, dedicating time to mapping the literature can prove a huge efficiency gain, and should be commended for its contribution in itself. Often, the information resulting from an RCRA is sufficient to begin project scoping within a city, whereby challenges are identified that can be further investigated during project identification and prioritization. By mapping the gaps and prioritizing need, future, more in-depth engagement can be better tailored, based upon strategic need. This can be pursued in a future, more in-depth, focused and strategic climate risk assessment.

2. **Consult and bring on board entities that have public investment decision-making power, early in the process:** This ensures that the needs, incentives, and challenges faced in infrastructure investment can be better reflected in an RCRA meant to inform actual investment. Getting the buy-in of investment-able entities further helps ensure findings from RCRAs continue onto more long-term outcomes.

   Investment decision-makers often sit within line ministries that have line budgets (as opposed to climate change agencies, which often serve more of a coordination function and do not actually make decisions related to investment). Often municipalities rely on national ministries for securing investment within cities, which further became apparent during the RCRA process, whereby national ministries are involved in local infrastructure planning, investment, implementation and upgrade. To this end, while the primary locus of interaction is the municipality, national line ministries will inevitably have to be involved when talking about future climate investments. It is therefore an advantageous opportunity to utilize the RCRA process to bring such decision-makers into the process early—at the very least to ensure their needs, incentives and challenges are reflected in the final assessment.

3. **Conducting RCRAs where there is strong local government appetite for investment can be a critical enabling factor for a well-informed assessment:** The success of an RCRA process is often best enabled when there is a strong local champion, who can help in framing the local context as well as making the time within their already full work program to secure the contacts and clearances needed to secure information and data. This is often the case when the local municipality itself is interested in seeking climate adaptation investment (and it is clear that the RCRA process is a first step in getting to there). Even during the process of procuring consultant services, GCA can begin discussion with local municipal counterparts about data requirements, so that the process of securing data is more advanced by the time the consultant is contracted. Often data can be made available for free, provided that there is enough notice.

   Importantly, a strong local champion within the municipality can also help in the generation of data. In Libreville, for example, the firm involved local municipal authorities in the enumeration and surveying, accompanied by a training session on key concepts regarding climate adaptation and resilience. Not only did the municipal civil servants become more familiarized with climate change concepts, they also received a learning-by-doing training in primary research methods when implementing the questionnaire with the firm—which can be used for other future activities.

4. **Informality represents a significant portion of urban economies in the developing world and must be understood if climate adaptation activities are to be effective:** Getting information on the informal economy often requires qualitative data gathering, further underscoring the importance of having a local city advisor with familiarity with local communities and local stakeholders (e.g. community officers).However, this requires significant money, time and resources as often there is limited literature on the informal economy within the city, and understanding this sector will require new knowledge generation.

   Experience from the RCRA process has demonstrated the importance of identifying a socially focused focal point early in the process (e.g. a university, researcher, NGO, social development organization, local knowledge institute) that can be helpful in answering questions pertaining to informality or making the contacts needed to gain this perspective. A


Photo: Tommy Trenchard/Panos Pictures

semi-structured interview with a well-informed set of socially focused counterparts can serve as a critical input to an RCRA—to at least get a finger on the pulse of critical items to consider when mapping hazard and risk (and their potential effects and impacts on the informal economy).

Still, understanding everything about the informal sector (in the context of climate and climate adaptation) is hard to accomplish under an RCRA process alone. RCRAs can serve as an initial review of what items of the informal sector and economy are worthy of being understood (in the context of urban climate adaptation) for follow-on research and investigation. This can be done through a combination of semi-structured interviews, analysis, and desk review.

5. **Dedicate time and space for reflective learning and experience exchange:** As a major incentive for implementing RCRAs stems from a long-term goal of identifying climate adaptation investments and policy reforms, the generation of assessments can easily become supply-driven (or perceived simply as a step toward an end). Still, it is important to also appreciate the collaborative nature of the RCRA process in itself, by which common understanding is developed and joint knowledge created. An RCRA can often serve as a codified document summarizing the overall state of climate adaptation within a city, providing a basis for collaborative governance, integration of different knowledge domains across sectors, as well as a consensus-building tool among various interests in a city. In all, RCRAs provide opportunity for reflective learning—a critical component of resilience planning.

Taking a dialogue and learning approach can increase connectivity of the city actors to fit the new climate realities. The connections do not necessarily need to be solid or formal, but climate adaptation works across sectors and line budgets, and coordination and collaboration are needed to pool resources and efforts. For example, many of the recommended no-regrets measures (e.g. cleaning up drainage from improved waste management) are part of existing measures in a city, and often not traditionally identified as climate adaptation; the RCRAs provide an important opportunity for providing an additional rationale to prioritize these actions on the urban agenda, as they contribute to resilience. As such, the RCRAs can provide a mandate for increased coordination and dialogue across sectors, benefiting existing actions on the sustainable development agenda such as climate-adaptive waste management.

Opportunities for reflective learning include through collaborative platforms such as the GCA Water Adaptation Community (WAC) (Box 4). The WAC has been promoting the RCRAs and inviting comments and engagement with the wider community of practice on risk assessments. This enables tapping into the existing body of experience from past risk assessments at a global level and the lessons learned from them. It also provides feedback on the right course of action. For the RCRAs described in this paper, the WAC will host a discussion webinar inviting key actors from the cities and firms involved, discussing the outcomes of the assessments—including the methodology, process and lessons learned.

Moving forward, the GCA RCRA methodology has been further fine-tuned based upon implementation experience shared by both the supervision team and firms, taking into account what items worked, what did not work, and what could be improved. These changes will be reflected in the implementation of GCA RCRA methodology in a second batch of African cities. The GCA RCRA methodology is subject to continuous improvement based upon additional acquired implementation experience and implementors' dialogues and knowledge exchanges (as detailed in Box 4).

With continued experience and more cities included, it will become possible to work out what ideas can be scaled up, drawn from the unique challenges of individual cities.For example, in the second batch of cities, an RCRA will be implemented specifically in a large informal section of a major African city—to not only understand the climate risk context, but to also gain experience in overcoming common

Box 4. The WAC as a Reflective Learning Tool

The WAC is a global multi-stakeholder platform for knowledge and action with an overarching goal to scale up and to accelerate water adaptation. It aims to support collaboration, learning, and practical action for water adaptation and resilience. It acts as a broker between solution seekers and solution providers in the water cycle. It has as one of its focus areas urban adaptations, to support urban actors to adapt to climate impacts through risk assessment and learning about urban adaptation solutions. WAC supports practical action and peer-to-peer learning through exchanges and Communities of Practice (CoP), including NGOs, scientists, experts, policymakers and decision-makers. It collects, consolidates, and supports knowledge brokering and innovation through stories, case studies, blogs, webinars and e-learning.

WAC works off the belief that climate adaptation actions, in general, require cross-sectoral knowledge integration. For this purpose, all around the world, platforms for knowledge exchange and learning such as WAC are becoming more important in urban areas, which can involve multiple actors, with different types of knowledge, bringing together knowledge relevant for cross-cutting actions. Knowledge integration also works to create innovations. Learning can be incremental, which is the most common and easy type of learning and involves adjusting established actions. However, there is also a need, from time to time, to allow for more bold learning, for example, when new practices are needed, such as NBS. Here, it is difficult to build on established actions, but fundamental principles of the work need addressing, which may feel challenging to the owners or stewards of established practices. For example, today many NBS are being brought in to complement drainage pipes, but they come with a whole set of different policy, financial and organizational requirements, which demand active changes by the local management, and sometimes also at the national level. To enable such changes, an ongoing dialogue is needed, to improve existing actions that we know are working, and at the same time have the capacity to embrace innovation and change.

implementation challenges such as gathering information using research methods that involve local community members. Recommendations and lessons learned will be distilled and tabulated so as to provide tips-of-the-trade to other actors implementing climate risk assessments in similar contexts.


Photo: Tim Dirven/Panos Pictures Pictures

Adaptation in the Desert to Power Program

Photo: Pascal Maitre/Panos Pictures

The need to invest in the resilience of energy production and distribution networks to climate change is becoming increasingly critical as the global energy and climate crises expose vulnerabilities in existing systems across the world and in Africa. Designing and operating the physical components of these energy networks to reflect climate change impacts is an important measure in building resilience into energy systems. In addition to energy production, it is important to also address climate risk for the supporting infrastructure—particularly the transmission and distribution systems—that transfer power to consumers and generate revenue.

The Sahel region is already highly exposed to the impacts of climate change. The Global Center for Adaptation's (GCA) climate hazard profile for the region, illustrated in Figure 1, reveals that historical and projected climate trends of the West Africa Sahel indicate an increase in the average temperature of 0.6° to 0.8°C higher than the global average between 1970 and 2010; by 2100, the region can expect an average temperature rise of 3° to 6°C. Droughts in the region are becoming increasingly intense, with temperatures rising 1.5 times faster than in the rest of the world. At the same time, climate change is also causing heavier precipitation, leading to destructive floods, such as in Mali and Niger in 2019. These hazards represent a severe threat to the livelihoods of more than 80 percent of the population, particularly in rural areas. Despite these risks, infrastructure assets, which provide critical services for people and the economy, are not currently being designed and operated to withstand climate risks and hazards.

While climate-related hazards are a concern for the region, the Sahel also provides opportunities to generate power through its tremendous renewable energy potential. The African Development Bank (AfDB), along with the Green Climate Fund, is leading efforts to tap into this potential through

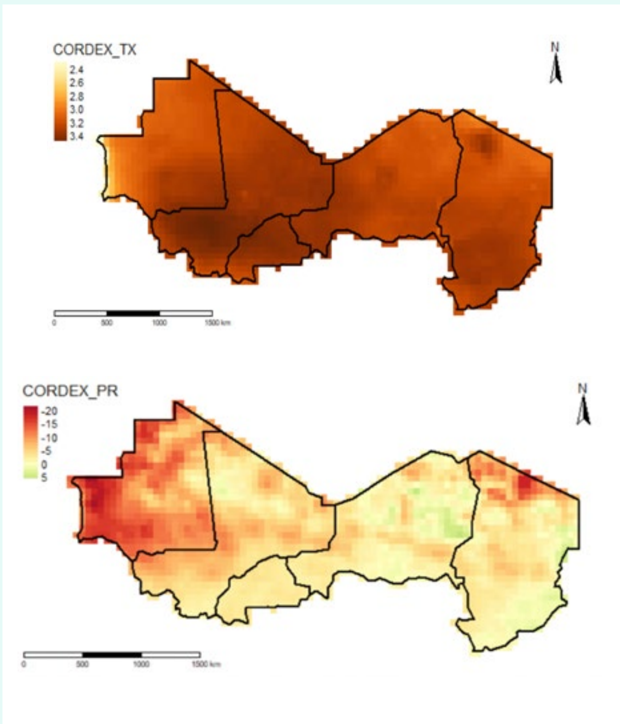
the flagship US$966.7 million Desert to Power G5 Sahel Financing Facility. This program, covering the countries of the G5 Sahel (Burkina Faso, Chad, Mali, Mauritania, and Niger), falls under the broader Desert to Power Initiative of the AfDB, which aims to support the achievement of the Sustainable Development Goals (SDGs) by installing 10GW of renewable energy–generation capacity and providing electricity access to over 250 million people across 11 African countries.

The Desert to Power G5 Sahel Financing Facility is designed to leverage and attract private-sector financing to facilitate up to 500MW of solar energy–generation capacity through Independent Power Producers by providing favorable loan conditions coupled with partial risk guarantees. It also complements investments made by the World Bank and the International Finance Corporation (IFC). The investment program is also a key pillar of the Great Green Wall Initiative. It aims to transform the desert region into an opportunity to address Africa's energy needs and to use clean technologies to deliver adaptation benefits, mobilize private-sector investments in solar projects, and develop institutional capacity in the Sahel countries to ensure long-term sustainability of their renewable energy programs.

The GCA is working with the AfDB and client governments in the region to ensure that assets and networks financed under the Desert to Power Initiative are resilient to projected climate change. GCA will provide upstream climate risk and vulnerability analytics to ensure that investments are designed to optimize the financial and operational performance of assets under projected climate-hazard and risk scenarios. GCA will also screen projects for climate-risk vulnerability assessment and provide practical risk management and climate-adaptation options to climate-proof investments in assets and the services they provide.

GCA's support for Desert to Power investments brings a new perspective on renewable energy investments as a core intervention for climate adaptation and resilience. Diversifying away from fossil fuels not only reduces carbon emissions but

Figure 1. Projected Climate Change by 2100 in the G5 Sahel Region



Source: GCA with data from WMO and CORDEX can also help build the resilience of energy systems that support people and the economy. In addition, designing and operating these physical assets to reflect climate-related hazards is an important measure in ensuring that climate-related damages to physical assets are minimized.

GCA is developing a Climate Hazard Geospatial Screening Tool to help client countries to optimize site locations of the solar plants and other key assets to avoid climate hotspots where possible. Solar photovoltaic panels, for example, are vulnerable to extreme heat and lose efficiency and risk burning out above 45°C. At the same time, floods can damage installations. Integrating grey and green solutions, such as elevating key assets, building flood walls, adjusting asset management protocols, and developing natural solutions to cool the systems, can have a cost–benefit ratio of 5–10, indicating a positive net present value.

GCA's support to develop climate-adaptation investment appraisals will leverage these returns by quantifying climate risk for solar generation assets and proposing cost-effective adaptation design solutions. In addition to informing the sovereign lending operations under the project, this data-driven approach to identifying and quantifying climate risk will be critical in informing the design of public–private partnership (PPP) components of the investment program. GCA will apply the principles and recommendations developed under

the Toolkit for Climate Resilient Infrastructure PPPs to mainstream adaptation in the PPP transaction structure and design.

In addition to energy-generation assets such as solar panels, the screening tool will be used to assess climate risk for critical supporting infrastructure, particularly the transmission and distribution systems, which cover large geospatial areas and are therefore exposed to a range of climate threats. Transmission towers and distribution poles in particular risk damage in floods and storms. Investing in grey adaptation options such as strengthening towers that are exposed to these hazards is a cost-effective solution, with a cost–benefit ratio of 3–6. The use of these tools in designing the Desert to Power investments will be mainstreamed through Climate Risk Dialogues and through an innovative Masterclass on Climate-Resilient Infrastructure with Senegal's Cheikh Anta Diop University (UCAD) to help build upstream capacity within the G5 Sahel countries.

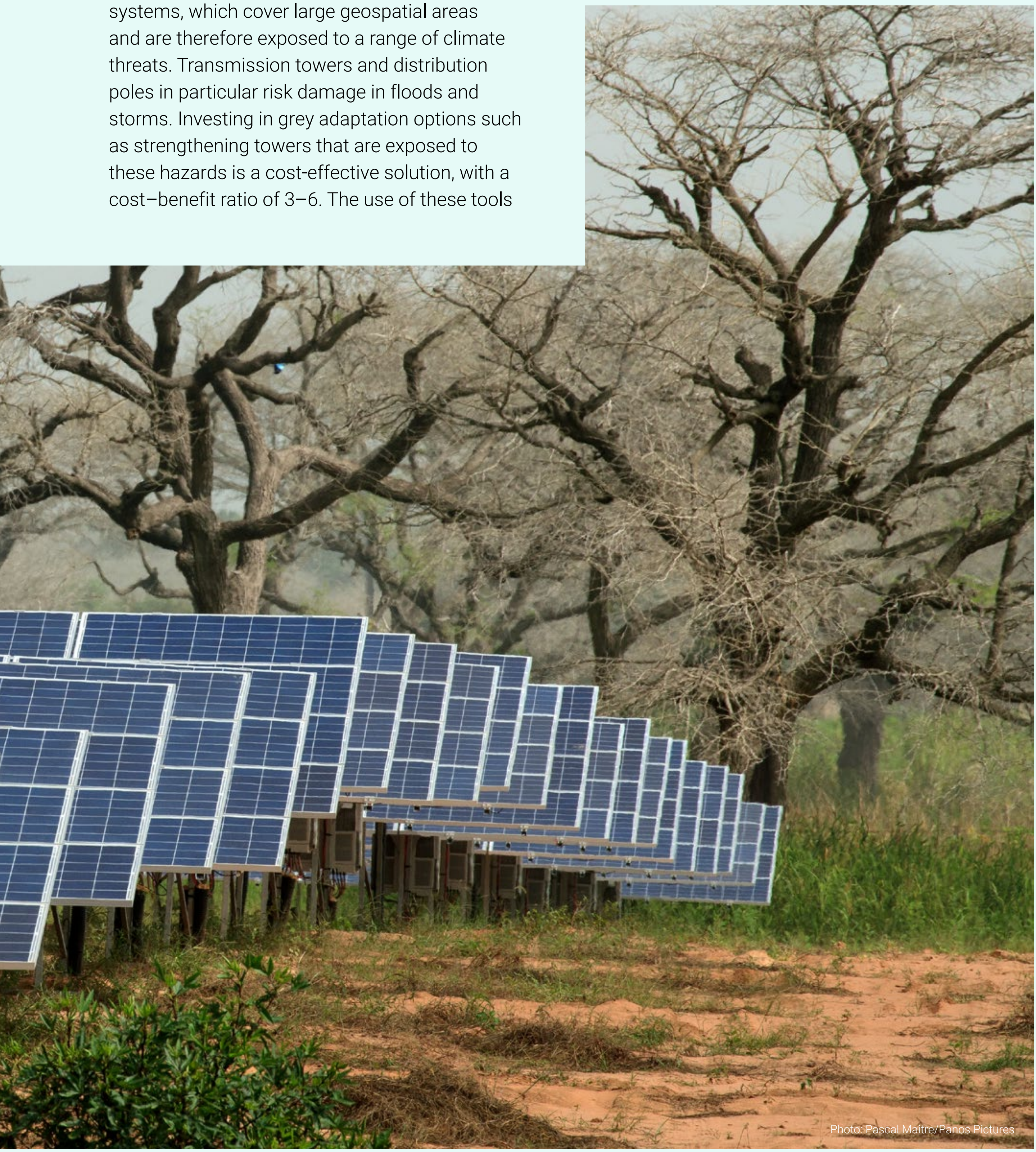


Photo: Pascal Maitre/Panos Pictures

Nature-based Solutions in Agroforestry

Photo: Mikkel Ostergaard/Panos Pictures

KEY MESSAGES

- Africa faces multiple challenges to improve the livelihoods of a rapidly growing population, most of whom are dependent on rural livelihoods that have already put pressure on African landscapes. These landscapes have been declining in productivity and are now becoming increasingly exposed to uncertainties arising from climate change.
- Nature-based solutions (NBS) will play a major role in managing these environmental concerns. NBS harness the power of nature to help build resilience against a range of environmental hazards. NBS also tend to create job opportunities for local people and encourage local ownership of the outcomes.
- Agroforestry, a land management practice where trees are grown around or among crops, pastureland, or homes to provide shade, shelter, fertilizer, fuel, food, fodder, and other products, is an important NBS that fits well with African farming systems, skills, and livelihoods.
- Many have simply called for more agroforestry and the planting of more trees. But agroforestry solutions must be carefully tailored to locations, to existing livelihoods, community skills and priorities, and to local markets.
- Despite lamentably poor financial support African scientists are tackling questions of finding the best solutions—site selection, farming system

and species selection, to name a few—but there is a need to blend this knowledge with that of communities to find solutions that fit the physical location and the communities' priorities. This requires a true co-production of solutions.

- Doing so will require new modes of continuous learning, better mechanisms for financing multiple agroforestry projects, and possibly recreating forms of governance based on traditional multilayered structures rather than the currently dominant top-down structures.

"

With its natural resources, in particular its rich biodiversity, the Democratic Republic of the Congo has the ambition to be a world leader in the use of nature-based solutions to strengthen its resilience. However, we are missing the financial resources that could help us contribute to a beneficial solution for all to climate change, setting up both mitigation and adaptation instruments. I therefore invite our development partners to support the Africa Adaptation Acceleration Program to help us achieve the objectives that we have set ourselves."

H.E. Félix Tshisekedi
President of the Democratic Republic of the Congo

INTRODUCTION

A theme of the Africa Climate Week held in Gabon in September 2022 was that even as the continent urgently seeks increased support for responding to climate change, it also has many resources both for mitigation and adaptation solutions.[1] It has large renewable energy potential, several minerals that are in high demand for energy production and batteries, and the potential for many nature-based solutions (NBS) that can support food production, conservation, and tourism among others.

The 2019 report Creating a Sustainable Food Future, the culmination of a multi-year collaboration between the World Resources Institute and several major international organizations, focused on how to feed 10 billion people by 2050 while protecting natural ecosystems.[2] If the target of limiting global warming to 1.5°C above pre-industrial levels is to be met, the report found, global greenhouse gas (GHG) emissions from agriculture need to decline by two-thirds, and almost 600 million hectares of abandoned or unproductive agricultural land need to be reforested. These multiple challenges will require the intensification of agricultural production in many areas, and the conversion of former cropland to more natural ecosystems in others. In many parts of the world, agroforestry—a blend of agricultural and pastoral practices with selective tree establishment—offers a unique opportunity to boost crop productivity, reduce GHG emissions, and restore ecosystems, all together. This is especially so in Africa.

This chapter reviews agroforestry as a particularly important category of NBS for Africa. It is organized into four sections. The first reviews NBS as a critical part of adaptation for the African continent. The second presents a deep dive into agroforestry as an NBS in Africa, with a specific review of lessons learned from programs that did not achieve their full potential. The third section proposes institutional and policy changes needed to make agroforestry an effective solution to climate adaptation and multiple other benefits. The final section presents the chapter conclusions.

NATURE-BASED SOLUTIONS IN AFRICA

Modern Africa has high reliance on natural ecosystems, as about 56 percent of its people, almost 790 million, live in rural areas.[3] These populations depend at least to some extent on agriculture, forests, and savannas to support their livelihoods—or else on sectors such as tourism that rely on wildlife within those natural systems. Africa has also long used green solutions, hereafter

Photo: Robert_Ford/iStock

called NBS, to reduce the impacts of a variable and changing climate. In this section we discuss how the concept of NBS has been defined, and specific ways in which NBS are being used in Africa.

What are Nature-based Solutions?

The International Union for the Conservation of Nature (IUCN) describes NBS as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits."[4]

It has long been understood that human wellbeing depends on the diverse range of services produced by healthy natural and managed ecosystems.[5] With the increasing threats to human wellbeing from the loss of healthy ecosystems—whether from direct human damage or more complex threats such as those from climate change—solutions that benefit both humans and natural systems are needed.

Various major international efforts have addressed the interface of natural and human systems, using different terms. The Millennium Ecosystem Assessment, for instance, used the term "ecosystem services" to highlight how ecosystems contribute to the economy and support human wellbeing.[6] The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) referred to "nature's contributions to people."[7] Other terms used to describe climate solutions involving ecosystems have included "green solutions," "green–grey solutions," or "ecological engineering."

Many organizations, including IUCN in the past, have used the term "ecosystem-based adaptation" (EbA).[8] An expert group convened jointly by the Convention on Biodiversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) defined EbA as an approach that "integrates the sustainable use of biodiversity and ecosystem services into an overall adaptation strategy" to help people to adapt to the adverse effects of climate change while recognizing that human wellbeing is critically dependent on the presence of healthy ecosystems, which should also be fostered.[9] But many saw this definition as being too human-centric and sought to promote actions that were more focused on the protection and rehabilitation of natural systems. Others felt that concepts such as EbA failed to encompass all the various components that contribute to human wellbeing, including cultural and ethical issues.[10]

The term "nature-based solutions" was first coined by a World Bank team in 2008,[11] but it was not fully described or defined at the time. IUCN began giving more emphasis to NBS over the past decade, providing the definition cited above and developing a global standard with eight principles underpinning the NBS approach.[12] Some argue that only actions that meet all eight principles should be called NBS, and any deviation from this standard weakens the meaning and value of the term.[13]

An editorial in the journal Nature in 2017 took a broader approach, recognizing "nature-based solutions" as an umbrella term for the multiplicity of terms already in use to cover efforts to achieve both healthier natural systems and improved human livelihoods.[14] It described NBS as "a newly coined umbrella term intended to sweep up all of the [existing] phrases, … and dump them into a policy-relevant pot, where sustainable practices that harness the natural world … can be devised, analyzed and then pulled out for use by politicians, scholars and researchers." Here we follow the advice of the editors of Nature and use NBS as an umbrella term.

The Potential for Nature-based Solutions in Africa

NBS are being applied widely across Africa, including in water security, human health, livelihoods, disaster risk reduction, and climate change mitigation and adaptation.[15] They are a core component of the Africa Adaptation Acceleration Program (AAAP), the Green Cities Initiative, and the West Coast Management Program (WACA).

There is huge potential for NBS in Africa, and there are frequent calls for the wider adoption of NBS from heads of state to local leaders. Technical documents on adaptation are replete with statements of the opportunities associated with NBS. For example, they are discussed in 14 places in the Africa chapter of the latest Intergovernmental Panel on Climate Change (IPCC) assessment on climate risks and adaptation.[16] The IPCC found that 36 percent of adaptation actions identified in Nationally Determined Contributions (NDCs) submitted by 52 African countries as of early 2020 involve NBS.[17]

NBS are best planned at a landscape scale and designed to meet critical needs both now and under future climates. As an example, NBS opportunities often arise in Africa in managing degraded water catchments by restoring vegetation based on local species. The goal may be not only to maintain high water yields from a catchment, but also to moderate extreme low and high flows. This can be achieved by establishing open woodlands with native tree species and grasses to sustain water yield, and reestablishing wetlands to moderate peak flows and also improve water quality by trapping silt. Species can also be selected with wider value to local communities, such as timber and fuel-wood, fruit or of cultural significance. In Africa, non-native species such as eucalyptus and wattles often need to be removed to better manage water flows and make way for native ecosystems to be reestablished. NBS also tend to create job opportunities for local people and encourage local ownership of the outcomes.

NBS can be combined with "hard" interventions such as recontouring landscapes or canal construction to assist in managing water flow. These are often called green–gray solutions. The important point is not to jump immediately to an engineered ("gray") solution to the problem, but to integrate both green and gray solutions from the outset, while also looking more widely at actions that will provide additional benefits to communities and help maintain biodiverse and healthy ecosystems. (A recent report from WWF has more examples of this type of NBS in Africa.)[18] The challenge is to create teams with skills in designing natural solutions and have them work with planners, engineers and financial specialists to create solutions at the scale needed to solve the problems facing us.

Put simply, NBS harness the power of nature to help build resilience against a range of environmental hazards. At the same time, they can provide or maintain wider social benefits, such as employment and continued access to traditional resources.

AGROFORESTRY AS A NATURE-BASED SOLUTION FOR AFRICA

While there are numerous NBS practices with direct relevance to Africa's adaptation,[19] this chapter focuses on agroforestry to allow for a more detailed discussion. Some of the messages presented here for agroforestry are applicable to other

Photo: Ministry of Environment - Rwanda

approaches that intend to leverage nature in adaptation programs.

Agroforestry is, essentially, agriculture with trees. This includes trees within agricultural landscapes, farming within forests, and tree-crops such as cocoa, coffee or rubber (see more examples on the World Agroforestry webpage).[20] The trees can be retained from the forests and woodlands present before the farmed land was converted to agriculture, or they can be specifically chosen and planted as part of the farming practice.

The benefits the trees bring are manifold and can include shade for crops, livestock and people; soil stabilization to prevent erosion from wind or water; improved soil nutrition and structure; and products such as food, fodder, and fuel. They also contribute to climate change mitigation by increasing the amount of carbon stored in the

landscape. Agroforestry can thus contribute to food security and climate objectives while preserving and strengthening the environmental resource base of Africa's rural landscapes.

Agroforestry has been used in one form or another in traditional agricultural practice throughout Africa, and over the past few decades has often been promoted as an option for smallholder farmers to increase and stabilize their agricultural production, especially in degraded landscapes.[21] Well-planned agroforestry builds upon existing farming skills, retains jobs, and can provide many intangible benefits, such as strengthening cultural connections.

In order to be considered an NBS, agroforestry must also benefit local biodiversity and the health of local ecosystems. This is usually readily achieved, but it requires the coming together of a range of skills: scientific and local, agricultural and biodiversity, financial and cultural. A well-designed agroforestry outcome derives from a true co-production incorporating multiple skills, multiple values and multiple players.

Issues in Agroforestry: A Review of Recent Research

While many agroforestry practices have numerous benefits, including adaptation, a recent review of agroforestry solutions in Africa provided some firm warnings, including that "policies that institutionally segregate forest from agriculture miss opportunities for synergy at landscape scale," and that "not all agroforestry options are viable everywhere, and the current state of knowledge offers very little guidance on what systems work where, for whom and under what circumstances."[22] Quantitative studies that integrate multiple aspects of agroforestry are rare, but there is activity in Africa that is helping to identify pitfalls in agroforestry planning and practice and to point to solutions and opportunities. A few of these are described below.

First, scientific research is often driven by narrow objectives relating to increased productivity but insufficiently related to the wider context of human livelihoods, including security and equity. A common reason for agroforestry is to rehabilitate degraded soils. A review of agricultural land rehabilitation in the Sahel found that most research efforts directed at soil rehabilitation and productivity improvement were driven by a single factor: the addition of chemicals and fertilizers.[23] Most showed positive outcomes from chemical additions in terms of yield, but few looked at the effects of combining the treatment with crop diversification, an approach that is already relevant in a region subject to climatic variability and that is likely to become more so with climate change.

In fact, most studies appeared to be disconnected from existing farmer practice and from the benefits of agroforestry practices that use trees for shelter and soil improvement and provide a diversity of products useful to the farmers. This problem is not confined to chemical trials. IPBES found that many studies of the impacts of climate change treated it as the single factor affecting biodiversity, thus failing to take into account the wider context relating to human livelihoods.[24]

These results are in contrast to the rise of Farmer Managed Natural Regeneration (FMNR), a low-cost land restoration technique that was developed specifically to build upon the existing pool of species using practices and seeking outcomes largely managed and determined by local farmers. It relies on the fact that many woody species can survive heavy cutting or grazing and remain as root stocks in the soil for decades. By working with local communities, simple methods and incentives have been found to encourage these root stocks to grow stems, which with careful pruning leads to a healthy small tree in a few years. This approach has been adapted and applied to meet farmer's preferences for several decades and is often credited with helping to regreen much of the Sahel. A study by World Vision Australia looked back at the development of the FMNR and described 24 beneficial outcomes from the practice.[25] But it also recognized that there were no substantial, controlled studies to back these benefits and to suggest ways of scaling up the approach even further. So here we have co-production of a valuable technique, but little "hard" scientific evidence to back it.

NBS are often cited as producing multiple benefits for agricultural yields, biodiversity, carbon storage, and ecosystem services such as wildlife attractive to tourists. A study in Ghana asked whether there were tradeoffs between these potential benefits from the threatened expansion of cocoa production into forests.[26] One option is to adopt high-yield, intensive farming on already cleared land, thus allowing forest to be spared elsewhere for conservation (land sparing); another is to adopt lower-yield, extensive farming over a greater area that retains more biodiversity and protects ecosystem services through wildlife-friendly agroforestry. By studying a series of existing cocoa plots, the researchers concluded that intensive cocoa production was actually the most effective in conserving biodiversity because it spared more of the original forest. However, the best carbon storage outcome depended on the cocoa yields that could be achieved in particular locations. These tradeoffs between clearing, cocoa production and biodiversity production will vary with location, but the study gives a sense of the analysis and planning that is needed before promoting and engaging in large agroforestry projects.

A study in Togo analyzed 25 agroforestry plots using satellite mapping of forest cover, field measurements and farmer interviews.[27] The researchers found rural development benefits were positively associated with adaptation benefits, but negatively with mitigation benefits (carbon storage). Biodiversity benefits showed no clear relationships with the other benefits. However, they identified a group of plots that provided a good range of benefits that point to management options and careful selection of species that may be able to support high delivery across all benefits. In this region of Togo, the most beneficial agroforestry mix includes shade trees, fruit trees, palms and bananas. It is not this particular solution that is important; rather, this type of study needs to become much more common in planning new agroforestry ventures.

A study in Madagascar took a broader look at land selection and management actions used in vanilla growing to understand how agroforestry affected biodiversity across a wide range of plant and animal species.[28] Vanilla is an orchid that is grown either on trees within an existing forest, or on trees established on fallow land that was formerly used for rice cultivation. Vanilla cultivation within old-growth forests led to the loss of 47 percent of endemic species, whereas vanilla established on trees planted on fallow land, i.e. agroforestry, provided substantial vanilla yields and could eventually reestablish 38 percent of the endemic species. The study concluded that agroforestry on previously cleared land can provide significant benefits for farmers and for biodiversity, especially if attention is paid to the diversity most sensitive to management practices.

In each of these examples, the selection of trees and associated species is one of the most important decisions in achieving a successful outcome. The goal in agroforestry, then, is not simply to reestablish the local species that existed on the site before it was cleared for agriculture, as they may not be suited to the new "ecosystems" that are being established by agroforestry practices or to changing climates.

Some trees are well suited for agroforestry in Africa, but again, not in all locations. The legume Faidherbia albida, for instance, is a nitrogen-fixing tree that is widespread and native to Africa. Its leaves are useful fodder for livestock, and it has an unusual annual growth cycle in that it sheds its foliage early in the rainy season and only regrows it early in the dry season. This means that it provides little competition to crop species as they grow during the rainy season, and so it has become a favored agroforestry species.[29]

In general, tree species selection for NBS should be based upon both local and scientific knowledge of the characteristics of indigenous species for local conditions. A study in Ethiopia, for example, found several dozen species in use in particular conditions.[30] The authors recommended three to six species for special consideration in each of the three geographic regions of Ethiopia. This is an important step to facilitate cooperative planning of agroforestry based on both scientific and local knowledge and community priorities.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INSTITUTIONAL CHANGE TO LEVERAGE AGROFORESTRY FOR CLIMATE ADAPTATION AND MULTIPLE BENEFITS

Not all smallholders are keen to adopt unfamiliar farming systems. The study in Ethiopia found constraints to the wider use of agroforestry approaches, including the belief by many smallholder farmers that trees are inevitably competitors with their crops, a lack of local knowledge of the value of their benefits as food, fodder and fuel, and an unwillingness to invest in land over which the farmer had limited tenure.[31]

Co-production of knowledge is needed to understand both local biophysical and socioeconomic conditions to address farmers' immediate needs and preferences.[32] Traditional knowledge pertains not just to the biology of a prospective species, but also to the particular benefits that it can contribute, its acceptability to the community, the workload involved in cultivating and managing any planting, and who will be expected to bear that workload.

Many smallholders will need external knowledge and financial support to make the transition from their current practices and turn to or retain cropping systems integrated with natural resources. They will also face commercial pressures to use new and expensive crop varieties and fertilizers. This constitutes a significant livelihood risk both to the smallholders and to those directly supplying financial support, whether that be local entrepreneurs, local banks, or civil society organizations. This risk is even greater for smallholders who focus on internationally traded products, such as cocoa and vanilla, and are exposed to the uncertainties of international trade.[33]

A detailed review of the practice and direct benefits of agroforestry across the African continent noted a lack of holistic studies of the benefits and potential problems of agroforestry on people's livelihoods in Africa.[34] Studies are scattered and often focus on only a few aspects of the agroforestry enterprise and its effects on livelihoods. Non-market benefits and disbenefits are usually overlooked or undervalued in their contribution to livelihoods. The opportunities for the protection or reestablishment of cultural benefits, including religious and traditional ceremonies and medicines, through agroforestry are rarely taken into account. The review authors looked to changes in African research institutions, and possibly stronger engagement by the private sector, to support their need for robust value chains to help address these gaps.

We have a glimpse of what some of these institutional changes could be in the lessons from the Great Green Wall (GGW) initiative. The initiative was originally designed in the late 2000s to create a 15 km-wide band of trees stretching 8,000 km across the southern boundary of the Sahara Desert. However, after rapid learning from many failures of tree planting and a greater recognition of the needs of local people, the emphasis moved from creating a wall of trees to improving the livelihoods of local people by a mix of sustainable land and water management and agroforestry actions. These fall under the umbrella of the global goal of The Bonn Challenge to restore 350 million hectares of degraded land globally, and also of AFR100, an initiative to restore 100 million hectares of degraded land in Africa by 2030 largely by tree planting.[35] Thirty African countries have pledged to take part, and currently the pledges exceed the original goal of 100 million hectares by 25 percent. However, restoration of the pledged land is still in its early stages.

Restoration across much of the Sahel and West Africa is supported by the Sahel and West Africa Program (SAWAP), run in partnership by the Global Environment Facility (GEF) and the World Bank to support the GGW. Under SAWAP, 1.6 million hectares have been restored from 2012 to 2019. The World Bank has recently reviewed progress and has found that while almost 20 million people have benefited, the range of activity types and sizes across projects has made it difficult to draw comprehensive conclusions.[36] But some lessons are emerging. Despite seeking a programmatic approach, most activities are being managed as small projects very specifically tuned to local conditions and preferences. Cost-effectiveness also varies greatly between projects, with some being prohibitively expensive to apply at scale and others very cost-effective. Projects rely too much on national agencies for implementation, with few achieving decentralized approaches leading to community empowerment and ownership. And the use of incentive payments to adopt specific practices appears to inhibit community ownership and may crowd out alternative approaches.

Many have proposed that greater capacity building is needed to fully integrate natural and human systems to the benefit of both. However, the finance and efforts directed toward capacity building over the past few decades have been substantial. We need to look more closely at just what is meant by capacity building in the context of what is needed, and what can be done. There still seems to be an assumption that there is a pool of existing technical knowledge that can be brought to participants via capacity building. Maybe we need to recognize that the technical know-how is weak and also needs to be considered along with traditional knowledge and community preferences to develop projects that are not only cost-effective, but also meet the needs

Photo: Robert Ford/iStock

of the community such that they take ownership of the task of continuing to create better and resilient livelihoods.

We also need to continue to explore more comprehensive models for financing. Multilateral and bilateral financing will always be cumbersome, as the funder must be able to show transparency and due diligence in the allocation, disbursement and outcomes of their funding. Financial intermediaries may offer a better model. The GEF and the African Development Bank have outsourced funding from the multilateral development banks to aggregators such as Althelia, E3 Life and the Moringa Fund, which are better equipped to manage the perceived risks of local investment.[37] Such an approach can help reassure investors—whether they be multilateral organizations, governments or banks, and especially the smallholders who will be risking their livelihoods on the outcome.

Some assessments, such as by IPBES[38] and the IPCC,[39] call for a form of polycentric governance system, claiming that it has always been practiced in Africa and has effectively addressed different interests in managing natural resources. Polycentric governance has multiple, often overlapping centers of decision-making, each of which operates with some degree of autonomy, while taking other centers into account.[40] It strikes a balance between the common centralized (e.g. national government systems) and fully decentralized community-meeting styles of decision-making.[41] It is grounded on processes of accountability through stakeholder and actor engagement, promoting learning and trust, harnessing co-benefits and added value, addressing tradeoffs, and adaptability when faced with new situations. But polycentric governance and top-down public and private management models often appear not to sit well with each other. This is an area that needs active engagement and experimentation.

CONCLUSION

Most of the reasons Africa has declining agricultural production and is losing tree cover are not the direct result of climate change. They include population pressures, weak governance, and conflict in many areas. These must be tackled, and now tackled with the additional uncertainty of climate change, if major improvements in agricultural productivity, livelihoods and equity are to be achieved.

It is important to go beyond the exhortations to protect forests, to plant more trees, and to tap the potential of agroforestry. The latest IPCC assessment report noted that from 1990 to 2019, only 3.8 percent of climate-related research funding was directed to research on Africa, and only 14.5 percent of that went to African institutions.[42] Research support is notoriously difficult to track, but to have less than 4 percent of funding going to support the climate future of Africa, when the continent has 15 percent of the Earth's population, is a severe mismatch.

It is essential to continue building the case for NBS as a critical adaptation measure, to set goals, and to seek financial support. However, it is equally important to mobilize the necessary support to identify which actions are cost-effective and most beneficial for both the farmers engaging in NBS and the ecosystems on which they are based. There are many examples of poorly designed efforts that are likely to undermine the goals of development, biodiversity maintenance, mitigation and adaptation.

Each type of project (agroforestry, catchment protection, barriers to desertification, or cooling villages and even cities) and each region will need to ask local questions of how to match NBS with the needs and skills of local communities, as also questions such as where to establish agroforestry and where to conserve or regenerate forests, and what type of plantings and with which species. To answer these questions traditional and local knowledge must be brought together with wider scientific knowledge in a true co-production of workable solutions.

The solutions to the above questions also need a new model for capacity building that seeks solutions based on technical skills, holistic insights and lived experience in a comprehensive co-production of knowledge focusing on solutions. It is critical to recognize that learning is a continuous process of adjustment, whether this is labeled "trial and error," "learning by doing," "continual learning," "ok-to-fail" or "adaptive management."

Many of the changes described here may seem small in the global response to climate change, but each is consistent with reducing the impacts of climate change and is potentially life-changing at the individual human scale. This is the transformation that is needed.

Blue Economy

KEY MESSAGES

- The main driving sectors of the Blue Economy in the 38 coastal countries of Africa are fisheries, aquaculture, tourism, transport, ports, coastal mining, and energy. However, these sectors depend on the marine ecosystem health and productivity, which is under constant threat from extreme weather events.
- Institutional development of the Blue Economy in Africa is very varied, with two-thirds of African countries having no formal strategies on their Blue Economies and a select few according great importance to Blue Economy development and adaptation to climate change.
- In the Nationally Determined Contributions of many African nations, there is a tendency to focus more on land-based spatial planning than on marine planning, despite most countries recognizing the potential devastating impacts that ocean-related climate change impacts could have on the environment and people.
- The lack of marine spatial planning (MSP) in the island countries is particularly concerning as they are highly vulnerable to climate change impacts. MSP could help them predict the impacts of such disasters, be better prepared for them, and thus prevent the loss of many lives and livelihoods.


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- As the natural resources critical to Blue Economies are, at times, shared by several countries, the prominent Regional Economic Communities (RECs) of Africa, which have developed individually and have different areas of focus, have a unique opportunity to contribute to shared resource management and encourage such management to follow sustainable Blue Economy principles.
- Coastal and marine protected areas (MPAs) can provide long-term protection for ecologically significant areas including salt marshes, seagrass beds, mangroves, and kelp forests. These ecosystems, when healthy, help to build resilience to climate change through their ecosystem services.

“

African economies need more trade and investment so they can adapt to climate change. Africa already faces a tremendous amount of costs, with respect to adaptation. Through trade, we can increase the return on investment and increase the resources available to African governments for adaptation.”

Ngozi Okonjo-Iweala
Director-General, World Trade Organization

INTRODUCTION

The Blue Economy of coastal countries in Africa is critical for their development. The potential of sustainable and integrated management of marine resources can be immense in areas such as job creation, poverty elimination, and coastal urban and rural development. The Blue Economy not only includes critical sectors such as tourism and fisheries, but holds enormous potential for future sectors such as blue energy, ocean mining, and blue carbon. According to the African Union (AU), the Blue Economy of the continent generates nearly US$300 billion and supports 49 million jobs.[1]

However, Africa's Blue Economy is currently facing enormous challenges, from the overexploitation of fisheries to coastal erosion. Pollution and the loss of coastal and marine biodiversity are putting substantial pressure on economic sectors that depend on a healthy environment. The impacts of climate change are amplifying and accelerating the pressures on the environment.

This chapter reviews the climate risks to African Blue Economies, the status of Blue Economy strategic development in African countries, and considerations of climate change in such strategic documents.

Photo: Gideon Ikigai/Shutterstock

It outlines the adaptation measures necessary for a sustainable development of African Blue Economies, and ends with some recommendations for policymakers.

CLIMATE RISKS TO THE BLUE ECONOMY OF AFRICA

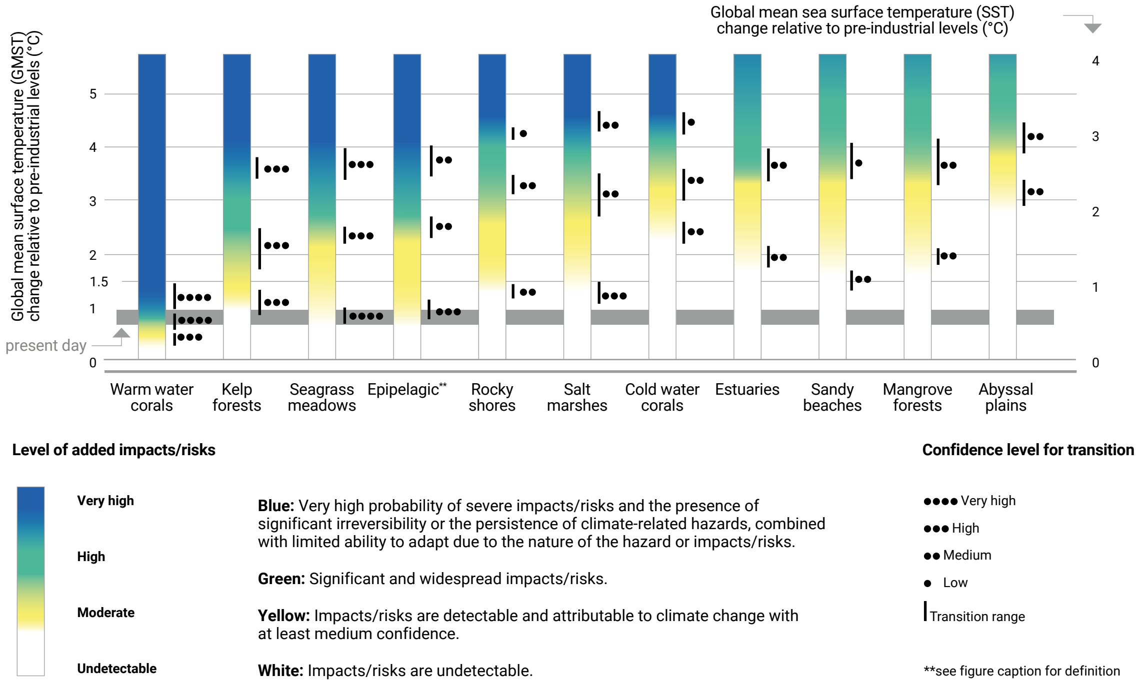
The main climate change impacts on the Blue Economy of Africa include sea-level rise, sea warming, increasing frequency and intensity of floods and storm surges in coastal areas, and heatwaves. Climate change amplifies the impacts caused by environmental degradation, the overexploitation of fisheries, coastal erosion, and pollution.

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report highlights several climate change impacts of concern for Africa's Blue Economy.[2] For example, African sea levels are currently rising slightly faster than the global average. By 2100, sea-level rise can reach 0.4 to 0.5 meters under low-warming scenarios and 0.8 to 0.9 meters under high-warming scenarios. As discussed in the State and Trends in Adaptation 2021 report, the rise of sea levels, combined with more intense and frequent rainstorms, will change the current 1-in-100-year coastal flooding events to a return period of only 10 to 20 years by 2050. By 2100, this return period reduces to between 5 years to annually, even under moderate warming. The implications of this trend for urban and rural populations of coastal Africa are enormous.

The rising temperature of sea water is projected to have significant impacts on marine biodiversity. For example, primary production by phytoplankton, as also fish distribution and abundance, are projected to be significantly affected. According to the IPCC, marine heatwaves are expected to continue to increase in frequency and intensity, especially around the Horn of Africa. Finally, increased water acidification due to climate change will lead to coral reef bleaching, destroying the habitat of fish and other marine life. West African countries may be some of the most affected countries.

Figure 1 shows the impacts and risks to ocean ecosystems in general from climate change, according to the IPCC's Special Report on the Ocean and Cryosphere (2019).[3]

Figure 1. Key Impacts and Risks to Ocean Ecosystems from Climate Change



Source: Adapted from Figure SPM.3, frame (d), in IPCC, 2019.[4]

INSTITUTIONAL ASSESSMENT OF AFRICA'S BLUE ECONOMY

The AU has identified Blue Economy development as a priority goal toward achieving the goals of "a prosperous Africa based on inclusive growth and sustainable development." The African Blue Economy Strategy, launched in 2020,[5] outlined five key driving sectors:

1. Fisheries, aquaculture, conservation, and sustainable aquatic ecosystems;
2. Shipping/transportation, trade, ports, maritime security, safety, and enforcement;
3. Coastal and maritime tourism, climate change, resilience, environment, and infrastructure;
4. Sustainable energy, mineral resources, and innovative industries; and
5. Polices, institutions and governance, employment, job creation and poverty eradication, and innovative financing.

The main driving sectors of the Blue Economy in Africa today are fisheries, aquaculture, tourism, transport, ports, coastal mining, and energy.[6] However, these sectors depend on the health and productivity of the marine ecosystem, which is under constant threat from extreme weather events, pollution, eutrophication, and widespread loss and modification of coastal habitats, including mangroves, estuaries, lagoons, and coral reefs.[7]

Status of Institutional Development of Africa's Blue Economies

For this chapter, the status of institutional development of Blue Economies in Africa was analyzed.[8] Figure 2 presents the summary results. Ten coastal countries have no strategic or policy documents guiding their Blue Economies. Another 16 have indicated that they intend to develop some form of Blue Economy planning or policies. This means that, in total, 26 African coastal countries, or about two-thirds, have no formal strategies or policies on their Blue Economies. However, eight countries have drafted and published official Blue Economy strategies, and only four additional countries have drafted action plans for their strategies. No African country has a holistic policy, with regulatory tools for Blue Economy development over the long term, passed into law.

The assessment also shows that the island nations of the Seychelles and Mauritius are the most advanced in their institutional approach to the Blue Economy, given its significant role in their economies overall. Both nations have an active Blue Economy coordinating unit (the Seychellois Ministry of Fisheries and the Blue Economy, and the Mauritian Ministry of Blue Economy, Marine Resources, Fisheries and Shipping).

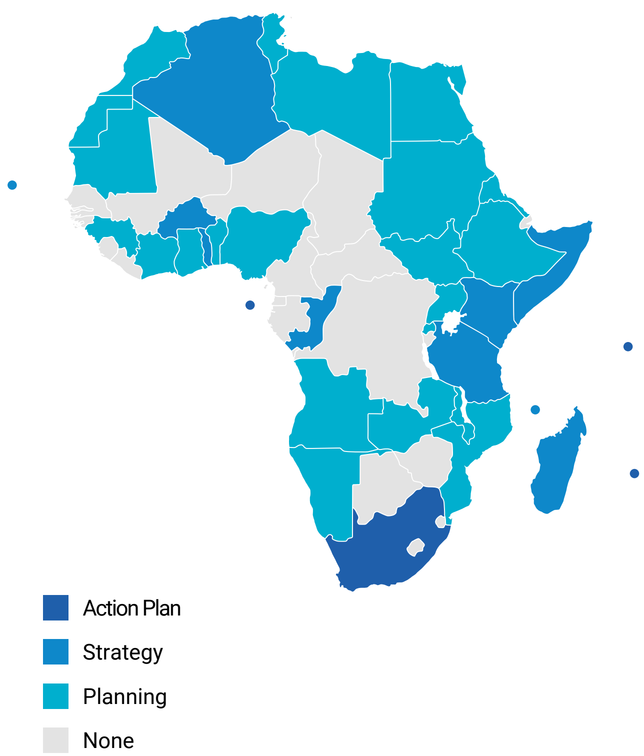
In the institutional development of Blue Economies, a holistic multisectoral approach that systematically develops plans, strategies, action plans, and policies is indispensable. Furthermore, countries building their Blue Economies have at their disposal a variety of planning and finance tools developed in recent years, including marine spatial planning (MSP), blue accounting, and blue financing.

Of the countries that have indicated a commitment to develop their Blue Economies—34 African countries in total—18 countries are using MSP, two are using blue accounting, three have established blue financing tools, and 11 have established national coordination units. Finally, there are only four countries (South Africa, the Seychelles, São Tomé and Príncipe, and Mauritius) that have a Blue Economy action plan to implement their respective strategies. An action plan is required to put a holistic strategy into practice.

While many countries have begun the development of policies and programs for various marine resources (such as tourism or fisheries), these cannot be equated to Blue Economy development because of the lack of cross-sectoral coordination and a holistic approach. The complexity of the multiple sectors involved in the Blue Economy calls for a national coordinating unit.

Few countries in Africa have put systems in place for blue financing, the most developed of which is Seychelles.

Figure 2. Institutional Status of the Blue Economy in Coastal African Countries as of June 2022



Source: Authors' own work.

The Role of Regional and International Bodies in the Development of Africa's Blue Economies

Regional and overseas bodies have played a notable role in supporting Blue Economy development across the continent. The United Nations Economic Commission for Africa (UNECA) has been instrumental in the drafting of several African states' Blue Economy strategies and action plans.[9] It has also pioneered the construction and application of the Blue Economy Valuation Toolkit in many African countries.[10]

In March 2022, the Kigali Declaration of the African Regional Forum for Sustainable Development organized by UNECA in collaboration with the AU, the African Development Bank (AfDB) and the UN System called at the ministerial level on African countries to support the Great Blue Wall Initiative. The goal of this initiative is to accelerate and upscale ocean conservation actions while enhancing socioecological resilience and the development of a regenerative Blue Economy. The initiative has set ambitious targets to protect 2 million square kilometers of protected and conserved areas, achieve net gain of critical blue ecosystems by conserving and restoring more than 2 million hectares of critical ecosystems and thereby sequestering more than 100 million tonnes of carbon, and unlocking regenerative livelihood opportunities for 70 million people in the Western Indian Ocean.

The additional innovative benefit of this initiative would be to unlock additional blue financing through the exploration of the development of a regional Blue Bond, taking into account the fiscal and debt constraints of the countries in the region and the limited capacity of these countries to attract substantial investments solely through national Blue Bonds.

The AU has developed a Blue Governance Framework for the implementation of the African Blue Economy Strategy.[11] This is an institutional arrangement that refers to the coordination, planning and monitoring of the Blue Economy activities initiated by AU bodies, Regional Economic Communities (RECs), other regional organizations, and member states.

Several African RECs have also drafted Blue Economy strategies, or are currently preparing them. These include the Common Market for Eastern and Southern Africa (COMESA;[12] the Intergovernmental Authority on Development (IGAD);[13] the Southern African Development Community (SADC); the Economic Community of Central African States (ECCAS);[14] and the 2014 Integrated Marine Strategy developed by the Economic Community of West African States (ECOWAS), which was accompanied by a regional action plan. Other regional organizations, such as the Indian Ocean Commission, have also been active in Blue Economy development in Africa. In addition, some North African countries are parties to the WestMED initiative, which promotes Blue Economy development centered on the Mediterranean Sea.

As the natural resources critical to Blue Economies are, at times, shared by several countries (e.g. river deltas, large marine ecosystems, and fish stocks), RECs have a unique opportunity to contribute to shared resource management and encourage such management to follow sustainable Blue Economy principles. RECs are also able to mediate the communications of their member states in resource management disputes and large-scale Blue Economy development plans.

The Intergovernmental Oceanographic Commission (IOC) has facilitated Blue Economy development for African Small Island Developing States (SIDS) such as Comoros, Mauritius, and Seychelles. The IOC's approach to the Blue Economy emphasizes the integration of social, economic, and environmental concerns, and encourages countries to work on developing the Blue Economy at the national level while simultaneously increasing cooperation and regional integration.[15]

CLIMATE CHANGE ADAPTATION AND RESILIENCE MAINSTREAMING IN BLUE ECONOMY POLICIES

The Blue Economy and climate change adaptation action are closely connected. Ecosystem services and nature-based solutions play a key role in supporting climate change adaptation efforts, since they reduce the negative effects of extreme weather events, sea-level rise, storm surges, eutrophication, and ocean acidification. Equally, many of the adaptation measures that coastal and marine environments need—from pollution reduction to sustainable management of fisheries and biodiversity conservation—rely on stronger ecosystems and their services.

This section reviews the climate change adaptation and resilience measures included in Blue Economy action plans and policies adopted by coastal African nations. This section also reviews these countries' Nationally Determined Contributions (NDCs) to see how much attention they pay to the Blue Economy.

Of the 12 African coastal countries that are implementing Blue Economy strategies or action plans, two—Mauritius and Seychelles—recognize the severity of climate change impacts on marine ecosystems and have practical activities for adaptation. Four countries—Algeria, São Tomé and Príncipe, Somalia, and Togo—have some planning for adaptation responses included in their Blue Economy action plan or strategy. Another four countries—Comoros, Republic of the Congo, Madagascar, and Tanzania—recognize the threats of climate change and the need to respond, but have little to no planning or activities in place to do so. Table 1 presents a summary of the findings.

Table 1. Integration of Climate Change Adaptation into African Countries' Blue Economy (BE) Strategies or Action Plans

Country	Extent to which climate change is integrated into BE strategies and action plans	Degree of integration (0–3)
Algeria	Good overall. The BE strategy integrates climate change adaptation in some of the BE sectors (fisheries, aquaculture, coastal infrastructure), but there are few concrete plans yet.	2
Comoros	BE strategy strongly acknowledges the impacts of climate change, but very little focus or planning for adaptation measures to deal with the impacts.	1
Cabo Verde	None. Strong focus on encouraging investments, but no mention of climate change mitigation or adaptation.	0
Rep. of the Congo	Is considering the development of strategies to be more climate change-resilient, but there are presently few concrete plans being prioritized for this purpose.	1
Madagascar	Acknowledges that the consideration of climate change must be scaled up and also made a priority for the fisheries sector, but there are few concrete plans regarding climate change adaptation.	1
Mauritius	Very good integration of climate change. Within the BE action plan it is recognized that climate change is an area of key vulnerability for the BE, and there are well-thought-out measures and plans to adapt to climate change. However, much of the focus for adaptation is on maintaining fisheries and tourism.	3
São Tomé and Príncipe	Relying on the BE to provide economic growth and poverty alleviation; also says that "Climate threats make achieving [a successful BE] even more urgent." Looking at ways to adapt various sectors to climate change.	2
Seychelles	The BE strategy acknowledges that the focus is foremost on adaptation and then on mitigation. The strategy reveals a holistic approach to BE and climate-associated integration.	3
Somalia	Aware of the risks of climate change to the economy. Although very focused on adaptation, the plans lack specificity.	2
South Africa	Focus of the BE strategy is on economic growth and job creation. Nothing on climate change and very little consideration of the environment.	0
Tanzania (Zanzibar)	Some acknowledgement of the importance of climate, but mostly focused on the more profitable sectors. Instead of utilizing the BE to improve climate resilience, it implies that climate resilience must be achieved first.	1
Togo	Generally well thought out in terms of climate change and related threats, as well as the interconnectedness between the sectors that are affected. Some planning for adaptation responses to climate change in place.	2

Note: The table covers only countries that have Blue Economy plans or strategies in place. The degree of integration is based on the number of times adaptation is mentioned in the Blue Economy strategy or action plan and its contextual relevance and practical application.

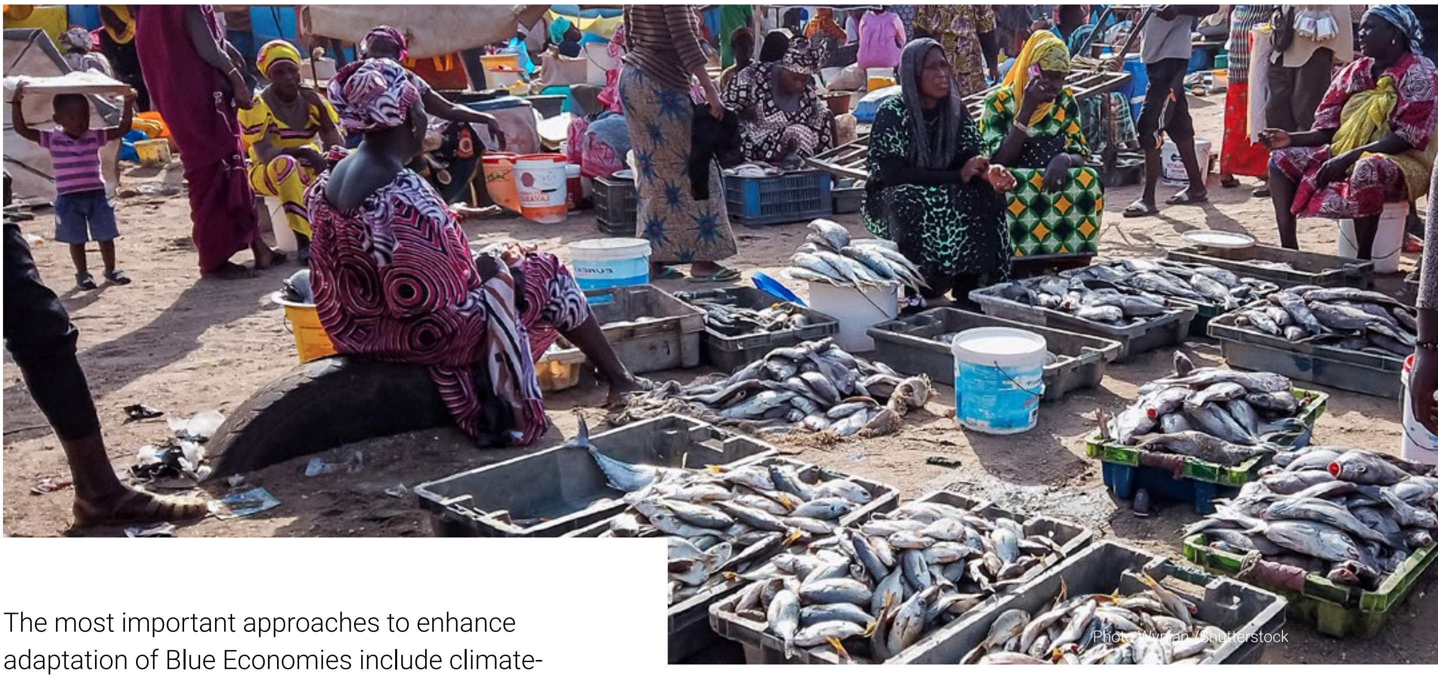


Photo: Wynian/Shutterstock

The most important approaches to enhance adaptation of Blue Economies include climate-informed coastal and MSP; the protection of marine and coastal ecosystems; and rehabilitation of marine and coastal areas.

Climate-informed MSP is a valuable tool for improving climate change resilience in marine and coastal areas. It assesses current and future climate risks and opportunities for informed decisions on the design, plan and implementation of integrated ocean-based strategies that improve countries' capacity to respond to climate events.[16] In particular, MSP can be used as a tool to identify areas especially vulnerable to climate change. For example, it can identify ecosystems and communities that will be displaced and directly affected by sea-level rise in certain coastal areas, or the extent to which sea-level rise will affect these areas. This allows for more informed adaptive responses to be implemented. Significantly, it can also simulate how biodiversity and adaptation capacity will change based on different protection or rehabilitation activities.

Spatial planning and MSP do more than just assist with climate change adaptation. MSP is an integral part of Blue Economy efforts, and it can help make more informed decisions about climate change adaptation actions to protect specific sectors. It can also reveal gaps and missed opportunities for other kinds of social, economic, and environmental development.

Unfortunately, most of the Blue Economy strategies and action plans of the coastal countries of Africa have low or no prioritization of MSP, with the exceptions of Congo and Mauritius. Similarly, in the case of Nationally Determined Contributions (NDCs), there is a general tendency of these documents to focus more on land-based spatial planning than on marine planning, despite most countries recognizing the potential devastating impacts that ocean-related climate change impacts could have on the environment and people. The Seychelles NDC, however, clearly acknowledges that MSP will help the country achieve "effective management of the 30% marine protected areas within the Seychelles' Exclusive Economic Zone" (Box 1).

The Mauritius Blue Economy strategy includes a high-level analysis of the enabling conditions for MSP and indicates climate change adaptation, aquaculture, and coastal beach erosion as the key drivers. It also looks at various scenarios and potential challenges for implementation.

The lack of MSP in the island countries is particularly concerning, as they are highly vulnerable to climate change impacts. MSP could help them predict the impacts of such disasters, be better prepared for them, and thus prevent the loss of many lives and livelihoods. For a country like Togo, with a relatively small coastline, MSP could help organize that territory optimally for projects such as aquaculture developments near the coast or even in the sea.

Box 1. MSP in Seychelles

The Seychelles Marine Spatial Plan (SMSP) Initiative was launched with three main objectives: to expand protection of marine waters to 30 percent (previously only 0.04 percent of marine waters were in marine protected areas [MPAs]), to address climate change adaptation, and to support the Blue Economy. At the center of this plan was MSP, which was used to help identify new MPAs and provide information about what is allowed and where to Government and stakeholders. Seychelles reached its 30 percent protection target in March 2020, 10 years ahead of the "30 by 30" target.

A case study of the SMSP reveals several factors that are likely to have contributed to its success:[17]

1. **Reliance on expert knowledge and administrative integration:** It was realized that Seychelles lacked previous MSP experience, technical capacity, and knowledge for the MSP process. The country sought out expert project managers to assist with the SMSP process design. It also established working groups for different sectors and topics (e.g. fisheries, tourism, finance, climate change) to provide space for technical discussions and developing draft products.

2. **Use of knowledge resources and scientific data to ensure that proposals were evidence-based:** The process was designed using numerous resources, including the United Nations Educational, Scientific and Cultural Organization (UNESCO) guidance, publications, reports, and information from discussions with experts. It also incorporated the best practices and lessons learned from other regions. Relevant scientific data and local knowledge were made available from the beginning. The MSP initiative identified many ecosystems within the Seychelles Exclusive Economic Zone (EEZ), including sea mounts, canyons, spawning sites, aggregation sites and more, all of which contribute to the ecological value of the Blue Economy.[18]

3. **Strong political will and involvement from top leaders:** There was strong political will behind the initiative from the beginning. High-ranking leaders understood the aims of and need for a proper MSP. Cabinet received regular updates throughout the project and looked to obtain information from decision-makers. Some stakeholders were concerned that the project focus would be on biodiversity, but they were assured that SMSP was multi-objective and both biodiversity conservation and sustainable livelihoods were Government priorities.

4. **Clear funding strategies to ensure sustainable finance:** In 2015, the Seychelles debt-for-nature conversion resulted in the Seychelles' Conservation and Climate Adaptation Trust (SeyCCAT), an independent public–private trust that is responsible for managing debt conversion proceeds and allocates a portion of the repayments for financing of marine conservation and climate change adaptation projects, and for the implementation of the SMSP.

5. **Consistent feedback and transparency:** Efforts were made to make sure that key stakeholders were present at discussions to ensure a variety of viewpoints were put forward and taken into consideration. This also helped ensure that the project was fully transparent. The public were also consistently informed on the progress of the project through the meetings' minutes being posted on the website and through public information sessions.

6. **Realistic time scales:** Stakeholders were given sufficient time to gather the information to present their arguments, and for discussions around these to occur. It was accepted that the process would slow down if disagreements or misunderstandings occurred. These obstacles were handled by focusing on gathering information to help resolve the issues and obtain a higher level of support.

Photo: Tommy Trenchard/Panos Pictures

Coastal and marine protected areas can provide long-term protection for ecologically significant areas including salt marshes, seagrass beds, mangroves, and kelp forests. These ecosystems, when healthy, help to build resilience to climate change through their ecosystem services. Most of the countries' NDCs and Blue Economy strategies do not prioritize the protection of marine and coastal habitats to the same degree as protected areas, apart from South Africa and Comoros. Many suggest MPAs for protecting economically important fish species, natural capital, and tourism, which would in turn improve resilience, but it does not automatically make it their primary objective.

São Tomé and Príncipe and Algeria are two countries whose Blue Economy strategies consider the protection of marine and coastal areas to be of top priority for "strengthening their resilience and restoring safe and productive oceans." Algeria's strategy calls for urgent action to protect and conserve seagrasses and corals for several reasons, one of which is adaptation to the effects of climate change for maritime and coastal infrastructures and activities. Most of the countries assessed are focused on prioritizing protection of areas that are tourist attractions, habitats for fished species, or ecosystems that help protect the coastline from storms and prevent coastal erosion.

In contrast, the NDCs of Cabo Verde, Republic of the Congo, Mauritius, Seychelles, and Togo prioritize the protection of marine and coastal areas more so than their Blue Economy strategies do. Cabo Verde's NDC strongly encourages all forms of climate adaptation and seeks to implement coastal protection in each island to protect endangered ecosystems (wetlands, seagrasses, salt marshes, sand dunes, reefs) and adapt to potential climate risks.

Similarly, Togo's priority adaptation measures include marine protection, and the country has developed pathways to achieve these. In the case of the NDC of Mauritius, although coastal protection is mentioned throughout the document, the links drawn between protection and adaptation are vague and may be in place more so for future food security and tourism. The Seychelles Blue Economy strategy notes that the country's coastal wetlands, particularly seagrass, mangroves and salt marshes, are critical for climate adaptation as they provide the "protection functions by buffering shorelines against the impacts of increasingly erratic weather patterns and coastal erosion."

Another key issue with the protection of marine and coastal areas is whether the rules and guidelines around these protected areas are being adhered to. As noted in a 2021 report on MPAs in the Western Indian Ocean, the proclamation of an MPA is no guarantee of effective protection due to a lack of human resources, skills, equipment, or institutional commitment.[19] Therefore, the ability of an MPA to provide climate change resilience largely depends on how well it is being managed, or if at all. Therefore, prior to declaring protected areas, governments need to come up with a set of laws and ensure that they make the surrounding community, as well as other stakeholders, aware of the restrictions. For the goals of the MPA to be achieved over the long term, they need to ensure that they have the personnel and resources available to enforce these laws.

Rehabilitation and restoration of these habitats refers to the intentional planting of nursery-grown corals back onto natural reefs or creating artificial reefs; the planting of mangrove seeds in damaged mangrove habitats; and the spreading of seagrass seeds, the transplantation of kelp, etc. Habitat loss and damage to these ecosystems can be attributed to anthropogenic causes in the area such as a rise in development near coastlines, destructive harvesting and fishing methods, and deteriorating water quality,[20] or sand mining as in Mauritius, among others. Prior to 2001, sand mining in coastal lagoons was causing the degradation of seagrasses, but notable recuperation of the seagrasses has been observed since the banning of sand mining. Despite this, the effects of climate change are likely to have the most severe impacts on these ecosystems.[21]

Of the assessed countries, three show moderate to high prioritization of marine habitat restoration across both their Blue Economy strategies and NDCs: Seychelles, Madagascar, and Mauritius. The Mauritius Blue Economy action plan includes restoration of lagoon systems, coral reefs and mangroves, and notes that it is "a 'no-regrets' investment, creating significant sustainable benefits for coastal fisheries, for the tourist industry, and by mitigating coastal erosion."[22]

The Cabo Verde Blue Economy strategy makes no mention of restoration, but its NDC does have a holistic view on the restoration of marine habitat for climate change adaptation. It notes that the use of nature-based solutions in planning and implementing coastal restoration "works to combine with or substitute for grey infrastructure" and seeks to "incentivize their use to sequester and store carbon and improve coastal resilience, while also delivering food, socioeconomic and cultural benefits (artificial wetlands or salt marshes, beach nourishment, reef creation, revegetation, dune fixing shrubs, nutrient cycling, expansion room for the sea or dunes)."[23]

Box 2. The Role of Blue Carbon as a Climate Adaptation and Resilience Response

Blue carbon refers to the carbon captured by coastal vegetated ecosystems (mangroves, kelp forests, seagrass beds, salt marshes, etc.) and stored in biomass and sediments. The carbon sequestered over long timescales represents a sink of carbon in these ecosystems. There is considerable global research that quantifies the capacity for sequestration and the contribution this could make to meeting NDC and other climate-related targets, using blue carbon as a mitigation activity.[24]

In addition to their role as natural carbon sinks, such that their restoration and rehabilitation can reduce net greenhouse gas emissions, coastal vegetated habitats also foster high levels of biodiversity and provide extensive ecosystem services.[25] This includes providing services to the fisheries sector by acting as nurseries, breeding grounds, and feeding grounds, which is particularly critical given the declining fish stocks associated with habitat loss and changes in stock distribution due to climate change.


Photo: Richard Volk/USAID-EGAT

Aside from this, these ecosystems also provide protection from coastal erosion. Thus, their protection and restoration as part of blue carbon mitigation efforts will also contribute to climate adaptation and resilience.[26] Conversely, when these ecosystems are degraded, the co-benefits are greatly diminished, along with the capacity to sequester carbon, and stored carbon can be released back to the atmosphere, along with other greenhouse gases.[27]

Blue carbon is at the heart of biodiversity and climate change and alongside its primary role as a mitigation response, acts as an incentive for developing adaptation as it promotes the conservation and rehabilitation of coastal ecosystems and therefore increases the ability for coastal countries to adapt to the effects of climate change. The increase in ecological health of these ecosystems associated with efforts to increase blue carbon sequestration also provides a multitude of indirect services such as filtering water and pathogens, reducing pathogens, and provisioning alternate resources,[28] all of which will aid in adapting to environmental fluctuations.

Of all the African coastal countries, only Seychelles refers specifically to blue carbon in its NDC document. Nine of the countries with Blue Economy strategies or action plans make reference to the significance of coastal vegetated ecosystems for adaptation. Within the Blue Economy strategies and action plans themselves, five countries (Seychelles, Mauritius, Republic of the Congo, Somalia, and Burkina Faso) have specific actions around blue carbon.

Given the urgency of coastal nations to respond to climate change, there is significant opportunity through the high potential of blue carbon to offer triple-value benefits in adaptation, mitigation, and resilience. Activities that restore and protect blue carbon also offer the potential for developing market-based mechanisms that take advantage of existing frameworks for carbon offsets.

Photo: ChrisVanLennep/iStock

RECOMMENDATIONS

Blue Economy development varies considerably across Africa. Some countries have achieved excellent progress toward climate-smart Blue Economies that include drafting and implementation of strategies and action plans in areas such as spatial planning and MSP; protection of marine and coastal habitats; restoration, nature-based solutions, and ecological engineering. In others, development is still at a rudimentary stage.

Based on the analysis prepared for this chapter and the lessons learned from leading coastal African nations, the following policy recommendations can be considered for governments and policymakers:

- Achieve a better alignment and integration of climate adaptation strategies with Blue Economy development strategies.
- Prioritize the formulation of Blue Economy action plans to integrate all the diverse elements of the Blue Economy, and make marine planning and marine spatial management an essential part of Blue Economy strategy.
- Accord the same degree of priority and emphasis to the creation of MPAs as other kinds of natural reserves so as to ensure the conservation and/or restoration and sustainable management of blue capital.
- Correct the bias toward land-based spatial planning in national strategies such as NDCs in light of the importance of marine planning and the Blue Economy to the many coastal countries of Africa.
- Empower RECs to play a greater role in the management of shared marine resources and encourage such management to follow sustainable Blue Economy principles.
- Ensure that there is sufficient political will, stakeholder involvement, and personnel deployment to implement marine protection legislation.

Coastal Erosion

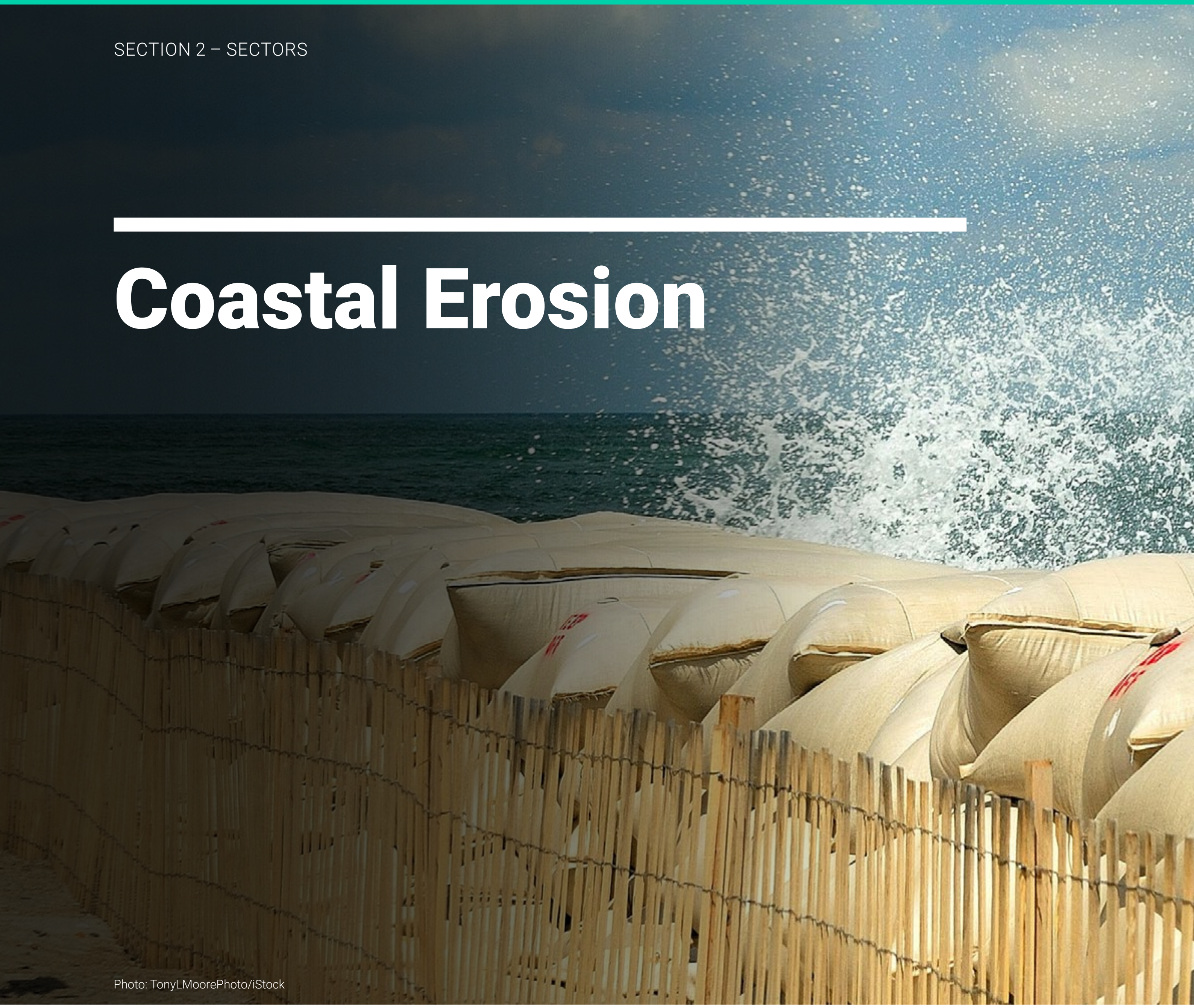


Photo: TonyLMoorePhoto/iStock

KEY MESSAGES

- Africa's ports are tremendously important as drivers of Africa's economic growth, but their activities could negatively impact Africa's coast and ecosystems if appropriate care is not taken. Many African deep-water ports were built without sufficient consideration of the potential impacts to adjacent communities and ecosystems. The lack of adaptation over the years has resulted in creating significant hazards for people, the built environment, and infrastructure, and the natural environment.
- Coastal erosion rates on the West and North African coasts are among the fastest in the world. Africa's coastal zones are highly vulnerable to these changes because of the presence of extensive and densely populated low-lying deltas with poor planning, limited levels of protection, and minimal early-warning systems.
- Without major planning and climate adaptation efforts, more catastrophic impacts to people, infrastructure, and the environment are expected along most of Africa's low-lying coast. It is critical to implement efficient but inexpensive solutions, starting with no-regrets measures like nature-based solutions (NBS), and thereby set the basis for further adaptation efforts.
- Implementing NBS, combined with the Blue Economy approach, increases coastal resilience

and at the same time boosts the economy and revitalizes ecosystems. Efforts to address coastal erosion should be integrated with measures required to tackle other key coastal degradation causes, namely flooding and pollution.

- Multi-stakeholder cooperation is required to overcome institutional and governance barriers, as well as to accelerate the mobilization of finance and the implementation of solutions implementation. Joint public and private initiatives related to transboundary sustainable and resilient coastal management, such as the World Bank's West Africa Coastal Areas Management Program (WACA), must be expanded upon and supported.

"

Invest in mitigation to decrease the need for adaptation. Invest in adaptation to decrease the need for loss and damage payments."

Lee White
Minister of Water, Forests, the Sea and the Environment, Gabon

INTRODUCTION

Coastal ecosystems are vital for humanity as 70 percent of the world's population lives within 100 km of the coast.[1] Coastlines are also central for the global economy, as 90 percent of the world's trade passes through coastal ports and maritime trade volumes are set to triple by 2050.[2] Several densely populated coastal locations around the world are being severely impacted by coastal erosion, a natural process exacerbated by human activities and climate change. These changes are threatening coastal cities throughout the world, including many in Africa. This chapter focuses on adaptation to coastal erosion in two regions of the African continent: West Africa and North Africa. These regions, specifically from Mauritania to Gabon in West Africa and the Maghreb in North Africa, were selected since they are experiencing most of the coastal area changes adjacent to seaports observed in the continent.

Section 1 of this chapter describes the coastal erosion mechanisms for the areas most affected in the African continent, due to the presence of large ports and river barriers. Section 2 presents the latest climate change projections for impacts on the coastlines of West and North Africa. Sections 3 and 4 present a deep dive for the two focus regions, including the state of the coast and intervention examples. Finally, Section 5 presents a summary of the policy recommendations required to address the main gaps.

EROSION MECHANISMS

Coastal erosion is the result of several processes that occur naturally, typically driven by the combined action of waves, currents, wind, tides, and mass wasting processes. As a result, some sections of the coast are gaining land (accreting), while others are losing land (eroding). Coastal erosion is exacerbated by the effects of anthropogenic climate change, namely sea level rise, and an increase of waves and extreme events. It is also harshly impacted by human activities such as sand mining, development of coastal infrastructure, inland river damming, and mangrove removal, all of which can significantly alter natural processes.

In West Africa and North Africa, anthropogenic pressures are the main drivers of coastal erosion, primarily due to the presence of large ports and river dams. This section details the scope and extent of the respective impacts of both these kinds of built infrastructure.

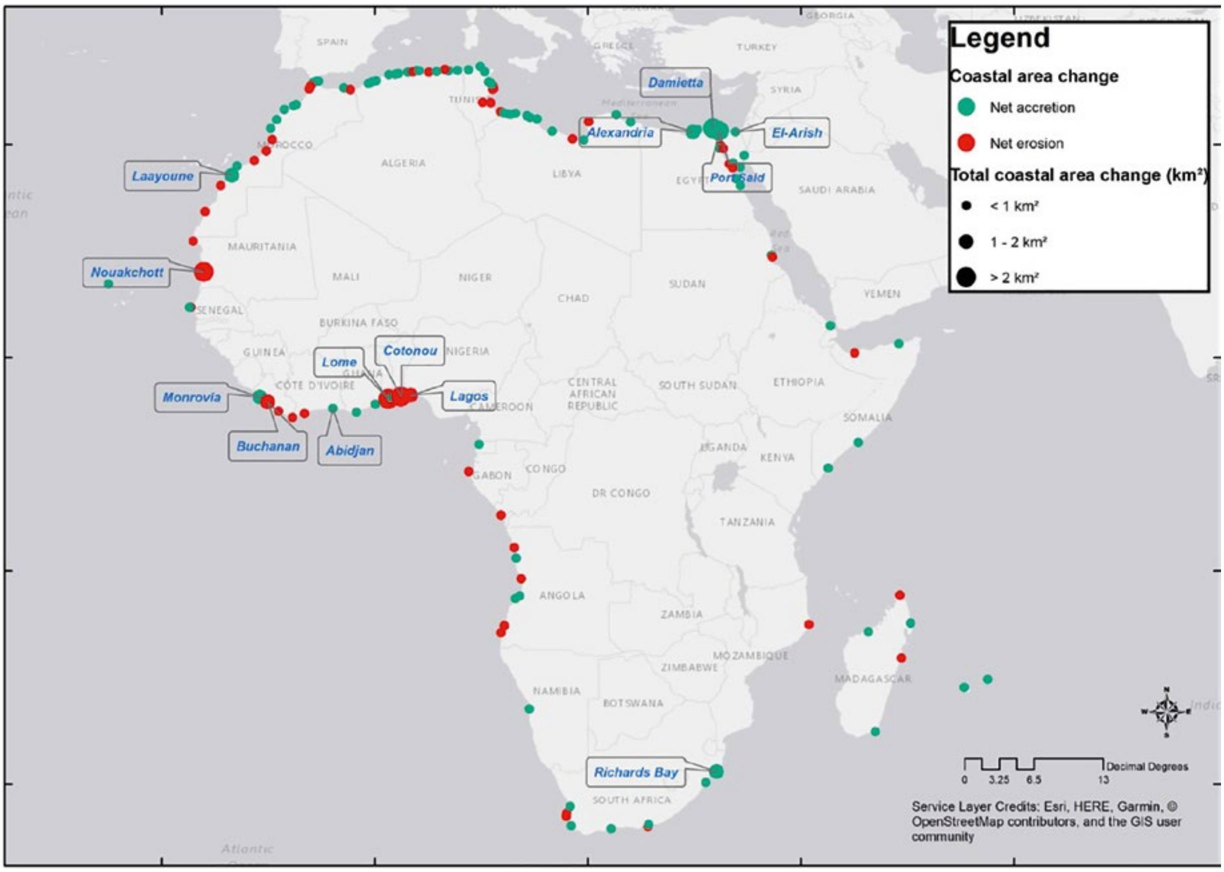
The Impacts of Ports

Natural coastal processes are strongly influenced by the development of shore-perpendicular breakwater structures, such as deep-water ports, which can starkly alter coastal sediment transport. This process, which starts immediately following port construction and continues thereafter, consists of erosion taking place downdrift from the port structure (in the direction of the net longshore sediment transport), and beach accretion taking place updrift of the port.

Most African deep-water ports were built with limited planning and consideration of the impacts to adjacent communities and ecosystems, and the lack of adaptation over the years has resulted in creating significant hazards for people, the built environment, and infrastructure, and the natural environment. Aside from the difficulties of addressing existing problems, the main challenge is that this shortcoming is still a feature of ports currently under construction. Further, it is likely to continue in the construction of new ports, especially in West Africa, where terminal operators and governments have laid out ambitious plans to further develop container facilities in both existing ports and planned new ports.[3]

As revealed in a 2019 study, at least 13 large ports in Africa are characterized by severe erosion on beaches adjacent to them. Most of these ports are in the West and North Africa region, located in open coastlines with significant alongshore sediment transport, and represent the top 10 percent hotspot ports in Africa, in terms of gross historic coastal area changes, as indicated by the text boxes in Figure 1.[4]

Figure 1. Geographical Overview of the Gross Coastal Area Changes Adjacent to 130 African Seaports

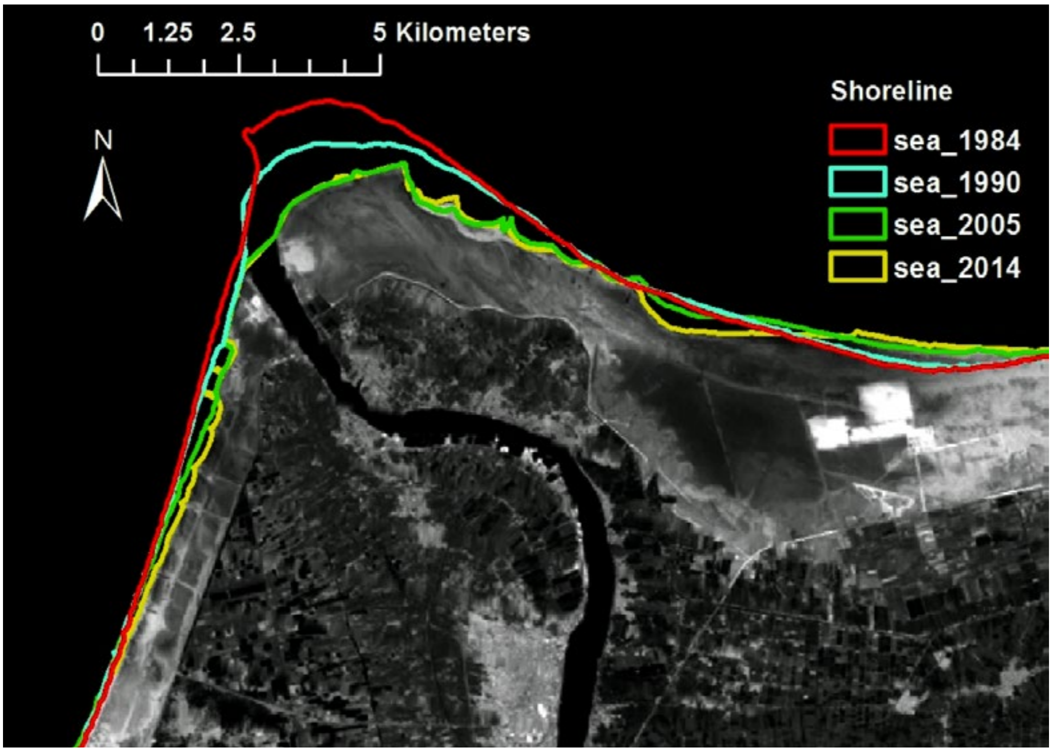


Source: de Boer et al. (2019)[5]

Note: The size of the dots represents the gross beach area change. The colors represent whether this change is dominated by accretion (green) or erosion (red).

Out of these, the most significant example is certainly the port of Nouakchott, in Mauritania, which over the course of the last 30 years has experienced extensive beach erosion downdrift of the port, in the order of 20 meters per year (Figure 2).

Figure 2. **Beach Change Detected for the Port of Nouakchott (Mauritania) between Jan 1984 and Dec 2017**



Source: de Boer et al. (2019)[6]

Note: The erosion area is indicated in red and the accretion area in green. Also shown in the figure is the baseline (purple), the latest satellite-derived shoreline (SDS, in blue), and the intersections (orange dots).

These dramatic erosion trends, combined with other forms of coastal degradation such as flooding and pollution, have severely affected millions of coastal livelihoods over the years and led to several mortalities. A 2019 World Bank study undertaken for Benin, Côte d'Ivoire, Senegal, and Togo estimates that coastal degradation affected about 1.4 million people in 2020 and causes around 13,000 deaths a year.[7] Furthermore, coastal degradation has a substantial impact on the economy. In 2017 alone, the cost of environmental degradation was estimated at about US$3.8 billion, or 5.3 percent of the GDP of these four countries. In these countries, 56 percent of the coastline is subject to an average erosion rate of 1.8 meters per year, and without immediate action impacts are likely to exponentially escalate in the coming years.[8]

Coastal erosion is also severely impacting coastal North Africa and in particular the Maghreb region, which represents a coastline of about 7,500 km across Algeria, Libya, Morocco, and Tunisia. A 2021 World Bank study revealed that coastal erosion entails substantial direct costs in the Maghreb countries, ranging from US$273 million per year in Libya to more than US$1.1 billion per year in Tunisia. In terms of GDP, the average cost of coastal erosion is estimated to be 0.6 percent of GDP annually in the Maghreb. Annual costs of land and infrastructure assets are equivalent to about 2.8 percent of GDP in Tunisia, 0.7 percent in Libya, 0.4 percent in Morocco, and 0.2 percent in Algeria.[9]

Investing in coastal protection will not only help affected communities recover from past impacts, it will also provide enduring adaptation capacity to cope with forthcoming climate changes and prevent other livelihoods from being impacted. However, this requires cooperation from various private and public stakeholders, and a change in the design, construction, and operation of main ports.

Like other ports around the world, during the last 20 years most African ports have evolved into semi-autonomous public/private economic players and are starting to acknowledge their environmental impacts.[10] They are tremendously important as drivers of Africa's economic growth through shipping, but their activities negatively impact Africa's coast and ecosystems. A combination of integrative solutions and approaches, such as the Blue Economy approach, are required to address harmful impacts to livelihoods and keep coastal and marine ecosystems healthy and productive, and at the same time to harness their vast potential to support socioeconomic development and sustainable growth. However, these measures are relatively new, especially to African ports, and further efforts are needed to ensure solutions are accepted and integrated operationally as part of the port's sustainability plans.

The Impacts of Dams

The presence of large river-transversal barriers, such as dams, also plays an important role in coastal erosion as they block fluvial sediment transport and lead to coastal sediment deficit and shoreline recessions. Due to the interconnectedness of river mouths and deltas to upstream river basins, variability of sediment supply caused by its interception by dams can result in coastal sediment deficits on the coast. Such sediment deficits resulting from dam construction have been observed in the Nile Delta, the Yangtze Delta, the Mekong Delta, and the Ebro and other Mediterranean deltas.[11]

This issue is significant for Africa, especially considering that several large dams were built across the continent in recent years, all with limited or nonexistent plans to manage sediment transport, and that numerous new ones are planned in the coming years. A 2018 study on large-scale sediment balances in West Africa found that a substantial amount of sediment is retained by river dams. Modeling showed that if the sediment was able to flow freely, sediment accretion on the coast could immediately increase by several meters per year.[12]


Photo: Africanway/iStock

CLIMATE CHANGE: PROJECTED IMPACTS

The effects of anthropogenic climate change are greatly aggravating coastal erosion mechanisms, in particular the change of wave patterns, sea level rise and subsidence, and the increase of coastal flooding events. Africa's coastal zones are highly vulnerable to these changes because of the presence of extensive and densely populated low-lying deltas with poor planning and limited levels of protection and early-warning systems.

Climate changes, when coupled with human activities, are impacting most of Africa's coastal and marine ecosystems, significantly reducing the provisioning, regulating, cultural, and supporting ecosystem services that these typically provide to communities. Without major planning and adaptation efforts, much greater impacts to people and the environment are expected by the end of this century along most of Africa's low-lying coast.

The most known current and projected effect of climate change is the increase of global temperatures, along with sea level rise and extreme weather events. But the effects of climate change also includes a number of deviations of physical and chemical factors at a local level. Out of these, the ones most affecting Africa's coastal zones are the rise of sea temperature, salinity and acidity, the alteration of sea oxygen concentration, ocean currents, vertical stratification, the increase of subsidence, the shift of tidal magnitude and rhythm,[13] and in particular (Box 1) changes in wave conditions.

Box 1. Changes in Wave Conditions


Photo: Dan Rata/Shutterstock

Changes in wave conditions, especially in combination with sea leave rise, are possibly one of the most significant factors for the coasts of Africa, West Africa in particular. Sea level rise in itself does not lead to increased erosion. However, as the sea rises, waves can expand their reach and therefore the level of erosion. Furthermore, recent research found that global warming is already making waves more powerful, particularly in the countries of the Southern Hemisphere.[14] The reason behind this is that waves are formed by winds blowing along the ocean surface, and as the sea surface becomes warmer (which is happening more rapidly in the world's south) wind patterns change and become stronger, thus forming more frequent and severe waves in the southern regions. New findings have confirmed the trend of these so-called "transitional wave climate regions" (coastlines with a future change in the occurrence frequency of a wave climate), which are showing an increase in wave frequency from 5 to 20 percent.[15] Since waves determine where and how much sediment is moved and deposited along the coast, changes in wave patterns are rapidly escalating the already high coastal climate risk for these areas. It is therefore critical to ensure adaptation for areas that will be affected by more severe wave conditions, and consequently by more dramatic increases of erosion, such as West Africa's coast.

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, *Climate Change 2022: Impacts, Adaptation and Vulnerability*, was finalized on February 27, 2022. The report underlines the urgency for rapid action on climate adaptation, to ensure the poorest countries are prepared for worsening climate impacts. It notes that action is most crucial in Africa.[16]

The risk for the millions of people living in low-elevation coastal zones of Africa will increase, due to the growth of population and urbanization that is expected in the next 50 years. It is estimated that by 2030, up to 116 million African people will be exposed to the effects of sea level rise (compared to 54 million in 2000), further increasing to 245 million by 2060.[17]

WEST AFRICA: SITUATION AND SOLUTIONS

According to the Fifth IPCC Assessment Report of 2014, West Africa in particular is a hotspot of climate change in the continent, and is expected to be severely impacted by climate change through the 21st century. The report indicates that the temperature in West Africa may rise by 0.5°C per decade, accompanied by increased rainfall variability and intensity and accelerated sea level rise of around 1 meter per century.[18]

A 2020 World Bank study focusing on Benin, Côte d'Ivoire, Mauritania, Senegal, and Togo also confirmed that by the end of the century West Africa is expected to experience sea level rise of up to 1.06 meters, 5,500 km^2 of coastline flooded, a temperature increase between 2°C and 4.6°C, and higher incidences of extreme rainfall.[19] In earlier terms, which are also easier to relate to given the high level of uncertainty of climate projections, by 2030 Mauritania and Senegal could experience a sea level rise of 0.18 m, while Côte d'Ivoire, Togo and Benin could see a 0.1 m rise. By 2050 in Mauritania and Senegal sea levels could rise by 0.6 m, and in Côte d'Ivoire, Togo, and Benin the rise could be 0.3 m.

This section assesses the state of coastal erosion in West Africa and introduces intervention examples to tackle this mounting challenge, including the use of nature-based solutions (NBS) and the integration of green and gray infrastructures, the application of the Blue Economy approach, and the implementation of governance measures such as regional planning.

State of the Coast

The West African coastal area, covering approximately 6,000 km of biodiversity-rich land over 13 countries, is characterized by sandy formations (from Mauritania to the Cape Verde peninsula), rocky capes and sandy coves (from the Cape Verde peninsula to Liberia), several estuaries (such as the Senegal River Delta and the Volta Delta in Ghana), mangrove forests (from the Saloum Delta in Senegal to the Sherbro River estuary in Sierra Leone), and large sedimentary basins of loose coastlines (from Côte d'Ivoire to Benin). West Africa's coastal zone is also a rich source of economic, recreational, and cultural activity and it is critical for the region's economy. Approximately one-third of the West African population lives in the coastal zone and 56 percent of the region's GDP is generated there.[20] Environmental degradation due to coastal erosion, flooding, and pollution, all of which are going to be exacerbated by the effects of climate change and poorly regulated development, is projected to escalate significantly in this region.

In 2019, the average coastline recession in Côte d'Ivoire, Senegal, and Togo was 1.4 m/year, 1.6 m/year, and 2.4 m/year respectively. Climate change-related effects such as sea level rise and an increased severity and frequency of waves and storms play a crucial part in coastal erosion mechanisms. Other anthropogenic activities contributing to high levels of coastal erosion in West Africa include the destabilization of sediment because of large port infrastructure, resulting in coastal accretion upstream and erosion downstream, and shortage of sediment caused by the construction of dams along rivers.[21]

Plastic pollution also represents a particularly demanding challenge for Africa. The continent is the second-largest contributor globally to annual plastic inputs from rivers into global oceans, with a current share of 7.8 percent and projected to reach 10.6 percent by 2025.[22] By continuing with rapid urbanization and poor waste management Africa could become the largest contributor to global mismanaged plastic by 2060.[23] Plastic waste presents severe health, financial and environmental impacts, as it enters the food chain and the bloodstream of human beings and contributes to spread of waterborne diseases. Plastic waste builds up in the environment and has other major consequences, as it clogs drainage systems and contributes to widespread flooding, destroys ecological, recreational, and touristic values, and alters coastal sediment dynamics.

Many West African ports were established during the colonial period and have historically constituted the most developed part of the transport network. With no land access to distant consumer markets and little production of high-value-added goods that could justify air transport, ports continue to represent the main links between West African economies and the rest of the world. Even though coastal erosion issues associated with West African ports are well known by port engineers and decision-makers, plans are in place to continue expanding existing and new ports, which could further exacerbate the problem of coastal erosion in the region.

The State of the Coast Report is the main document presenting management actions for the West African coast as well as measures to strengthen regional cooperation.[24] The 2020 edition, which was prepared by the Centre de Suivi Ecologique (CSE)[25] under the leadership of the West African Economic and Monetary Union (WAEMU), was reviewed by a scientific committee and then politically validated by West African Ministries of Environment in June 2022.[26] The study includes detailed maps showing changes since the 2016 edition, highlighting the most critical interventions required for Benin, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, São Tomé and Príncipe, Senegal, Sierra Leone, and Togo. See below the example for the state of the coast and possible measures in Saint-Louis, Senegal (Box 2).

Shoreline recession situations are directly linked to sediment deficit noted at the local level. Most of West Africa's coastal sediment stock is fed with wind inputs from Mauritania to the Cape Verde peninsula and with river inputs on the remaining part of the coast.[27] The amount of sediment reaching the coast from West African rivers used to be abundant. However, large quantities of sediment are nowadays retained by river dams. This is particularly evident on the Volta River, which used to carry the largest volume of sediment to the West African coast, and across which sizeable river dams have been constructed. The construction of large dams such as the Akosombo Dam, Ghana, has created a hefty deficit in the sediment balance in the river's delta as well as downstream of the longshore drift, toward Togo and Benin, as the river is no longer carrying sediment to the coast. Since 2011 more than 150 large dams have been built in West Africa and about 40 new dam projects are planned in the region in the coming years.[28]

Current shoreline management practices in West Africa rely heavily on traditional engineering solutions, also known as "hard" (or "gray") infrastructure. Groynes, breakwaters, jetties, revetments, and dikes are the most common coastal defense structures in West Africa and are built on an as-needed basis. Hard infrastructure can be remarkably effective and appropriate when the risks are high. For example, a major breakwater was constructed successfully in Abidjan, Côte d'Ivoire, to protect strategic areas such as the Abidjan port. However, construction of hard infrastructure is expensive, and evidence shows that when it is not part of a wider coastal plan and is poorly maintained, it does not serve as a long-term solution.[29]

To address coastal vulnerability, West African countries need to rapidly deploy interventions that support the use of NBS, also known as "soft" or "green" infrastructure, to successfully protect coastal communities and help them to thrive, as well as for ecosystem sustainability and longevity.[30] Findings from a recent report identify the existing knowledge gaps in the potential economic benefits of NBS and the challenges faced by economic policymakers, public-sector institutions and agencies, investors and financial institutions, and industry and Nature-Based Enterprises (NBE) in delivering NBS.[31] The report includes a number of recommendations, including the need to:

- Develop international standards for NBS (to address all stages: planning, delivery, management, monitoring, and sustainability), to be incorporated into NBS procurement processes.
- Report on natural capital and adopt a holistic approach to include non-monetary ecosystem service valuation, including appropriate incentives and penalties to ensure compliance (especially for public organizations and large private players).
- Better integrate NBS into existing economic policy approaches (e.g. circular economy, bioeconomy, Blue Economy, The EU Green Deal Investment,


Photo: Damian Pankowiec/Shutterstock

Smart Specialization and InvestEU strategies), and into other key policy fields (i.e. climate change; soil, land use and planning; energy and building; social and health policies; smart technologies and digitalization).

- Enable accelerated investment in NBS by both the public and private sector (public-sector investment in NBS should double at all policy levels) and develop new policy measures to stimulate further increase of private sector investment in NBS (e.g. by strengthening of NBS in the EU Taxonomy, alignment with the Taskforce on Nature-related Financial Disclosures), and to increase financing in large-scale NBS projects as well as community-led, small-scale projects.
- Increase investment for research on market data, demonstration of practical cost-effective methodologies, and tools to measure the effectiveness of NBS.
- Increase investment for awareness measures to raise the support among the public for investment in NBS, empower citizens and communities to engage in decision-making and governance of NBS, and build the capacities of stakeholders.

Since hard infrastructure such as concrete seawalls serve only as medium-term solutions, it is vital to invest in NBS and encourage coastal ecosystems to adapt and build resilience. NBS such as restoration of dunes, sea grasses, salt marshes, coral reefs, mangroves, and other coastal forests, are cost-effective measures that can contribute to protecting the coast from erosion and other forms of coastal degradation. Current global investments in NBS amount to US$133 billion, with 86 percent of this funding coming from the public sector. However, to successfully address the inter-related nature, climate, and land degradation crisis, investment in NBS should be increased to US$285 billion by 2050.[32]

Mangrove ecosystems in particular have long provided benefits to communities and fisheries. In recent years, they have been recognized for their important role in mitigating climate change impacts and protecting vulnerable coasts against storm events and associated coastal erosion and flooding, as well as for carbon sequestration and storage.[33] With climate change expected to increase both the severity and frequency of storms, the restoration and protection of the remaining mangroves can significantly help reduce wind and swell waves, buffering the impacts of storms. The financial benefits from flood protection from mangroves are estimated to be more than US$65 billion per year globally.[34] When restoration is not possible, such as in the case of mangroves that have been lost to urbanization, the use of hard infrastructure, combined with beach nourishment and other soft measures, will be required. This approach is also necessary to protect specific economic and natural capital assets, including existing mangrove areas that are under threat.

West Africa's dynamic coastal zone is characterized by a large presence of mangroves, which are present in about 48 percent of West African sedimentary coastline, with a total mangrove area of 20,000 km^2 (2 million hectares), representing 13 percent of mangrove forests worldwide.[35] The largest area of mangroves (40 percent) is in Nigeria, followed by Guinea-Bissau and Guinea. The single largest mangrove forest is in the Niger Delta region of Nigeria, comprising about 80 percent of the country's mangrove area. Furthermore, approximately 14 percent of the West African region's mangroves are found in protected areas and constitute a complex ecosystem with diverse interdependent biodiversity.

Most mangrove ecosystems in West Africa have been affected by population growth, poorly planned coastal development, increased resource exploitation (related to population growth and urbanization) and weak governance. In addition, climate change poses a risk to the remaining West African mangrove areas, primarily due to sea level rise and increased sedimentation. Between 2000 and 2016, the largest loss of mangrove extent occurred in Nigeria and Guinea, with Ghana and Guinea recording the highest percentage of loss.[36] The main cause of loss in the region was clearcutting, selective logging, and dieback due to oil pollution, accounting for 56 percent of mangrove losses in Guinea-Bissau. Erosion is the main driver of loss in Senegal, The Gambia and Togo, while urban expansion is the main driver in Liberia. While most countries have experienced a net loss of mangroves, the extent of mangroves managed to stay constant and they are even increasing in some areas. This is the case of Senegal, where mangrove cover expanded from 2000 to 2016 by 2.6 percent, offsetting losses caused primarily by erosion.

One of the main side effects of mangrove forest loss in West Africa is the increased impacts from flooding. Mangroves provide an effective buffer against coastal flooding, as well as a form of protection against river and pluvial flooding. The ongoing loss of mangrove habitat is expected to lead to a significant increase in flooding hazards for West African communities. Mangrove loss is also frequently associated with the proliferation of invasive species that can compete with regenerating mangroves, as is the case in Nigeria where the invasive Nypa palm competes with overexploited mangroves in the Niger Delta and the Calabar estuary.

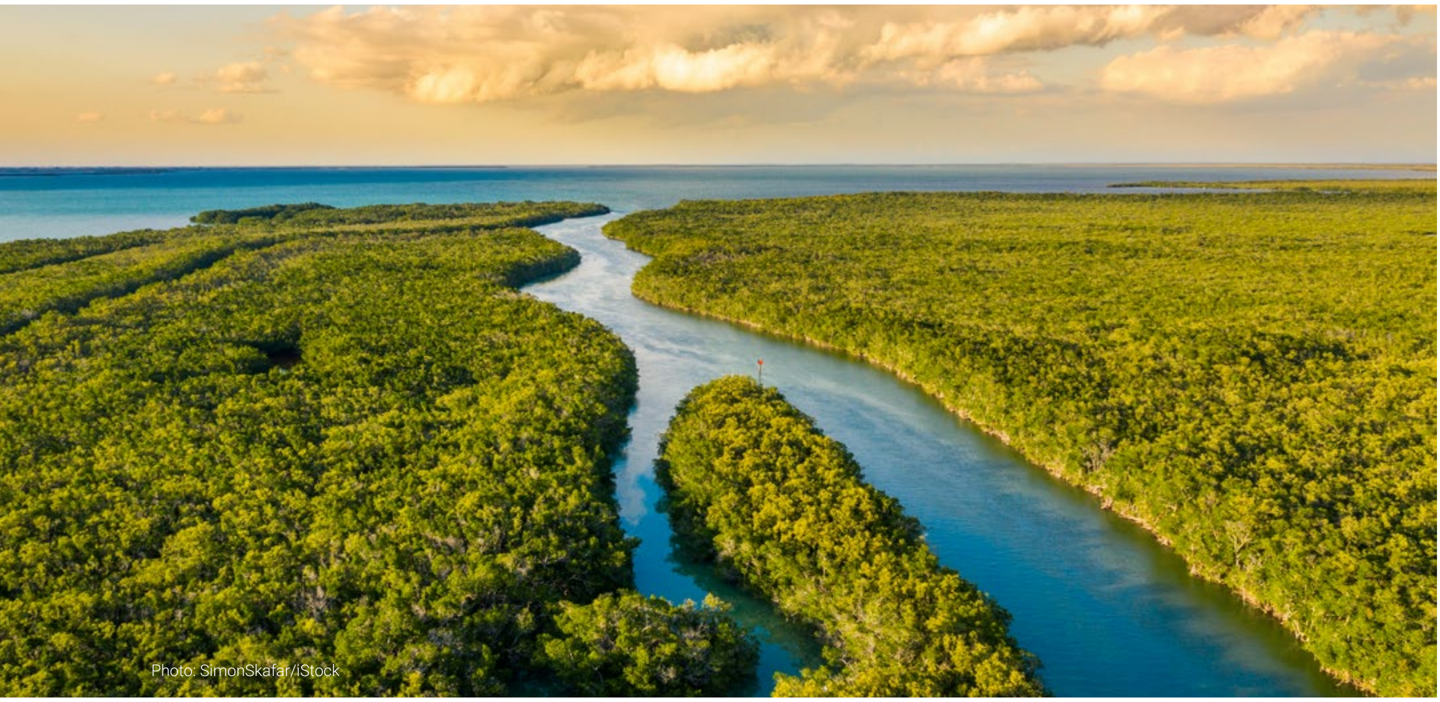


Photo: SimonSkafar/iStock

Intervention Examples in West Africa

As the West African coast is already experiencing some of the highest rates of erosion in the world, a mix of climate-resilient infrastructure, disaster risk management plans, and NBS are urgently needed to protect coastal livelihoods, infrastructure, the built environment and ecosystems. Several government and organizational initiatives have been already set up to reduce vulnerabilities and risks affecting coastal communities.

For example, the West Africa Coastal Areas Management Program (WACA), a World Bank initiative launched in 2018, supports efforts led by countries and regional institutions to strengthen the resilience of coastal communities and ecosystems. The program, which includes engagements with the private sector to identify new public–private partnership (PPP) opportunities, serves as a regional platform for multi-stakeholder cooperation to facilitate the goal of the WAEMU and the Economic Community of West African States (ECOWAS) of mitigating and adapting to natural and anthropogenic coastal environmental degradation.[37] The WACA program boosts the transfer of knowledge, fosters political dialogue among countries, and mobilizes public and private finance to mainly tackle coastal erosion, flooding, pollution, and climate change in West Africa.

The program, which consists of country projects, regional integration and support activities, and a platform to scale up knowledge, dialogue, and finance, is currently engaged with US$226 million finance from the International Development Association (IDA) in nine countries. However, all West African countries are targeted as part of the regional integration activities. A first set of six national investment projects under the WACA program (known as Resilience Investment Project 1, ResIP1) is proving to be successful. At its mid-term review, leaders emphasized the transformative impact of the program.[38] The next set of three national projects under WACA (known as Resilience Investment Project 2, ResIP2), is in the pipeline for US$241 million of World Bank IDA financing, and will help address other challenges, such as flooding and coastal and marine plastic pollution.[39]

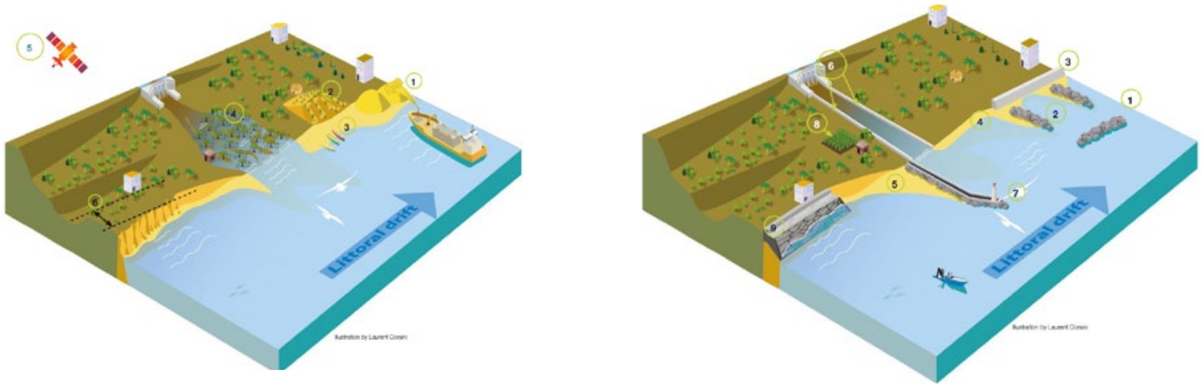
With this, WACA will widen its geographical span and add new development themes: The Gambia will focus on urban resilience and flood risk management; Ghana will concentrate on coastal ecosystem restoration and resilient infrastructure design; and Guinea-Bissau will expand mangrove restoration and community-based development. The participation of more countries means greater efforts and better results for regional integration. Other donors have or will come in, including The Global Environment Facility (GEF), the French Development Agency (AFD), the French Facility for Global Environment (FFEM), and the Spanish Development Agency (AECID).[40]

On February 28, 2020, the World Bank Group launched a Call for Innovation as part of the WACA program to identify innovative and feasible solutions to address coastal erosion issues associated with the ongoing development of large commercial ports and maritime operations in West Africa.[41] Following a review process, five innovations were shortlisted out of a total of 22 received. Shortlisted innovators were then asked to pitch in front of a grand jury on November 17, 2020, which selected the three winning innovations.

The first-placed innovation, WAC-App, is a proposal to create an interactive online-based application to assess the effects of coastal interventions and enable communication between decision-makers and stakeholders. The second-placed innovation, Trans-Sand, consists of setting up a transnational bypassing scheme, to be funded by a public–private dredging fund, to provide dredging capacity for all partner countries, reduce escalating costs, and increase environmental performance. The third-placed innovation, SA-PoD, proposes a stakeholder-inclusive approach to shift the focus of port development from business and engineering to an integrated environmental economic and social perspective, and promote sustainable coastal development. The World Bank Group, in collaboration with the Port Management Association of West and Central Africa (PMAWCA), is currently exploring ways to further increase the visibility of these winning proposals and identify potential funding mechanisms for their implementation.

As part of the WACA program, thanks to the efforts of the French National Research Institute for Sustainable Development (IRD) and the Africa Center of Excellence for Coastal Resilience, and the support of the Nordic Development Fund and the Global Facility for Disaster Reduction and Recovery, a new Compendium of Solutions was produced as a repository of feasible solutions to existing coastal issues, and to provide a common language to talk about challenges (Figures 3 and 4).

Figure 3. Soft Engineering, Coastal Planning, and Risk Management Solutions (left), and Hard Engineering Solutions (right)



1. Nourishment of the beach to give it back its natural shape
2. Dune restoration through the plantation of trees
3. The beach regains its width through the normal supply of sediment
4. Natural flooding in estuarine areas allows the traditional rice-crop system and the rehabilitation of the wetlands and mangroves
5. A flood early-warning system using satellites allows people to leave the agricultural camp in time in case of flooding
6. Setback and relocation to prevent the danger of building damage and collapses

1. Breakwater
2. Groynes
3. Seawall preventing flooding event
4. Shrinking beaches due to lack of sediment supply
5. Accretion
6. River embankment
7. Jetty to prevent silting of the estuary
8. Water-controlled irrigated agriculture replaces flood agriculture and mangroves
9. Cliff stabilization

Source: World Bank Group (2022)[42]

WACA's financial and cooperation platform also supports the Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, known as the "Abidjan Convention," which provides an overarching institutional framework for its country members. Thanks to the convention, which was signed on March 23, 1981 in Abidjan, Côte d'Ivoire, and went into effect on August 5, 1984, several commitments and coastal management protocols are integrated into country members' national laws, alongside national action plans, including the "land-based pollution" protocol[44] and the "sustainable mangrove management" protocol.[45]

The latter, validated in Bissau in May 2016, represents a fundamental outcome to acknowledge the roles of mangrove coastal forests as productive ecosystems able to provide vital services for West African communities, including protection from the effects of human activities and climate change, particularly erosion, flooding, and pollution. This protocol triggered a series of studies to better understand the functions provided by mangroves and their role of stabilizing the coastline and reducing coastal flooding, by increasing the resistance of soil against erosion, reducing the hydraulic load onto the surface, and increasing friction. One of the main advantages of mangroves is that their erosion mitigation and wave-dampening capacity is to some extent climate-proof, thanks to the ability of mangroves to trap sediment and "grow" with sea level rise. Mangroves also provide many other valuable ecosystem services that contribute to human wellbeing in West Africa, such as climate regulation, carbon sequestration and storage, biodiversity habitat, fisheries support services, timber and raw materials provision, tourism, and water purification.

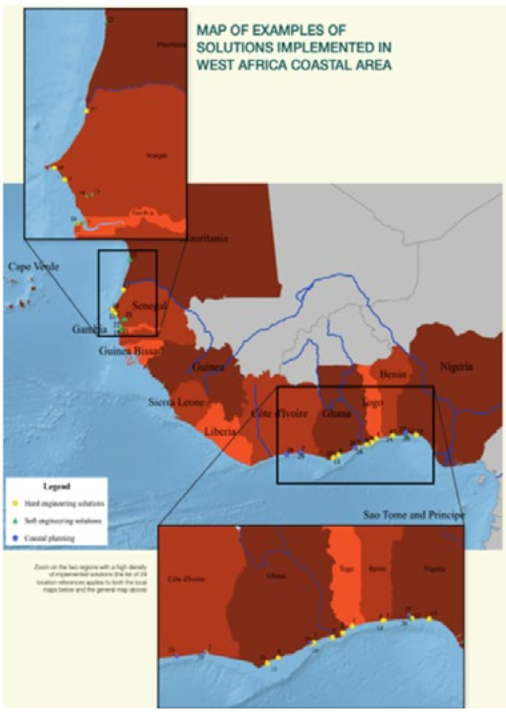
According to research undertaken in Indonesia, which is home to an estimated 20 percent of the world's mangroves, on average these sets of services yield US$15,000/ha every year in benefits, but some provide benefits totaling nearly US$50,000/ha a year.[46] Despite these services, mangroves are under pressure and declining globally due to natural and anthropogenic pressures. Mangroves represent a solid example of NBS to mitigate climate and disaster risks, and detailed vulnerability assessments are necessary to develop mangrove-based coastal management strategies.

With sea level rise, the submergence of low-lying coastal areas, and increasing wave heights, which may lead to unprecedented erosion rates, the present West African mangrove forests are expected to move landwards. However, if migration of the forests is restricted by the presence of infrastructure (e.g. seawalls, roads, or built-up areas), suitable areas for mangrove habitat will decline, and ultimately disappear. Also, without sediment accretion, most mangrove areas will drown, as the submergence time will become too great for mangroves to survive. Hence, ensuring sediment availability and accretion potential in mangrove areas is vital for their survival under sea level rise. When mangroves are no longer able to provide a useful buffer for sea level rise and wave/storm impacts for communities living close to the coast, the combined use of soft and hard infrastructure and the relocation of the most critically affected houses should be considered as the most effective interventions.

Further studies are required to better understand the role of mangroves in protecting the West African coast, whether as a single intervention or in combination with other types of interventions. Such research, which should ideally focus on selected hotspots where mangroves already play an important role in trapping and retaining sediment, would help to define how mangrove-based coastal management strategies could be a relevant approach for the various sites along the African coast experiencing erosion and associated threats such as flooding, salinization, and subsidence. The study of existing mangroves in places where they play an important role (both for the ecosystem services provided as well as for the local population) is also critical to understand the factors that have led to mangrove forest degradation and, possibly, to estimate the costs of not having healthy mangroves.[47]

Several restoration and protection initiatives are being undertaken in West Africa, notably in Sierra Leone, Côte d'Ivoire, and Senegal. The project "Management of Mangrove Forests from Senegal to Benin," for example, funded by the European Union for

Figure 4. **Examples of Soft Engineering and Hard Engineering Solutions Implemented in Coastal West Africa**



N°	LOCATION	TYPE OF SOLUTION
1.	Lomé	Offshore Breakwater
2.	Abidjan	Offshore Breakwater
3.	Petite côte	Offshore Breakwater
4.	Cotonou	Offshore Breakwater
5.	Cotonou	Groynes
6.	Keta	Groynes
7.	Sakumono	Groynes
8.	Elmina	Groynes
9.	Ada	Groynes
10.	New Takoradi	Groynes
11.	Petite côte	Groynes
12.	Lagos	Groynes
13.	Elmina	Jetties
14.	Cotonou	Jetties
15.	Lagos	Jetties
16.	Accra	Revetments
17.	Saint-Louis	Revetments
18.	Rufisque	Seawall
19.	Serekunda	Seawall
20.	Lagos	Beach nourishment
21.	Banjul	Beach nourishment
22.	Kololi	Beach nourishment
23.	Nouakchott	Dune rehabilitation
24.	Djimda (Fatick)	Wetland restoration
25.	Guagué Sherif	Wetland restoration
26.	Accra	Early flood warning system
27.	Lagos	Early flood warning system
28.	Grand-Lahou	Relocation
29.	Abidjan	Relocation

Source: World Bank Group (2022)[43]

Box 2. The Eroding Coast of Saint-Louis, Senegal

Photo: Job Dronkers/coastalwiki.org

The coastal area of Senegal, covering about 198,000 km^2 and home to 60 percent of Senegal's population and contributing to 68 percent of the country's GDP, is affected by increasing erosion at various locations. At the same time, coastal areas are developing fast, leading to increasingly frequent risk situations. Senegal has integrated coastal zone plans for certain segments of the coast that are the instrument for coordinated action on coastal development, including Saint-Louis.[50]

The city of Saint-Louis on the northern coast of Senegal faces drastic challenges from climate change and coastal erosion. This city of 258,592 people is located on the mouth of the Senegal River and its economy is strongly dependent on the tourism and fishing industries. From 1872 until 1957, the city operated as the capital and economic hub of Senegal and in 2000 it was listed as a UNESCO heritage site. Saint-Louis has already suffered significant impacts from climate change-induced sea level rise and coastal erosion. Encroaching waves have destroyed homes, schools, and mosques, and displaced thousands of people.

The highest point of Saint-Louis stands just 4 m above sea level. It is particularly vulnerable to flooding and erosion from the Senegal River during the rainy season, and from storm surges and wave impacts from the Atlantic Ocean. The residual spit downdrift of the Senegal River mouth has suffered from significant wave erosion due to a drop in longshore sediment transport. By 2012 the erosion of the spit led to rapid widening of the mouth from around 2 km to 5 km. This river mouth expansion now functions as a depocenter for sand transported alongshore from updrift, reducing the shoreline protection against wave impacts.[51]

Services and investments within poor and vulnerable settlements, most of which are in the first row along the shoreline, have historically been lacking. Despite a number of networks for facilitating adaptation action and flood resilience, lack of support from higher-level government institutions has limited the capability for municipal staff and local actions to enhance resilience.[52] More than 10,000 people have been displaced as a result of coastal erosion in Saint-Louis. The World Bank is providing US$80 million in funding to directly support the 927 households that have thus far been evacuated, and to support those still vulnerable to flooding and erosion through the Saint-Louis Emergency Recovery and Resilience Project. Sea walls have been constructed in the past to protect the city. The last colonial wall lasted several centuries, but new conditions degraded it. In some locations of the city, managed retreat appears to be the only viable solution against coastal erosion as climate change continues to overwhelm villages and livelihoods.

While the priority is to reduce the risks for the exposed populations and to preserve the heritage of Saint-Louis, it is also essential to protect the delta ecosystem, which is largely dependent on the gradient of salinity. Requalification and reorganization of landing areas and fish processing sites at landing is also a key priority. There are different solutions currently being examined, with the main alternative out of the options for nonintervention consisting in consolidating the existing breach and securing its depth (delivering protection against floods and stability for the fishers), but at the price of a degradation of the natural environments of the delta, or the attempt to restore the initial situation.[53]

Required actions include:

- Ensure the safety of exposed populations, including the possibility of relocation.
- Prepare a submersion risk prevention plan and study of possible solutions for coastal protection and development (especially for the historic city of Saint-Louis).
- Support for the relocation of affected economic activities.
- Redesign the tourism development plan, considering the evolution of the Langue de Barbarie, to be integrated into a sector scheme.

A portfolio of World Bank projects is being implemented in the region with partners. They are:

- West Africa Coastal Areas Resilience Investment Project
- Description of ongoing projects and initiatives that may influence the development strategy of the urbanized coastal area of Saint-Louis
- The Saint-Louis Emergency Recovery Project
- Project "Monitoring Coastal Risks and Soft Solutions in Benin, Senegal and Togo – intervention at Pilote Barre," a WACA program supported by Fonds Francais Pour L'Environnement Mondial
- Saint-Louis Emergency Recovery and Resilience Project
- Stormwater Management Program
- Cities-IAP: Sustainable Cities Initiative supported by GEF
- Urban Master Plan of Saint-Louis

a period of five years (2019–2024), aims to achieve integrated protection of mangrove ecosystems in West Africa and enhanced resilience to climate change.[48] Dunes, which are formed of sediments mobilized by wind, currents, or waves, also play a critical role in beach stabilization and reducing the impact of erosion and flooding. Coastal interventions should include rehabilitating the functional processes and ecosystems integrity of degraded, damaged, or destroyed coastal dunes.[49]

New feasibility studies on main interventions are also planned. WAEMU has commissioned a technical assistance study to prepare a strategic regional action plan for investments for all West African countries to provide guidance and identify transboundary or coordinated interventions, or to inform changes in the protection paradigm by considering wider co-benefits. This will hopefully lead to further investments in mangroves and dunes restoration.

NORTH AFRICA: SITUATION AND SOLUTIONS

This section presents a summary of the state of coastal erosion in North Africa and details examples of interventions to tackle this challenge, including recommended on-the-ground measures, with special focus on the use of NBS and the integration of hard and soft (gray and green) infrastructure, and important governance measures available to governments such as regional planning.

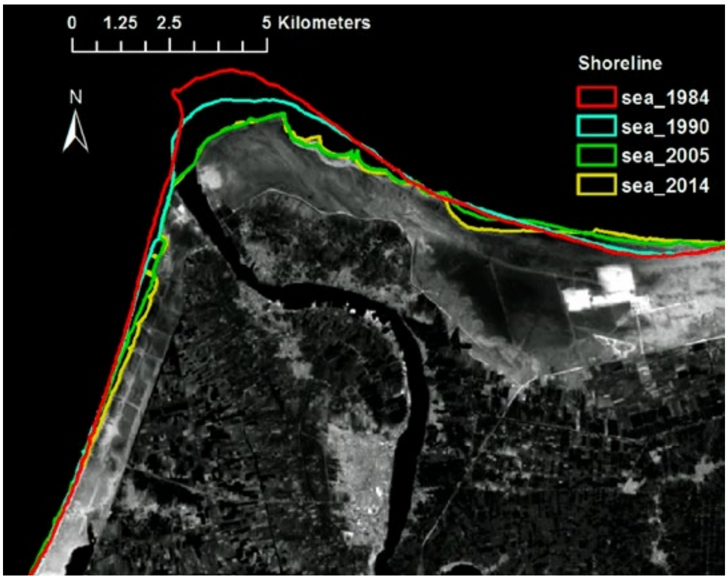
State of the Coast

Coastal erosion rates in some North African countries, mainly Morocco and Egypt, exceed the global average by up to 10 times.[54] Inadequate management of coastal assets, exacerbated by unsustainable development along the coasts and climate change, has increased erosion of the region's shores. The region also experiences low GDP growth, low employment, a large informal sector, poor foreign direct investment inflows, poor participation in global value chains, rising levels of debt, and low investments in climate action. The COVID-19 pandemic has worsened these long-term structural challenges and has resulted in a major setback on poverty reduction.[55] Despite this, the region's recovery from the pandemic provides an opportunity to undertake new paths for a Greener, more Resilient, and more Inclusive Development (GRID).

The Maghreb coast includes Algeria, Libya, Morocco, and Tunisia. Coastal erosion rates of the Maghreb coast are among the fastest in the world. Haphazard development along the coast, in combination with an increased frequency and severity of storms linked to climate change, have culminated in the retreat of the Maghreb shoreline. Globally, the average annual coastal erosion rate is 7 cm.[56] A World Bank-funded study revealed that between 1984 and 2016, the average annual rate of erosion for Maghreb coastline was 15 cm, a figure only outpaced by South Asian coasts. According to the research, Tunisia suffers from extremely high rates of coastal erosion at 70 cm a year, followed by 28 cm in Libya, while the Moroccan shoreline is retreating by 12 cm a year on the Atlantic coast and 14 cm a year on the Mediterranean coast.[57]

Relative to the Maghreb countries, Egypt's average rate of erosion is less extreme at 10 cm a year.[58] However, in some locations coastal erosion is rapidly eating away the Egyptian coast. Urbanization, coastal structures, the removal of sand dunes, floodwater and sediment management, alongside climate change are contributing to erosion in Egypt.[59] Since its construction in 1964, the Aswan High Dam has diminished flow and sediment discharge to the coast, reducing beach areas and eroding shorelines in the Rosetta Promontory by 124 m/year between 1964 and 1984, and 37 m/year between 1984 and 2014. Erosion rates decreased due to concentrated coastal protection efforts in the area, as shown in Figure 5.[60]

Figure 5. Shoreline Changes in Rosetta Promontory between 1984 and 2014



Source: Masria et al. (2015b) [61]

The share of the total population living in the coastal zone of Maghreb ranges from 65 percent in Morocco to 85 percent in Tunisia. Maghreb coasts are major hotspots for industries and economic activity in North Africa, with every single capital city located there. Such severe rates of coastal erosion threaten the economic stability of the region, especially sectors such as tourism and fishing that rely on intact beaches and clean seas. Annually in Maghreb, the average cost of coastal erosion is estimated to be 0.6 percent of GDP, ranging from 0.2 percent of GDP in Algeria to 2.8 percent in Tunisia. Annual costs of lost land and infrastructure assets are equivalent to about 2.8 percent of GDP in Tunisia, 0.7 percent in Libya, 0.4 percent in Morocco and 0.2 percent in Algeria.[62] Shoreline recession can have drastic impacts on the Blue Economy for countries where coastal tourism plays a large role. For example, the tourism sector and connected industries contributed 14.2 percent of GDP in 2018 in Tunisia, providing jobs to more than two million people, and around 18.6 percent of GDP and 16.4 percent of employment in Morocco in 2017.

The Egyptian coast extends for approximately 3,500 km along the Mediterranean and Red Sea. A major distribution of Egypt's industrial activities can be found here including petroleum and chemical industries, as well as highly populated centers like Alexandria. Alexandria facilitates about 40 percent of the country's industrial capacity and is an important tourist destination.[63] Coastal erosion and flooding exacerbated by climate change have the potential to cause significant economic losses in Egypt. In Alexandria, with subsidence and expenses for preventative measures, an annual loss of US$504 million to US$581 million may be incurred by 2050 from coastal flooding damage.[64] It is predicted that sea level rise and the subsequent coastal erosion of beaches will significantly reduce coastal tourism.[65] This decline in tourism will cause economic losses in the coastal regions, where tourism makes up a large portion of the economy. It is expected that by 2050, beach tourism in Sahl Hasheesh and Makadi Bay along the Red Sea may contribute to losses in revenue that exceed US$350,000 per day.[66]

Without adaptation measures, intensifying coastal erosion, inundation risk and coastal pollution present significant risks for coastal communities and livelihoods. The importance of a healthy coastline and beaches in the Maghreb region is not only essential for livelihoods, but also to sustain its rich biodiversity, as the Mediterranean basin is among the world's 25 most important biodiversity hotspots. Other sectors, such as fisheries, also depend on the intactness of coastal and marine areas. Jobs in the Blue Economy, such as fisheries and tourism, are particularly important for low-income households, and losing them would cause many fishers and tourism employees to fall into poverty, comparable to disruptions caused by COVID-19.[67]

A large share of the workforce in the Blue Economy, such as in the fishing and tourism sector, is informally employed and hence particularly vulnerable to income losses caused by coastal erosion. In Morocco around 700,000 people are employed in fishing and fish processing activities, many of them informally. Informality is less prevalent in the tourism sector but still present. In Tunisia, the informal sector produces between 30 to 40 percent of GDP, with many workers, especially young people, employed in the tourism sector. Coastal erosion, slowly but steadily, eats away an important part of their work and hence increases their vulnerability.[68]

North Africa is also severely affected by other forms of environmental degradation, such as coastal and marine plastic pollution. The region has some of the highest per capita amount of plastic waste entering the sea. On average, annual costs of marine plastic pollution amount to 0.8 percent of regional GDP, and exceed 2 percent in Djibouti, Tunisia. Furthermore, the Mediterranean, renowned for its natural beauty, is among the world's most plastic-polluted seas.[69]

Intervention Examples in North Africa

Across the North African coast, local and central governments and institutions have been implementing solutions to attempt to counteract the erosion of the coastline and the subsequent loss of livelihoods. The Government of Morocco has launched the National Integrated Coast Management Plan (NLP) with the goal of improving environmental, economic, and social resilience on the country's coastline. To assist the implementation of the NLP at the regional level, the World Bank has provided technical support to help develop the first Regional Coastal Scheme (RCS), or Integrated Coastal Zone Management (ICZM), plan in the Rabat-Salé-Kénitra region. The RCS aims to achieve sustainable development of the coast that involves diverse industries, land use, natural resource management, and city planning.

In Egypt, the "Enhancing Climate Change Adaptation in the North Coast of Egypt" project was established in 2016 and aims to safeguard the densely populated low-lying lands in the Nile Delta, the home of 25 percent of the Egyptian population, which have been identified as highly vulnerable to climate change-induced sea level rise. The Ministry of Water Resources and Irrigation is implementing the project with financing and support being provided by the Green Climate Fund (GCF) and the United Nations Development Program (UNDP), with US$73.8 million in funding being provided by the Ministry of Water Resources and Irrigation and US$31.4 million in funding from the GCF. The project will expand the inexpensive dike systems to reduce the risk of flooding during storm surges, and an ICZM plan is to be developed to link plans for shore protection and sea level rise with the national development plan of the coastal zones.[70]

Egypt is also implementing large-scale reforestation programs for mangrove forests along the Red Sea, while artificial reefs have been used in Morocco.[71] As Maghreb countries adopt the GRID paradigm, managing coasts sustainably is critical. Some drivers of coastal erosion, such as ones caused by climate change, are outside of the immediate control of Maghreb countries. Nonetheless, there are steps that can be taken. First and foremost, combating coastal erosion and managing coastal development requires a holistic view on changes in the coastal landscape and the stakeholders interested in its further development. This challenge necessitates the implementation of comprehensive ICZM schemes. One such ICZM scheme, the regional coastal management plan in the Rabat-Salé-Kénitra region, with support from the World Bank and the Italian government, was launched recently in northern Morocco.[72] Such schemes can also come with fiscal incentives, as for example in France, where the revenues of a tax on coastal construction work is redistributed to local authorities to support land policies that contribute to coastal area conservation.[73]

There are also concrete engineering measures that can combat coastal erosion as part of ICZM schemes. As with West Africa, the focus should be placed on NBS, which not only increase the resilience of coastal assets but also simultaneously revitalize important ecosystems. These include dune stabilization through vegetation, seagrass planting, or rehabilitating coral reefs. "Soft" measures, such as beach nourishment or wind fences for sand accumulation, are also viable options for North Africa. Tunisia has used several soft measures to combat coastal erosion, including the erection of over 4 km of pinewood fences to stabilize dunes.[74]

Banning illegal sand mining and the effective enforcement of bans are important to support efforts for dune stabilization and accumulation. Similarly, the removal of redundant dams or retrofitting operational ones to allow for improved sediment transport is effective in reducing coastal erosion further downstream, as demonstrated by global

examples. Sediment fluxes were fully restored after the completion of major dam removals of the Elwha and Clines Canyon Dams from the Elwha River, in Washington, USA.[75] In the months following the dam removal, new topographic measurements showed that sediment accretion was occurring along beaches adjacent upcoast and downcoast from the river mouth. The removal also spurred the restoration of multiple ecosystems from the previous location of the dam to the coast.

RECOMMENDATIONS

This section provides a summary of governance and institutional recommendations for the two focus regions, predominantly from the studies presented above. The main challenge, common to the whole African continent, is that currently there are far too many institutions with overlapping responsibilities, and a new institutional model is required to tackle coastal erosion and other environmental degradation issues.

To avert catastrophic impacts on coastal communities, Africa's coastlines must adapt sustainably. Given that coastal erosion rates in parts of West and North Africa greatly exceed global averages, governments need to swiftly implement effective, efficient, and inexpensive solutions to


Photo: LynMc42k/iStock

restore and maintain the coastline and protect vulnerable communities, starting from the readily available and most practical no-regrets measures, like NBS, that can set the basis for further adaptation efforts. Coastal degradation is already costing African countries billions of dollars annually, and climate change is expected to exacerbate the existing problems and threaten Blue Economy sectors such as tourism and fishing if adequate intervention actions are not taken. Joint public and private initiatives related to transboundary sustainable and resilient coastal management, such as the WACA, must be expanded upon and supported.

With the development of adaptation solutions, sufficient thought must go into adopting solutions that successfully address the issue at hand in a green and sustainable way, while also addressing the inequities in adaptation and protecting the most vulnerable communities, industries, and ecosystems. The following recommendations could help in charting the way forward.

Improve access to data

To effectively address the problem of coastal erosion, the problem itself must be understood in all its complexity. Access to data must be improved so that erosion hotspots can be clearly identified and studied.[76] This requires monitoring and computational modeling of coastal morphology, sediment flows, and fluid mechanics as well as the impact of coastal developments in many locations.

On a regional scale, an observation network should be activated where data centralization and open data sharing is available, and the existing educational system should be strengthened in Masters, PhDs, and thematic workshops. Relying on data from observatories and scientific programs is not only necessary to monitor the coastline's evolution, assess risks and identify solutions, but also to identify possible institutional, financial, environmental, and sociological obstacles to such solutions and to evaluate the effectiveness of interventions.[77] The use of communities' local knowledge, interdisciplinary scientific studies and technicians' operational know-how is also recommended, as it promotes the acceptability, efficiency and sustainability of management solutions envisaged.

Consider at least two geographic scales to analyze risks and implement measures

Given the dynamic nature of beach accretion and erosion processes, it is necessary to invest in site-specific research to better understand coastal erosion projections and other degradation risks and to identify localized and context-specific adaptation options. For this process, it is best to consider at least two geographic scales to analyze risks and implement measures. Risks often originate because of global or regional dynamics and local factors of vulnerability. When considering risk in a management plan, it is necessary to consider incorporating geographical measures in hazard formation and risk construction, as well as administrative capacity in development and implementation of territorial public policies.[78]

Expand information sharing and participatory problem-solving

The information acquired from detailed analysis of hotspots should then be relayed to public and private actors so that they can plan feasible actions. Cross-border cooperation on data and information sharing is crucial to identify regional erosion drivers and viable and sustainable preventative actions. This requires a holistic and multidisciplinary approach that engages stakeholders in every step of the planning and management process and guarantees successful outcomes.[79] Joining stakeholder forces is an essential requirement throughout the entire process, from data collection and monitoring, to modeling and solution planning.

Stakeholders may include a vast range of players including government authorities and institutions, Blue Economy sector organizations, nature conservation specialists, and local communities. All actors will need to be involved to identify opportunities and develop the management plan. This involves sharing the conclusions of preliminary studies including territory diagnosis, defining the management plan objective in a collaborative manner, and deciding on various management options that can be applied. This participatory approach should be continued during the implementation phase, particularly to ensure the communities' support for plans.[80]

Implement transboundary ICZM schemes

The output of this process should be the preparation of transboundary ICZM schemes, to be used by stakeholders at all levels for effective decision-making and comprehensive planning. To produce sustainable ICZM schemes that include spatial and temporal dimensions, it is central that this effort is coordinated across borders, as coastal erosion and its effects are transboundary by nature. Such comprehensive ICZM schemes, which would need to be regularly and cost-effectively updated, will help addressing site-specific coastal erosion and other degradation risks, and at the same time will encourage coastal sustainability and the identification of economic opportunities.[81] ICZM planning will also help in informing policies through prospective management as well as reactive management and control interventions.

Current coastline management practices have suffered from a disharmony between legal instruments, institutional segmentation, and national and local governments.[82] Too often, the various private and public actors within the economic or political sphere have worked in isolation or direct opposition to one another. Participatory legal and institutional reforms are to be implemented to ensure

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transboundary ICZM schemes can be prepared, and identified solutions executed.

Promote holistic and multi-sectoral investments that support a green, resilient, and inclusive development, and the use of NBS on land and sea

Countries affected by coastal erosion can increase the natural protection provided by coastal vegetation cover and ecosystems through planting or restoring mangroves, dunes, seagrass fields, coral reefs, wetlands and other natural vegetation and ecosystems in coastal zones.[83]

These NBS are not only cost-effective options that can help address coastal erosion and other forms of coastal degradation, but they can also be used to boost the health of coastal and marine ecosystems and their performance. If suitably planned, NBS can enhance the provisioning to coastal communities, including food, food, fuel, timber, and other material provisioning, and support ecosystem services like carbon sequestration, climate regulation, water purification, and biodiversity. There is also a direct opportunity to produce economic benefits from NBS, since labor is required to implement these interventions and also because of the potential ecotourism revenues generated through the sustainable management of natural resources.[84]

Address the problem of coastal sediment deficit because of dams

In recent decades in West and North Africa, population and economic growth alongside rapid urbanization has led to the construction of several dams for hydroelectricity, agriculture, water supply, and flooding protection purposes. As discussed earlier in this chapter, the damming of rivers often has the unintended consequence of reducing sediment fluxes to the coast.[85] One option to restore the sediment transport deficit is to alter dams to reduce the amount of sediment that they trap, or to completely remove redundant dams or in-river structures altogether. For this, it is necessary to better assess the volume of sediment trapped behind existing and planned dams and the opportunities of effective sediment management to support coastal protection. This transboundary information, which should be included in the ICZM schemes, should be joined with institutional and financial reforms to encourage relevant stakeholders to take actions to directly restore sediment budget deficits and promote beach accretion.

Adopt a flexible approach during policy and program implementation

It is necessary to adopt a flexible approach to ensure management plan objectives can be reevaluated and activities adjusted according to the evolution of the risk environment.[86] Some options could include a combination of short-term effectiveness, for example protecting infrastructures with a dike, with long-term effectiveness, such as the relocation of the infrastructure. With demographic and economic changes taking place rapidly in Africa, it is best to rely on projections established by scientists for this purpose.

The World Bank's Country Climate and Development Report for the G5 Sahel Countries

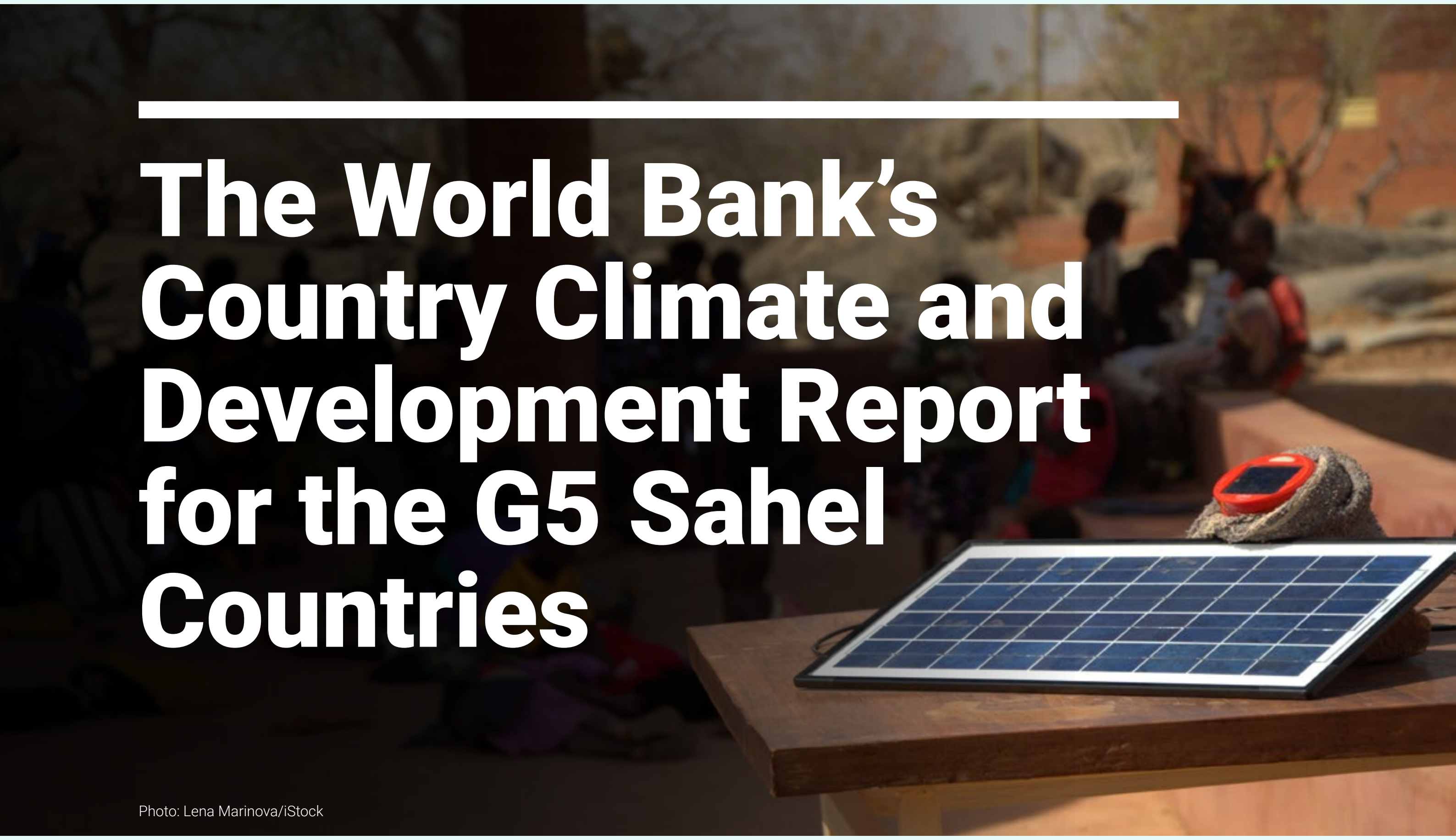

Photo: Lena Marinova/iStock

The World Bank Group's Country Climate and Development Reports (CCDRs) are new core diagnostic reports that integrate climate change and development considerations. These reports identify the main pathways for reducing climate vulnerabilities and enhancing low-carbon development. The reports analyze the costs, challenges, benefits, and opportunities associated with resilient low-carbon growth pathways. The CCDRs also review the institutional set-up for these new growth pathways using the Climate Change Institutional Assessment, as discussed in the Institutional Arrangements chapter of this report.

The CCDRs aim to inform governments, citizens, the private sector, and development partners on their potential role and opportunities in a resilient and low-carbon development trajectory. The reports are designed to help countries prioritize the most impactful actions to boost adaptation and support a resilient transition while delivering on broader development goals. This insert reviews the recently published CCDR for the five G5 countries in the Sahel region of Africa: Burkina Faso, Chad, Mali, Mauritania, and Niger.[1]

THE CHALLENGES

The G5 Sahel countries are among the least developed countries in the world and face multiple crises, including the COVID-19 pandemic, increasing political instability, rising insecurity, and a growing food security crisis exacerbated by the war in Ukraine. These are all exacerbated by climate shocks.

The region is expected to face an average temperature increase of between 1.5 and 4°C compared to pre-industrial levels, depending on the climate model projections. This increase will add substantial pressure on ecosystems, the different sectors of the economy, and livelihoods.

Across the G5 Sahel countries, it is estimated that by 2050, without adaptation policies and investments, there would be an increase in the poverty rate from 27 percent in the medium-growth baseline (no climate change) to 29 percent in the wet and optimistic scenario and 37 percent in the dry and pessimistic climate scenarios, respectively. Niger and Chad are projected to have the highest increases in their poverty rate.

Reduced labor productivity due to climate change is likely to affect the agricultural and industrial sectors most negatively, as these have the largest share of outdoor workers. Additionally, under the wet climate scenario, infrastructure such as roads and bridges will be damaged, impacting the economy and people's livelihoods. For the agriculture sector, which constitutes the single largest economic activity in the G5 Sahel countries, rainfed crop and livestock yields are expected to decline under a dry climate scenario and increase under a wet scenario, with variations within countries. Smallholder farmers will be forced to deal with stark annual climate variability. The resulting shocks can create a serious food insecurity crisis in the Sahel.

The Sahel region has been heavily affected by conflict of various kinds. Resource competition due to the triple effect of climate change impacts, high demographic growth, and lack of inclusive development policies is one factor that has led the G5 countries into a realm of instability. Further, there is low public confidence and trust in state institutions, a lack of sufficient provision of basic services, and a lack of security, among others. The COVID-19 pandemic posed additional challenges to development in the G5 Sahel countries, halting the momentum of GDP growth and pushing an additional 2.7 million people into extreme poverty. When combined, these effects make climate-resilient sustainable development all the more challenging.

THE OPPORTUNITIES

The Sahel region is rich in mineral resources, including the minerals and metals needed for several "green" technologies that are globally in high demand. The G5 countries also have immense renewable energy resources, presenting an opportunity for large-scale development of renewable energy projects. Renewable electricity generation could reliably bring affordable electricity to two-thirds of the population currently without access to electricity. These factors could drive economic and entrepreneurial opportunities in agricultural processing. The Sahel can also become a renewable energy supplier for West African and European markets. There are also significant opportunities for the region to expand exports beyond basic commodities through value-adding agricultural manufacturing and production.

The G5 Sahel countries are relatively close to European and Middle Eastern markets and have a young and growing labor force. These opportunities, however, remain largely untapped. The G5 Sahel countries thus have a great window of opportunity to realize the demographic dividend, raise incomes and living standards, and forge a pathway toward climate-resilient economic growth.

INVESTMENT NEEDS

Based on the figures supplied by the G5 countries in their most recent Nationally Determined Contributions (NDCs), their total adaptation investment costs to 2030 are around US$33 billion (which comes to about 44 percent of their combined 2021 GDP). On average, annual adaptation costs for each G5 country would average 4.6 percent of its GDP under the medium-growth scenario and 4.3 percent under a higher-growth scenario between next year and 2030. The adaptation needs vary across countries, with Burkina Faso estimating its needs by 2030 to be US$2.79 billion (lowest) and Mauritania US$10.63 billion (highest). Further, G5 countries have voiced the need for external grants, new concessional borrowing, and private-sector financing, as these adaptation needs alone would absorb large shares of annual tax revenues.

G5 countries have made some strides toward including climate considerations in their financial arrangements. For instance, Mali has established a dedicated fund within the national budget to address climate change adaptation and mitigation, with a small part set aside for responding to disasters. Mauritania has set up a budget reserve that addresses disasters and set up a national Environmental Intervention Fund to mobilize additional national financing and external funds. Burkina Faso also has an Environmental Intervention Fund to mobilize additional national financing, as well as the Fonds National de Solidarité, which uses an annual budget of about US$750,000 to help disadvantaged individuals and victims of natural disasters and humanitarian crises. Chad has established a Special Environmental Fund, and

Niger operates a large central relief fund financed by donors to improve food security in the country (about US$15 million annually). Nevertheless, substantial challenges remain as the G5 Sahel countries still have an undiversified economy that is mainly reliant on agriculture, which makes reallocating resources to respond and adapt to shocks complicated.

THE BENEFITS OF ADAPTATION OUTWEIGH THE COSTS

The CCDR recommends that climate investments that deliver more benefits, in terms of economic damages avoided, at lower costs should be prioritized. Expanded irrigation for rainfed crops, improvements in livestock feed practices, and investments in climate-resilient roads and bridges are adaptation interventions that could reduce damages from climate change and potentially deliver gains above losses avoided. Across countries, there is some variation in the cost—benefit ratios of investments analyzed, highlighting the need to individualize adaptation action to country-specific contexts.


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Adaptation investments require significant resource mobilization, including from the private sector, as costs are still significant in comparison to the countries' fiscal capacities. There is also an urgent need for the G5 countries to expand or create institutions, capacities, planning processes, and regulatory frameworks needed for implementing and achieving their adaptation targets (see the Institutional Arrangements chapter in this report for a Global Center on Adaptation analysis of the institutional arrangements of ten African countries as presented in their NDCs and National Adaptation Plans [NAPs]).

Other areas in need of expansion or improvement are disaster risk management, early-warning systems, agricultural insurance, social protection systems, environmental regulation, risk finance instruments, urban land-use planning, land ownership and governance policies, and hydrological and meteorological capabilities.

Further, there is a need to develop mechanisms for local communities to participate in climate adaptation decisions, natural resource management, and disaster risk management. This will help leverage local knowledge and promote community ownership of climate-smart solutions.

RECOMMENDATIONS

The following recommendations emerge from the CCDR:

Increasing institutional capacities: Policy recommendations for increasing institutional capacities include:

- Building institutional foundations for the planning and monitoring of budgetary processes, strengthening social protection systems, and managing land governance;
- Clarifying roles and responsibilities for adaptation actions among government agencies;
- Identifying and supporting specific areas of technical expertise needed within key institutions;
- Establishing a country-focused technology portal, defining a robust coordination mechanism across all stakeholders, and capacity building for decision-making on climate-related financial risk management; and
- Building inclusive institutional processes at the local level.

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Further, the private sector is also crucial for exploiting the Sahel region's abundant renewable energy and mineral resources, as well as in the development of transportation and communication infrastructure.

Increasing financing for climate action and managing climate risks: This would entail harnessing existing financial resources by making them more climate-informed, and mainstreaming climate considerations into budgeting and planning processes.

Harnessing and attracting the participation of the private sector: Making climate-resilient investments will require significant resource mobilization from the private sector. Private-sector involvement can help increase the resilience of the agriculture sector in the G5 Sahel region by distributing climate-resilient seeds, investing in affordable post-harvest storage solutions, expanding access to irrigation systems, and introducing insurance innovations, among others.

Priority sectors identified for the G5 Sahel countries are energy, landscapes, and cities: The CCDR provides short- and medium-term policy recommendations for these sectors as well as sector-specific interventions and projects.

In addition to these specific recommendations, **resilient and inclusive growth requires structural transformation, addressing gender inequality and building human capital, and addressing the drivers of fragility and conflict:** Investing in the expansion of safety net programs, climate insurance, and other adaptive social protection tools, as well as ensuring climate-informed curricula, developing green skills, and propelling research and development, are needed to lower the risks of the negative effects of climate change on poverty.

Section 3
Cross-Sectoral Themes

Photo: Pascal Maitre/Panos Pictures

Locally Led Adaptation

KEY MESSAGES

- Locally led adaptation (LLA) is about ensuring that local people have individual and collective agency over the adaptation process. Over 80 entities spanning international organizations, national governments, non-governmental organizations, climate funds, private sector companies and social enterprises have now formally endorsed the Principles for Locally Led Adaptation and committed to operationalizing them in different ways.
- For Sub-Saharan African countries, where over 60 percent of the population are smallholder farmers and where over 55 percent of the urban population live in informal settlements, LLA holds the promise of unlocking variegated responses to highly localized risks in contexts marked by deficits in formal governance machinery.
- There are several options for deploying LLA on the ground. Broadly, in countries with mature state machinery, strong democratic institutions and institutional structures for devolution, LLA might be best supported by government-led national financing mechanisms, whereas mechanisms that rely on civil society organizations or constituent-based organizations might be more appropriate in fragile contexts.
- Transitioning to this mode of adaptation action requires an enabling environment with a few key components. There is a need for capacity building, as local actors often may not have a complete appreciation of the full spectrum of climate risk and can struggle to access, manage and deploy adaptation finance, and for patient institutional support over long timeframes.
- Effective LLA requires institutions that can access climate finance and channel it to relevant programs, projects or investments. Many countries


Photo: Alex Wynter/KRCS-Climate Centre/Flickr

in Africa have strong national institutions to access and/or deliver climate finance, including national funds and government agencies such as Ethiopia's Climate Resilient Green Economy (CRGE) Facility and FONERWA in Rwanda. In countries where these institutions do not exist, international funders should support governments with patient finance to develop them.

- Putting local communities in a leadership position within a process of adaptation that tackles structural drivers of risk through strengthening local institutions may indeed be more complex and, in certain cases, have higher upfront costs than top-down, technocratic interventions. However, the evidence on returns on investment from adaptation initiatives that focus on the agency of communities suggests that the benefits far outweigh the costs.

“

Denmark has set a clear goal. Sixty percent of our climate aid will help developing countries to adapt to climate change.”

H.E. Mette Frederiksen
Prime Minister of Denmark

INTRODUCTION

There is incontrovertible evidence that the world is grappling with a marked increase in climate risks with the intensification of hazards, growing numbers of vulnerable people and an expansion of areas exposed to climate impacts.[1] Africa is particularly at risk. The 10 countries in the world rated as most vulnerable to climate change on the latest ND-GAIN Country Index, for instance, are all in Africa.[2] This is why the time is ripe for governments across the continent to urgently shift away from existing, incremental methods for climate change adaptation and move toward more impactful, transformational approaches geared to ameliorate the scale of risks that countries in Africa face.

Locally Led Adaptation (LLA) is being widely recognized as an effective, efficient and equitable paradigm of delivering adaptation action. This approach to adaptation is about ensuring that local people have individual and collective agency over defining, prioritizing, designing, monitoring and evaluating adaptation actions.[3] LLA ensures that mechanisms for managing risks are aligned with local contexts, embedded within local institutions, deliver a high return on investment, and result in outcomes that are more equitable than "business as usual" approaches. For Sub-Saharan African countries, where over 60 percent of the population are smallholder farmers[4] and where over 55 percent of the urban population live in informal settlements,[5] LLA holds the promise of unlocking variegated responses to highly localized risks in contexts marked by deficits in formal governance machinery.

This is also why over 80 entities (including the governments of the United States of America, the United Kingdom, Costa Rica, Nepal, Ireland, The Netherlands, Denmark, and Sweden) have formally committed to this agenda by pledging to implement the Principles for Locally Led Adaptation (Table 1) in different ways. For instance, the Government of Nepal is committed to delivering at least 80 percent of its climate change adaptation funding to the local level.[6] The USA through its Agency for International Development has committed to ensure that 25 percent of funds go directly to local partners within four years, and that 50 percent of its programming places local communities in the lead by 2030.[7] The UK Government is integrating a thrust on LLA into its investments, including in the £274 million Climate Action for a Resilient Asia initiative that aims to help vulnerable communities lead local adaptation efforts.[8] Other countries are in the process of determining specific actions that they will implement but have formally committed to supporting this model of climate adaptation action.[9]

Along with the positive momentum in favor of adopting LLA, there is a recognition that governments in Africa will need to overcome a few key challenges to operationalize this agenda. This is because at the heart of LLA is an emphasis on devolving decision-making agency and financing to local institutions. However, local public institutions in countries across the continent continue to have low administrative and fiscal capacity.[10] Also, international finance institutions (IFIs) that channel most of the international public climate finance are, by and large, mandated to engage directly with national ministries, who then have the authority to devolve funding further. However, a range of political-economy challenges prevent this from happening effectively.

Despite these challenges, we are beginning to see strong examples from across Africa of LLA that can be operationalized through approaches that aim to respond to high levels of vulnerability to climate impacts such as drought, erratic rainfall, and extreme weather in both rural and urban contexts with the speed and scale needed. This chapter highlights the growing momentum toward LLA in Africa. It begins by outlining the rationale for LLA and explaining how LLA has been operationalized through different financial delivery mechanisms in Africa. The next section presents the enabling conditions for LLA, along with notable LLA case studies from across the African continent, before discussing some of the challenges faced in scaling up LLA in Africa. The next section analyses the experience of implementing LLA to date, summarizing key lessons that have emerged. The chapter concludes with lessons for governments, funders and civil society on how they can scale up LLA in Africa.

Box 1. Key Concepts: “Local” and “Participation vs Agency”

It is important to acknowledge that the term “local” is interpreted quite differently by different stakeholders. In climate and development, it refers to: stakeholders within a developing country; actors below the national level; community-level institutions; households; and individuals.[11] For the purposes of this chapter, local actors encompass the people and communities on the frontline of climate change. This also includes the formal and informal institutions below the national level that are composed of or directly accountable to local people, making them better placed to give local people agency over the process to enhance their adaptation to climate risk.

Similarly, to some “locally led adaptation” means that local actors “participate” in determining and/or implementing adaptation. However, we consider that LLA is not simply about delivering adaptation benefits at the local level by soliciting the “participation” of local communities in incremental decision-making. Rather it is about local people having individual and collective agency over defining, prioritizing, designing, monitoring and evaluating adaptation actions, and working with higher levels to implement and deliver adaptation solutions. Enshrined within this idea is an acknowledgement that while not all adaptation challenges can be met at the local level, decisions and actions *must* take place at the lowest effective tier of governance.


Photo: Rwanda Green Fund/Flickr

STATE AND TRENDS IN LLA

Over 80 entities spanning international organizations, national governments, multilateral organizations, bilateral institutions, non-governmental organizations, climate funds, private sector companies and social enterprises have now formally endorsed the Principles for Locally Led Adaptation and committed to operationalizing them in different ways. These entities have pledged to "mainstream" or "integrate" the Principles within activities that are aligned with their individual mandates and institutional objectives. The LLA Principles with indicative pledges are included in Table 1.

Table 1. Principles for Locally Led Adaptation

Principle 1: **Devolving decision-making to the lowest appropriate level** ensures that those most affected by climate change have agency over decisions about adaptation finance and programming that will affect them.
Principle 2: **Addressing structural inequalities faced by women, youth, children, people with disabilities, people who are displaced, Indigenous Peoples, and marginalized ethnic groups** entails actively recognizing and redressing the power dynamics, imbalances, and development deficits that create vulnerability, poverty, and marginalization.
Principle 3: **Providing patient and predictable funding that can be accessed more easily** requires that funding mechanisms be simplified, and finance provided over longer, more predictable timescales to enable greater access to funding by local actors, support adaptive management and learning, and adequately strengthen local institutions.
Principle 4: **Investing in local institutions to leave institutional legacies** means building and strengthening local institutions by building capacity to understand climate risks and uncertainties, capacity to generate resilience solutions, capacity to facilitate and manage adaptation initiatives, and capacity for local fiduciary responsibility and management so that these institutions can provide grants and loans to other local actors for local adaptation actions.
Principle 5: **Building a robust understanding of climate risk and uncertainty** supports locally led adaptation by ensuring that interventions reflect understanding of local climate risks, current resilience-building practices, and uncertainties about direct and indirect climate impacts on local communities, as well as provide access to appropriate tools to handle uncertainties.
Principle 6: **Flexible programming and learning** recognizes that it is important to maintain budget and programmatic flexibility as well as space for adaptive management and learning.
Principle 7: **Ensuring transparency and accountability** requires that decision-making and governance structures are made explicit, so it is clear which decisions are made at what level of the organization and by whom. It also should be ensured that financing flows are made transparent and can be publicly tracked, and ultimate accountability should be to local actors themselves.
Principle 8: **Coordinated action and investment** by donors, aid agencies, and governments recognizes the need for multiple levels of coordination, horizontally among communities and across sectors and vertically across levels of government and policy processes.

The Case for LLA

LLA has been widely endorsed because of its many benefits. These are summarized here.

First, **ensuring that adaptation interventions are locally led enhances their effectiveness.** An important dimension of this is that local leadership ensures that interventions are calibrated with local social, political, and cultural contexts—which, in turn, leads to increased impact.[12] This is because successful adaptation actions must respond to highly localized, multiple-interacting stressors (as no two communities can ever have identical risk profiles) and incorporate diverse priorities, values, perspectives, inherited wisdom and interests, particularly of the most vulnerable.[13] This is difficult to achieve if adaptation processes are being led by exogenous entities that are unfamiliar with the specificities of the local milieu in which they are being implemented. Additionally, the devolution of decision-making also leads to a greater degree of agility, allowing for adaptation interventions to shift with changes in the operational environment while continuing to deliver benefits. Another important dimension of effectiveness is sustainability, and this is why a key emphasis within LLA is on developing and strengthening of local institutions. Transferring agency to local public and private entities develops their capacity to assess risks and deliver adaptation beyond individual projects.[14] This is in contrast to the "business as usual" model where parallel project delivery mechanisms are established and run by external experts who only stay in situ for the duration of a project.[15]

Second, **shifting to a model of adaptation that is locally led also leads to enhanced efficiency**. Efficiency pertains to an idea of "optimization," where "any investment in adaptation should maximize benefits of the intervention and minimize its costs."[16] Given the relative novelty of this framing, cost–benefit analyses of interventions that identify as LLA have not yet been developed. However, insights from existing, adjacent and analogous paradigms shed some light on returns from adaptation approaches where local actors have a strong influence on decision-making. For instance, a desk-based cost–benefit analysis of 23 such initiatives (eight from Africa) found that most delivered value for money, very few showed negative returns, and overall there was evidence that these delivered return-on-investment ratios ranging from 1:1 to double digits, with the highest yielding a return of 87:1 (in other words, US$87 in benefits for every US$1 spent).[17] While financial costs are one important element, social costs have come to be another, since adaptation can contribute to vital but non-monetizable measures of wellbeing such as a quality of life or the preservation of important cultural sites.[18] One study that draws on data from Africa and includes social cost in its methodology reaches a similar conclusion to find that such initiatives deliver a high rate of return on investment amounting to 400 percent.[19] The reasons for this include the effective identification and use of existing institutional structures (as opposed to establishing new mechanisms); co-financing from local actors in the form of time, labor and expertise; and also the willingness of communities to invest in actions that deliver multiple co-benefits (as opposed to actions that deliver benefits only under specific climate scenarios).[20]

Third, **employing the LLA Principles to design and deliver adaptation interventions also leads to more equitable benefits.** There are different streams of evidence that can support this, including the work of the Nobel Prize–winning economist Elinor Ostrom, which demonstrated how entrusting local communities to manage local resources and development processes delivered outcomes that were fairer and more just than processes that were led by those external to local contexts.[21]

More directly, for far too long the orientation of accountability mechanisms of international and nationally funded development initiatives (including those that have focused on adaptation) has been directed toward those providing the funding, whereas LLA underlines the importance of initiatives primarily being accountable to beneficiaries.[22] Evidence from large initiatives that have piloted the use of such 'business as usual' accountability mechanisms (such as India's nodal social protection initiative) conclusively demonstrates how this shift permits local actors to scrutinize investments, highlight malfeasance, and enhance equitable outcomes.[23]

It is important to acknowledge that LLA builds on existing paradigms that have been employed in African countries. This includes community-based adaptation (CBA) and community-driven development (CDD). CBA is understood as "a partnership between institutions and communities—rather than something done for and imposed upon local peoples";[24] CDD "focuses on strengthening the capacity of communities to play a greater role in their own development."[25] In essence, all three paradigms accord importance to the views of communities in decision-making and aim to deliver action in close collaboration with local actors and to ensure that interventions are aligned with local norms and values. However, LLA goes a step further to underline the critical importance of putting local communities in a **leadership position** within the process of adaptation over the long term through local institutions and flexible programming that is delivered with a high degree of accountability to beneficiaries.

Transitioning to this mode of adaptation action requires an enabling environment with a few key components. There is a need for "capacity-building," as local actors often may not have a complete appreciation of the full spectrum of climate risk and can struggle to access, manage and deploy adaptation finance. However, in contrast to this lack of capacity being used as a justification for their reduced role in adaptation decision-making, this actually proves the need for investing in them. Progress on adaptation is impossible without strengthening local institutions, people, and their communities by building a range of capabilities that includes the ability to analyze risks, execute actions adaptively, and form alliances and networks as well as access and manage resources.[26] This

Photo: Thomas Wyness/Shutterstock

is only possible by ensuring a thrust on capacity development for LLA in organizational charters, policies and program strategies (as has been done for instance by USAID, the UK Foreign, Commonwealth and Development Office (FCDO),, and the Government of Nepal).

It is also important to recognize that it is easier to operationalize LLA in contexts that already exhibit with a high degree of decentralization. However, in centralized regimes, instead of defaulting to ”business as usual” approaches (where local communities are deprived of agency) adaptation actors must invest over the long term to operationalize the eight Principles to the degree possible by shaping policies and institutions through sustained advocacy for LLA.

Delivery Mechanisms

The emergence of LLA as a novel framework for climate action has resulted in important experimentation with different approaches to delivering LLA in practice. Local organizations (including civil society organizations, subnational governments, traditional authorities, communities, self-help groups, financial institutions, etc.) have worked in partnership with a range of national, regional and international partners to access finance to deliver LLA in their localities. Many of these global organizations have even made formal commitments to support LLA, as outlined above. These include adaptation actions in sectors such as agriculture and food security, water security, ecosystem management, and urban housing.

Based on this experimentation, a clearer picture is emerging on the types of financial delivery mechanisms that are being used by governments, civil society organizations (CSOs) and the private sector to deliver LLA on the ground. These mechanisms are of three types:

1. Government delivery mechanisms such as national climate platforms, devolved climate finance (DCF), and adaptive social protection
2. Civil society delivery mechanisms such as regional funds and institutions delivering devolved grant programs, constituency-governed organizations, and microfinance
3. Private-sector delivery mechanisms such as formal finance and aggregators and risk-sharing facilities

These are now detailed in the following subsections.

Government Delivery Mechanisms

National climate platforms—delivering devolved grant programs accessed through enhanced direct access (EDA): Several countries have established funds or institutions at the national level with a mandate to finance and implement climate-related programs in line with the country's national climate policies and strategies. These include Benin's Fonds National pour L'Environnement et le Climat (FNEC),[27] Ethiopia's Climate Resilient Green Economy (CRGE) Facility,[28] the Environmental Investment Fund (EIF) of Namibia,[29] the Rwanda Green Fund (FONERWA)[30] and South Africa's National Biodiversity Institute (SANBI).[31] National funds or agencies access finance from international sources—for example, global climate funds like the Green Climate Fund (GCF), the Adaptation Fund (AF), multilateral development banks like the African Development Bank (AfDB), or bilateral donors.

While these financing structures are not new, a recent innovation by several global funds, including the GCF, is the use of EDA financing windows. EDA enables national funds to access GCF finance, which is used to capitalize devolved grant programs or loan facilities. These programs then on-grant or on-lend to local CSOs, local government bodies, or natural resource management groups, who design projects themselves and apply for funding to implement their locally defined adaptation initiatives. This new financing modality runs counter to traditional climate programming, which is designed at national and international levels. Instead, it devolves decision-making on adaptation investments from national to subnational levels in line with the first LLA Principle of subsidiarity. For example, in 2016 Namibia's EIF (the subject of Case Study 3 later in the chapter) accessed the first ever GCF EDA project, which allowed community conservancy organizations to develop projects and apply for finance under three thematic windows related to climate-resilient agriculture, climate-resilient infrastructure and ecosystem-based adaptation.

DCF: LLA is also being delivered through existing channels of devolution and subnational planning. This is an important mechanism because it mainstreams local adaptation planning, investment selection, and financing into formal government systems at the local level, instead of delivering adaptation interventions through parallel delivery structures that exclude local governments and decision-makers. DCF can increase the sustainability of adaptation finance, since governments can allocate their own finance (either own-source revenue, or finance from donors) on a regular, predictable basis (via fiscal transfers from the national treasury to subnational government departments and agencies) to make adaptation investments that are based on the needs of local stakeholders.

Integrating climate planning and financing into devolution processes is a relatively new LLA financing mechanism, as climate planning and financing has typically been the purview of national ministries and agencies. A notable example of this in practice is the DCF program in Kenya, Tanzania, Mali and Senegal, (the subject of Case Study 2 later in the chapter), where subnational adaptation funds are established and capitalized through regular fiscal transfers from the central government. These funds are managed by local governments and used to invest in adaptation projects that are selected through an extensive consultative process with agricultural and pastoralist communities facing the impacts of drought and water scarcity.

Adaptive social protection: Social protection programs, such as Ethiopia's Poverty Safety Net Programme (PSNP),[32] Kenya's Hunger Safety Net Programme,[33] and Uganda's Northern Uganda Social Action Fund,[34] are key poverty reduction programs in Africa. These programs provide vital cash transfers to the rural poor, and in the case of public works programs, help construct rural infrastructure and undertake landscape management practices that support local livelihoods. While many social protection programs are designed and have entitlements set by actors at the national and international levels, some programs are integrating new processes for climate risk management that are grounded in local decision-making. PSNP in Ethiopia, for instance, is beginning to integrate climate information services and vulnerability analysis into planning led by local officials and field staff, so that they can work with communities to select productive assets for construction that will provide longer-term resilience benefits.[35] This complements cash transfers, which can be used by local people to help manage climate-related shocks.

Civil Society Delivery Mechanisms

Regional funds and institutions—delivering devolved grant programs: In some parts of the world, regional institutions are taking a lead role in supporting LLA. This is particularly evident in the Pacific and Caribbean, where a highly dispersed geography and low population density makes it practical for a regional institution to aggregate demand for climate finance, act as a central hub for accessing finance, and disperse it across the region to actors at the subnational level for investments in locally identified and designed projects. The Micronesia Conservation Trust (MCT)[36] and the Caribbean Natural Resources Institute[37] both serve this role. MCT is accredited to both the AF and the GCF and has accessed finance through EDA to finance a grant program that delivers small grants to NGOs, civil society organizations, communities, local governments, marine or forest management groups, church groups and other local actors across five states and territories in Micronesia. MCT's grants programs have supported these actors to implement management plans for marine protected areas, to carry out ecosystem-based adaptation in coastal areas (including mangrove and coral reef regeneration), and to build sustainable livelihoods in aquaculture and improve fishery management, among other local initiatives. While this modality has not been applied in the same way at the regional level in Africa, it provides a model that could be replicated by regional organizations or public development banks for devolved grant or loan programs in Africa.

Constituency-governed organizations: These are organizations whose decision-making body or management structure is made up of representatives from the constituencies that those organizations serve. They are often membership-based federations or networks that represent a specific group of people or tackle a specific socioeconomic issue. Some examples of constituent-based organizations that deliver LLA are Slum Dwellers International (SDI), which focuses on urban poverty in 478 cities across 32 countries in Africa, Asia, and Latin America;[38] the Huairou Commission, a woman-led network of grassroots women's organizations across 45 countries;[39] and the Pawanka Fund, which supports Indigenous Peoples in 60 countries around the world.[40]

Though constituency-governed organizations are not new in themselves, what is innovative about them in the context of LLA is that they have begun operating specific climate resilience funds or funding windows to deliver finance to their members. These funds are available to communities or grassroots federations to invest in locally defined adaptation priorities. They can be delivered through small grants programs. For example, the Huairou Commission's Community Resilience Funds have provided finance to organizations like the Shibuye Community Health Workers in Kenya to empower grassroots women to build resilience and become leaders of development processes in their communities.[41] They can also be delivered by pooling member contributions and distributing those resources as revolving loans to be invested in local development actions with adaptation co-benefits, as in the Gungano Urban Poor Fund in Zimbabwe, which invests in secure housing for households living in urban poverty.[42]

Microfinance: This has long been recognized as a tool that supports poverty reduction by providing finance for households and micro-, small and medium-sized enterprises (MSMEs) to invest in their livelihoods and businesses. Microfinance can also help households weather the shocks associated with climate change, both in that it can be used to invest in resilient, productive livelihoods, and also by households using surplus income from productive investments for subsistence expenses such as food, shelter, healthcare and protection of livestock when shocks occur.

Microfinance is not a new financial mechanism, nor are there any major financial design tweaks in how microfinance is being used to support LLA. What is new, however, is that microfinance providers are increasingly aligning their financing strategies to provide capital to households and MSMEs that invest in climate-resilient livelihoods. In many instances, this is accompanied with specific information or capacity-building support to its clients to help manage climate risks.[43] For example, Rwanda's FONERWA has provided capital to microfinance institutions that establish revolving loan facilities with low interest rates (2 percent, compared with 18 percent for market loans) for investments in agriculture that make them more resilient to climate impacts.[44]

Private-sector Delivery Mechanisms

Formal finance: Private-sector finance also has an important role to play in financing LLA. This could include project financing of climate-resilient infrastructure, equity investment in green businesses, and subnational green bonds. A strong example of formal finance for locally led climate investments is the Cape Town Green Bond launched in 2017.[45] This was only the second municipal green bond ever launched in Africa, making it a unique case of a city government designing an investment vehicle that would provide formal finance for climate-resilient infrastructure. It was launched in the context of a severe water crisis that affected Cape Town, and included finance that the city has used for investments in water management, sanitation treatment and coastal protection.

Municipal green bonds can be good examples of LLA because they group together projects that are designed by municipal actors (assuming those projects are adaptation-focused) into a financial vehicle to attract outside financing; investment decisions from these are made by local actors, and proceeds contribute to the strengthening of local institutions. Once financing has been secured, the projects are then financed through the city government's capital expenditure budget and implemented by local agencies or contractors. While municipal green bonds are an innovative tool, there is a challenge in replicating these widely as many cities do not have the devolution frameworks allowing municipalities to borrow from private markets.[46]

Aggregators and risk-sharing facilities: Aggregation platforms and risk-sharing facilities are increasingly being used to scale up finance for individuals, enterprises and projects that are too small to qualify for formal finance, but too big to qualify for microfinance. This financial delivery mechanism works by pooling the aggregate demand for finance across a group of local actors, who can use their collective bargaining power to access finance to launch projects or invest in businesses. For investors, aggregators have the benefit of having sufficient economies of scale to make an investment bankable, making it possible to provide larger amounts of finance at concessional rates.

Aggregators are a relatively new financial model in themselves. They are unique in that they provide finance directly to smaller-scale enterprises and household businesses operating at the local level by aggregating demand for investment. Their unique application in the context of LLA is to support businesses that provide products and services to customers and households that make them more resilient to climate impacts. To date, aggregators that support LLA have predominantly focused on the agriculture and renewable energy sectors. The Africa Enterprise Challenge Fund's Renewable Energy and Adaptation to Climate Technologies (REACT) financing window[47] and Rwanda's Ignite Food Systems Challenge[48] are examples of aggregators that can support private-sector LLA. The Ignite Food Systems Challenge, for example, has provided start-up businesses with seed and scale-up capital to enhance resilience and provide business solutions to Rwandan farmers such as crop testing, hydroponic technologies, market connectivity, and reduced post-harvest losses.

It is important to note that these mechanisms—whether they are funds, organizations, policy processes or programs—are not in themselves unique new delivery modalities for (adaptation) finance. Many of them (e.g. microfinance institutions, national funds, devolution processes) are well-established mechanisms that have been around for decades. What ***is*** new is that these mechanisms are being adapted to support climate action—and, in particular, climate action that aligns with the LLA Principles. This is an important point for policymakers and financial providers: supporting LLA does not need to involve reinventing the wheel and creating entirely new financing mechanisms. But what it does require is tweaking these mechanisms so that they are centered around delivering finance into the hands of local actors to deliver on their own local adaptation priorities. In many countries in Africa, these mechanisms already exist in some form; efforts should not focus on duplicating existing financing channels, but rather adapting these existing mechanisms so that they better align with the LLA Principle of decision-making subsidiarity.

The following section goes deeper into how LLA has been delivered across the African continent, focusing in particular on some concrete examples of how these different delivery mechanisms have been used in different contexts to support LLA.

THE LLA LANDSCAPE IN AFRICA

This section outlines the experience of implementing LLA in Sub-Saharan Africa. It begins by looking at some of the enabling conditions for LLA that exist across the continent, including institutions for accessing and managing climate finance, national climate change strategies, and decentralization processes. It then turns to an examination of case studies on LLA in Africa. It concludes by outlining some of the challenges and constraints that inhibit the scaling up of LLA.

Enabling Environment

In the African continent, South Africa, Ethiopia, the Democratic Republic of the Congo, Tanzania and Burkina Faso are among the top five recipients of climate finance.[49] Overall, even though flows of finance are not commensurate with needs and Africa receives less finance than other developing regions, it is attracting increasingly significant flows of climate finance. However, globally less than 10 percent of funding committed under international climate funds to help developing countries take action on climate change is directed at the local level.[50] While computations of financing going to the local level in African countries do not yet exist, it is reasonable to expect that they will be equal to or lower than the global average.

The funding flows to countries on the continent have been facilitated by the development of national institutions for accessing and managing this finance. A good example of this is the CRGE facility in Ethiopia that was formed to help mobilize, access, and combine finances required for tackling climate change.[51] CRGE aims to support institutions at all scales of governance, including local and community-based, to execute actions aimed at tackling climate change. For example, the institution's operational approach includes an emphasis on the importance of accommodating the specificities of local contexts in adaptation planning, strengthening local financial institutions to enable them to play a role in climate action, building the capacity of local actors/institutions, and ensuring that the views of local communities influence monitoring and evaluation.

This emphasis is also reflected in operational initiatives that the CRGE facility supports. For instance, the Resilient Landscapes and Livelihoods Project foregrounds the role of local institutions (e.g. local watershed associations), drawing on local expertise and indigenous knowledge and establishing local channels of finance. In South Africa, the Green Fund of the Department of the Environment, Forestry and Fisheries plays a broadly similar role,[52] and aims to support the transition of the South African economy to a low-carbon and climate-resilient growth pathway through a focus on supporting varied institutions, including local governments. More specifically, the fund has a dedicated financing window open to municipalities and municipal entities, enabling these bodies to lead on a range of actions promoting local adaptation. As previously described, analogous institutions in other African countries, such as EIF and Rwanda's FONERWA, are attempting to play a similar role.

The development of these institutions is accompanied by an increasingly mature policy environment. Just over a fourth of all countries on the continent have developed a National Adaptation Plan (NAP),[53] and two-thirds have a National Adaptation Programme of Action (NAPA).[54] While all emphasize the importance of focusing on local priorities, some of these plans reflect LLA as a priority more than others. For instance, Kenya's NAP emphasizes county-level climate financing mechanisms for adaptation where local actors play a decisive role in investment decision-making. Along with this, a large number of countries have developed domestic climate change strategies. For instance, in addition to the NAPA, Malawi has formulated a National Climate Change Management Policy and National Climate Change Investment Plan; Kenya has a National Climate Change Action Plan, a Climate Risk Management Framework and a National Climate Change Finance Policy; and Ethiopia has a CRGE strategy.

Again, while most of these policies highlight the importance of local agency and leadership in one way or another, some align with the tenets of LLA more than others. Taking just one example, Ethiopia's NAP underlines the importance of enhancing the capacity of local institutions (Principle 4), coordinated action at the local level (Principle 8), employing indigenous knowledge (Principle 5) and orienting monitoring and evaluation approaches toward the local level (Principle 7). The country's CRGE strategy too focuses on strengthening the rights of local people (Principle 2), building local institutions (Principle 4)


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and developing a robust understanding of climate risk, variability and uncertainty in determining adaptation action (Principle 5). Policies such as these provide models that can be amplified by others.

Across the board, countries in the region have varying degrees of decentralization (political, administrative, and fiscal) with some countries such as South Africa and Uganda being on the higher end of the spectrum, the Central African Republic, Niger, Sierra Leone, and Chad having very low decentralization, and most other countries falling somewhere in the middle.[55] Even though up-to-date data on this is scant, there is an emerging consensus that despite major challenges, countries in the region are gradually devolving an increasing amount of authority to governance institutions below the national level.[56]

Therefore, there are flows of climate finance as well as institutions and policies with a stated aim of supporting local climate action operating in a context of gradually increasing decentralization, providing the right enabling environment for LLA.

Case Studies

Across Sub-Saharan Africa we are beginning to see important examples of LLA emerge and mature. These case studies can serve as beacons for governments, civil society and international funders alike – providing important lessons for replicating, adapting, scaling out and scaling down across the continent.

CASE STUDY 1: Mukuru, Kenya

Mukuru is one of Nairobi's largest slums, housing some 100,000 families. While people have lived here since the 1980s, housing conditions are extremely poor with frequent incidents of flood, fires, and other hazards apart from poor sanitation, water, and access to other basic services. To remedy the situation, the Nairobi City County (NCC) officially declared Mukuru as a Special Planning Area (SPA), ceasing further development activity for two years until a Mukuru Integrated Development Plan is produced. Central to the SPA has been the creation of consortiums where community groups work alongside local government, academic institutions, and international organizations to identify investment priorities in the areas of water, sanitation and energy; health services; education, youth and culture; environment and natural resources; housing, infrastructure and commerce; and community organization.[57]


Photo: Linda Ogwell/Oxfam/Flickr

To shift away from a "business as usual" way of working where "experts" exclusively assess risks, local organizations have employed community-centered methodologies to identify risks and develop action plans to address them.[58] This has resulted in a model of climate-resilient slum redevelopment that is authentically locally led. Much of this was made possible through financial support from international donors such as Misereor, the Ford and Rockefeller Foundations, and the Swedish International Development Cooperation Agency that was then channeled to constituent-based organizations with a strong local presence such as the Akiba Mashinani Trust, Muungano, and local affiliates of SDI. These organizations then catalyzed community planning processes with household-level representation.[59] In contrast to the usual approach where philanthropic and bilateral agencies would have funded international intermediaries (such as multilateral development banks or INGOs), in the case of Mukuru donors channeled money into mechanisms controlled by vulnerable communities and their representatives.

This example demonstrates how devolved decision-making can be operationalized to ensure that marginalized communities have a voice in the development of sustainable solutions for enhancing resilience in a transparent and accountable manner. It also demonstrates how local institutions can be strengthened to lead on adaptation planning with support from governments and non-government actors, and how "robust" decision-making that relies on melding insights from experts and communities can be operationalized. As such, this clearly aligns with the core tenets of LLA.

CASE STUDY 2: Devolved Climate Finance in Kenya, Tanzania, Mali, and Senegal

DCF is an LLA mechanism that delivers finance to subnational governments via the national treasury so that local governments can finance their adaptation investment priorities. Under DCF, subnational climate funds are established within local governments (e.g. in Kenya at the county level). Climate Change Committees are then established at the local level. These Committees conduct local climate risk assessments, consult with communities, and engage vulnerable groups, to identify and prioritize resilience-building investments—for example, the construction of water infrastructure for communities, or rangeland management activities for pastoralists in the drylands. The Committees then provide recommendations to local governments who approve funding for these investments from the subnational funds. Bespoke tools for climate risk assessment, planning, and monitoring and evaluation are developed to support Committees identify, prioritize, and monitor adaptation investments.

The first DCF pilot was initiated in Kenya in 2011 in Isiolo county. In 2013, DCF scaled out to four additional counties (Garissa, Kitui, Makueni and Wajir), collectively covering 29 percent of Kenya's land mass and 3.3 million people. Tanzania began piloting DCF in three districts in 2014, followed by Mali and Senegal in 2015. By 2019, DCF in Mali and Senegal had reached over 1 million people with climate-related investments.[60] As of 2019, a total of £6 million had been invested across the four countries for a total of 284 community-prioritized investments in water, improved soil, agroforestry, livestock, natural resource governance, livelihoods, and food security. A review of DCF mechanisms in 2019 showed that DCF provided more cost-effective, accountable and locally relevant climate decision-making compared to existing government planning approaches, with approximately 10 percent of finance being allocated for administration and planning and 90 percent for concrete investments at the local level.[61]

DCF is a successful model of LLA because it works within existing government systems to downscale climate finance to the local level. DCF works in governance contexts where planning and financing is significantly devolved to lower tiers of government, as in Kenya, which enacted a new Constitution in 2010 that devolves executive and legislative functions of government to 47 county governments. Rather than bypassing the government, DCF uses financial resources that are channeled from the national treasury (finance can come from own-source revenue or international donors) to county governments. County governments establish the adaptation funds and commit regular resources from national government transfers to these funds. In 2016, Wajir became the first county to specifically earmark finance from its budget, formalizing a commitment of 2 percent of its development budget for the County Climate Change Fund.[62]


Photo: boezie/iStock

Overall, this financing mechanism for LLA is a radically different approach from donor- or INGO-funded adaptation projects, since it works to strengthen national financial systems and empowers local government bodies to take the lead on adaptation finance. In Kenya, intermediary organizations such as the International Institute for Environment and Development have worked with county governments for 10 years to provide patient support to develop the institutional architecture for county-level adaptation funds and to build the capacity of local actors to identify and finance climate-resilient investments.

The DCF approach has not been without its challenges. Securing donor finance for the development and strengthening of DCF institutions in Kenya, Tanzania, Mali and Senegal has required accessing funds from multiple donors over many project cycles, since no single long-term source of international finance exists for the development of climate finance institutions. At the local level, there also continue to be challenges in ensuring that marginalized groups such as women, Indigenous Peoples and youth can participate in decisions around adaptation investment selection due to entrenched power structures that privilege men when it comes to decision-making. Accessing downscaled climate data and integrating information that is relevant, understandable and usable for local actors who make adaptation investment decisions has also been a challenge.

After 10 years of patient investment and institutional strengthening, DCF in Kenya received a massive boost in 2021 with the announcement by the World Bank of the Financing Locally Led Climate Action (FLLoCA) program.[63] FLLoCA will pool funding from donors and deliver over US$150 million in investment to strengthen and scale up DCF across Kenya between 2021 and 2026. This commitment represents the largest single investment so far in an initiative that embodies the LLA Principles.[64] It shows that there are opportunities for international donors to scale up investment in LLA, and highlights the value in providing patient, long-term support to build the capacity of local institutions to manage and deliver their own adaptation finance.

Photo: Oleg Znamenskiy/Shutterstock

CASE STUDY 3: Namibia's Environmental Investment Fund

The EIF is a national fund that finances equitable development and the sustainable management of natural resources in Namibia. The fund was launched in 2012 and is capitalized by environmental taxes and levies from the national government, as well as through climate finance from international and bilateral donors. In 2016, the EIF became the first organization to access finance from the GCF through its EDA financial modality for the US$10 million Empower to Adapt project.

Empower to Adapt provides finance to gazetted communal conservancies and community forests, which are community-based institutions that are self-governed, through representatives elected by local people.[65] The program has a dedicated US$8 million grant facility where the EIF provides grants to community conservancies who apply for funding under different thematic grant windows. The grant facility provides community conservancies with grants ranging between US$50,000 and US$400,000 for a period of one to three years to invest in climate-resilient agriculture, climate-resilient infrastructure, and ecosystem-based adaptation. In total, 33 grants have been awarded to date, 76,000 people have benefited, and 7.2 million hectares of land have come under sustainable landscape management in Namibia.[66]

Empower to Adapt is an example of LLA where a national fund accesses international climate finance and delivers it to the local level for investments that are identified and designed by local actors themselves. It is an important example of LLA because it was the first GCF EDA project, which helped establish the viability of this financing mechanism for a major international funder. EDA is different from traditional donor financing models since the national fund that accesses GCF money is not responsible for project implementation; that role

Photo: Paul Weinberg/Panos Pictures

is devolved to community conservancies. In addition, the actual projects that were funded by Empower to Adapt were not pre-selected and approved by the GCF; rather, projects were designed by community organizations, and the decision on which projects were funded was made at the national level. As such, "individual sub-projects neither [had] to be presented in the funding proposal nor subsequently submitted to GCF for approval. Instead, the decision-making mechanism for such sub-projects [was] devolved at the country level through pre-approved selection criteria."[67]

The EDA financing modality used by Empower to Adapt meets the LLA Principle of subsidiarity, by devolving project design and implementation to the local level. However, it also still centralizes the overall decision-making process through which adaptation initiatives get funded with the EIF at the national level, which is not entirely in the spirit of the LLA Principles.

The duration of support (one to three years) also fails to meet LLA Principle 4 around patient and predictable finance. The future design of EDA initiatives could therefore approach financing as a longer-term commitment to strengthen local institutional capacity, rather than just a short-term grants program.

Despite these shortcomings, looking forward, there is still a rationale for using EDA to finance adaptation, albeit with some design tweaks that improve its alignment with the LLA Principles. However, further financial commitments to EDA have stalled in recent years. Since 2016 only two other EDA projects have been approved by the GCF. This highlights the need to scale up EDA in the future; with the LLA Principles offering guidance on how such scaling up could bring better localization of decision-making and institutional support.

CASE STUDY 4: Local Climate Adaptive Living Facility (LoCAL)


Photo: 2015CIAT/Georgina Smith/Flickr

Since 2011, the United Nations Capital Development Fund (UNCDF) has been implementing the LoCAL program in over 30 countries across the world, 22 of which are in Africa.[68] LoCAL supports local governments to mainstream adaptation into regular development planning processes and provides governments with financial resources to make adaptation investments. It does so by delivering climate finance through government systems to local government authorities and their communities. Payments are referred to as "performance-based climate resilience grants" (PBCRGs), which involve a mixture of capacity support and grant finance, so that money can be effectively spent on climate-proofing local infrastructure. PBCRGs provide a financial "top up" to cover the additional costs of making development investments climate-resilient. This enables local governments to fund "the adaptation element of larger investments, allowing for holistic responses to climate change…[and] provide an incentive for local governments to integrate adaptation and climate-proof local development."[69]

LoCAL is delivered through a four-step process that gradually scales out support in each country as subnational governments build capacity to finance adaptation investments. It begins with a Design Phase that involves scoping of the appropriate financial circuit to channel funds to the local level, establish institutional arrangements, and define the size of the grants and the indicative menu of eligible investments depending on local climate, ecosystem, and economic contexts. Then, Phase I involves piloting the LoCAL approach in two to four local governments. Within Africa, Burkina Faso, Lesotho, Malawi, Mali, Senegal, Tanzania, and Uganda are in Phase I of the LoCAL approach. Phase II scales up the LoCAL delivery mechanism to 5–10 percent of a country's subnational governments. Benin, The Gambia, Ghana, Mozambique and Niger are all in Phase II. Phase III concludes with a full national roll-out of LoCAL based on the lessons of the previous phase. At this stage, domestic and international climate finance are brought in to finance adaptation investments. No countries within Africa have reached Phase III yet. Bhutan and Cambodia are the only two countries globally that have begun a full roll-out of LoCAL.

LoCAL is an example of LLA financing because it puts financial resources in the hands of local governments that have the mandate and authority to plan climate change responses but which often lack the finance to do so. It uses the decentralized climate finance mechanism described in the previous section, providing performance-based resilience grants through national financial systems, which are then channeled to local governments. LoCAL is also unique in its commitment to patient and predictable financing. Over LoCAL's four-stage process, subnational governments are gradually strengthened and support is eventually scaled out from a few pilot governments to all subnational governments across the whole country. This approach underlines how development financiers can take the long view of building capacity over time so that gradually subnational governments can build capacity to mainstream climate adaptation into planning and financing.

Challenges for Delivering LLA in Africa

Challenges for operationalizing LLA in Africa can broadly be categorized as those that are on the **supply side** (i.e. pertaining to those providing finance) or on the **demand side** (pertaining to those receiving and utilizing finance for LLA). Furthermore, challenges within these two broad categories can further be divided into those that are "institutional" and those that are "technical."

On the supply side, one major institutional challenge is that IFIs that provide much of the international public climate finance are mandated to deliver finance through multilateral actors or to national-level actors (mostly government agencies and ministries). While EDA modalities that include subnational institutions do exist, these are still far from being the norm as the focus is still largely on national institutions.[70] This is a function of the political economy of national governments, which seek to retain agency in allocating finances coming in. For example, while Nigeria has a federal structure, "the relationship between state and local government is more of domination and hijacking of local government functions."[71] This is also a function of weak institutional capacity of local governments across Africa. On average, only 14.1 percent of staff expenditure in the public sector in Africa is allocated to local governments, which are responsible for only 11 percent of all public investment.[72] These figures are less than half the global average and much lower than those for low- and lower-middle–income countries outside Africa.

Many local governments lack the trained staff and the budget to operationalize policies effectively—particularly in sectors that require a degree of technical know-how such as adaptation to climate impacts. Additionally, studies undertaken in the context of particular countries on the continent also yield insights on how "…local authorities lack the legal mandate, resources, and technical know-how to successfully implement climate change adaptation."[73] This results in major impediments to operationalizing the subsidiarity principle inherent in LLA, whereby decisions and actions should take place at the lowest most effective institutional unit.[74] However, instead of this lack of capacity being employed as a reason to avoid investments in LLA, it should be recognized as an urgent gap to be filled through strategic investments and support for delivering long-term and durable gains in vulnerability reduction.

On the demand side, an important challenge is around "readiness" for accessing, managing and utilizing climate finance. While there are examples of simplified access modalities (where, for instance, applications have been permitted in video format or in regional languages), these are far from the norm.[75] The fact that many local organizations lack the know-how to utilize financing received in line with donor expectations, or are unable to meet the fiduciary standards stipulated by them, also leads to impediments for channeling finance to local institutions. Linked to this is the challenge that there are a range of technical impediments when it comes to delivering adaptation at the local scale. One element of this is the lack of user-friendly climate information. Much of the climate information available for Africa comes from global data sets (e.g. CMIP5) with broad geographical coverage. However, local institutions (e.g. municipalities) are often concerned with much smaller geographical units, reducing the usefulness of these models.[76]

The ideal alternative is to focus on developing "low regret" adaptation actions that would deliver benefits under a range of possible climate scenarios, but the capacity to develop and execute these continues to be a challenge. This is closely linked to a challenge faced by recipients around developing a "climate rationale" where they are expected to demonstrate how the issue that they want to tackle is caused in whole or part by climate change (as opposed to only tackling development deficits)—a task fraught with technical impediments, not least because determining attribution at local scales is expensive, time-consuming, and requires expertise.[77] In African countries these challenges are acute; for instance, 70 percent of local governments report a lack of awareness about ways of tackling climate change or of local climate impacts.[78]

KEY INSIGHTS ON LLA

The preceding sections have demonstrated the growing salience of LLA as a new paradigm for adaptation that has a coherent set of underpinning values and a growing number of operational examples that can be emulated and amplified. This section presents some key insights that are emerging from this new set of principles on financing and delivering LLA.

First, while LLA offers a new framing for how international and national actors can support adaptation processes, it is not necessary to create entirely new delivery structures to deliver LLA. One of its main innovations is linking global and national sources of finance with subnational institutions and actors who can take charge of delivering adaptation initiatives based on clearly defined local priorities, using existing financing modalities. As a result, government actors and development partners wishing to scale up LLA can adapt existing financial mechanisms that already work but integrate a more concrete approach to "subsidiarity" that devolves decision-making on adaptation investment to lower levels.

Second, there is no one-size-fits-all solution for operationalizing LLA. The section on delivery mechanisms for LLA highlighted several such mechanisms that are starting to demonstrate impact. Which of these is suitable, and where, is dependent on national and subnational governance structures, fiscal characteristics, and the policy environment. For instance, LLA might be best supported by government-led national financing mechanisms in countries with mature state machinery, strong democratic institutions and institutional structures for devolution, whereas mechanisms that rely on civil society organizations or constituent-based organizations might be more appropriate in fragile contexts. Investments in LLA must therefore be preceded by close scrutiny of the operational context in partnership with communities and other key stakeholders.

Third, while scaling up LLA is an important piece of the puzzle, it is equally important for governments and development partners to strengthen institutional capacity for delivering LLA. National and subnational institutions need to build financial and program management capacity so that they can increasingly absorb larger flows of finance and/or channel such flows into local adaptation investments. This is precisely the action called for in Principle 4. Local institutions need patient support to improve their financial management and accounting practices; investments in human resources to hire, train and retain technical and professional staff; capacity to analyze climate projections and undertake scenario planning to identify the most robust investments for a range of potential climate futures; and scaled-up program management capacity to deliver longer and more complex adaptation programs. Much of this capacity is still nascent in LLA delivery mechanisms and will require patient institutional support over long timeframes.

Finally, the preceding sections help repudiate two common misconceptions about LLA. First is the charge that LLA is an advocacy-oriented agenda and pathways of operationalizing it are not yet evident. In fact, a number of mechanisms are already in place that can be leveraged to put LLA into practice, and different approaches are already in use in African countries and are delivering impact. These provide models that can be translated, emulated and employed to help tackle climate risk expeditiously across the continent. The second charge that is leveled at LLA is that it is "resource intensive." Putting local communities in a leadership position within a process of adaptation that tackles structural drivers of risk through strengthening local institutions may indeed be more complex, and in certain cases, have higher upfront costs than top-down, technocratic interventions. However, the evidence on returns on investment from adaptation initiatives that focus on the agency of communities suggests that the benefits far outweigh the costs.

RECOMMENDATIONS

Based on the insights outlined in the previous section, we offer the following recommendations for how international funders (such as multilateral development banks, climate funds and bilateral donors), national governments and civil society actors can scale up LLA in Africa.

Recommendations for International Funders

International funders should provide finance to establish and/or strengthen institutions that can channel adaptation finance at the local level

Effective LLA requires institutions that can access climate finance and channel it to relevant programs, projects or investments. Many countries in Africa have strong national institutions to access and/or deliver climate finance, including national funds and government agencies such as Ethiopia's CRGE and FONERWA in Rwanda. In countries where these institutions do not exist, international funders should support governments with patient finance to develop them. Where these institutions already exist, IFIs and climate funds should provide long-term finance for institutional strengthening so that these institutions can increasingly access larger amounts of finance and manage longer-term initiatives. This should include support for strengthening financial management systems; human resources; safeguards and compliance; the hiring, training and retention of technical and professional staff; communications; and monitoring and evaluation.

International funders should significantly scale up the volume of climate finance that they deliver through LLA mechanisms

International funders do not deliver a significant amount of finance that is aligned with the LLA Principles, instead favoring traditional programming modalities of delivering finance to national governments or implementing programs through large multilateral organizations and international NGOs. There is a significant opportunity for funders to put their financial weight behind delivery mechanisms—whether they be national, regional, subnational, constituency-governed or private sector—that put finance and decision-making power into the hands of local people and organizations. Such a scaling up should include both greater amounts of finance and a longer duration of financial support (say, seven or more years). The FLLoCA program in Kenya highlights one way in which IFIs can scale up finance in the context of decentralized climate finance.

International funders—in particular global climate funds—should create channels for providing finance directly to subnational governments and institutions

EDA programs in Namibia and South Africa have been successful in demonstrating that international finance can be channeled to the local level (via national institutions) to help communities and local groups adapt to climate change. In the first instance, EDA should be expanded and simplified so that more countries can develop experience in downscaling climate finance to subnational actors. However, this model can also be downscaled one step further. Subnational and city governments should also be able to access climate finance from international funds. Importantly, they require simplified access procedures so that there are not multi-year delays in accessing finance while they become accredited and have projects approved. For climate funds, this type of modality could involve establishing new financing windows or disbursement rules for subnational entities to access finance. It will also likely involve the need to provide technical support to build the capacity of local actors over time. The City Climate Finance Gap Fund, financed by the World Bank and the European Investment Bank to provide technical assistance to city governments in OECD Development Assistance Committee (DAC) countries to develop project pipelines and bankable projects, is one example of how new funds can specifically promote subnational climate finance.[79] Recent changes at the GCF to provide streamlined access to GCF resources for non-accredited entities under the "project-specific assessment approach" show that even large funders like the GCF can develop new solutions to respond to innovative demands for accessing finance, meaning that the possibility of subnational accreditation and accessing should be considered within the GCF going forward.[80]

International funders should significantly increase finance to constituency-governed organizations that provide some of the most locally grounded adaptation solutions

Constituency-governed organizations are embedded in marginalized and vulnerable communities and play a vital role in supporting equity and inclusion—values that go to the very core of LLA. They provide finance to invest in adaptation solutions that require patient investment and support to alter power structures that have traditionally excluded specific groups (e.g. women, Indigenous Peoples, ethnic minorities). Organizations like SDI, the Huairou Commission and the Pawanka Fund often provide regular, recurrent capital to their membership base, albeit in relatively small volumes since they operate on smaller budgets and do not have access to larger-scale finance from international funders. IFIs (which provide the bulk of international public climate finance) should explore new partnerships with constituency-governed organizations to position these groups more prominently to deliver adaptation at scale. This should involve finding ways to reduce the transaction costs of supporting smaller organizations, and developing workable arrangements that balance the needs for strict fiduciary management arrangements and reporting systems, etc. with the ability to deliver agile investment that supports livelihoods and resilience on the ground.

Recommendations for Governments

Countries with devolved governance systems should establish subnational adaptation planning and investment processes so that climate action is downscaled to local governments

Many successful examples of LLA emanate from contexts that have crossed a critical threshold with regard to decentralization and devolution. This chapter has highlighted several examples of this, including DCF mechanisms in Kenya, Tanzania, Mali and Senegal, and the LoCAL program, which is supporting decentralization with performance-based resilience grants to climate-proof investments in more than 20 African countries. In these contexts, there are structures through which subnational institutions and local actors can voice their adaptation needs, identify priorities, and shape investments. Delivering LLA through devolution can also enable governments to provide their own-source finance to meet investment gaps.


Photo: Nyani Quarmyne/Panos Pictures

In countries without devolved government systems, governments should build the capacity of national climate finance institutions to deliver finance in line with the LLA Principles

Not all countries have devolved governance systems. However, countries with centralized governments can still use national climate funds and government agencies to deliver climate finance to the local level in a manner where local actors (e.g. community institutions, natural resource management groups, businesses, etc.) can design investments, propose projects, and access central funds. This could include EDA-type initiatives with on-granting or revolving loan windows, which would ensure a certain downscaling of adaptation decision-making around the design of locally relevant investments. This chapter has highlighted two examples of EDA in South Africa and Namibia, but there is a wealth of national funds across Africa that could learn from this experience and replicate such an approach.

Where governments deliver local level development programs with adaptation co-benefits, these should be aligned with the LLA Principles

In many African countries, national governments and their agencies at subnational and local levels finance and implement vital programs that reduce poverty and improve livelihoods and wellbeing. These include social protection programs, agricultural extension programs, natural resource management and many more. Many of these initiatives deliver strong adaptation co-benefits alongside the core development objectives of the programs. African governments should mainstream climate risk management into these programs in line with LLA Principles, as Ethiopia is currently doing with the PSNP.

Governments should explore the possibility of creating and/or capacitating subnational climate funds and institutions that can access adaptation finance

At present, international climate finance earmarked for governments is predominantly delivered to national-level institutions and agencies. However, there is a need to downscale capacity so that subnational institutions—at state, county, provincial, regional, city or community levels—can access finance to implement adaptation initiatives. Subnational funds and institutions could develop project pipelines, develop investment vehicles like green bonds, deliver adaptation programs, and deliver resilience infrastructure investments. Where relevant, subnational actors should explore avenues to become accredited to international climate funds, or to establish partnerships through subnational platforms and donor initiatives to access climate finance. One example of where this is already coming to fruition is in the urban context, where several global platforms exist to improve climate finance delivery to cities, such as the AfDB's Urban and Municipal Development Fund.

Recommendations for Civil Society Organizations

Civil society organizations should expand the coverage of tried and tested LLA delivery mechanisms, while also deepening support so that they are longer-term and more predictable

This chapter has highlighted several effective delivery mechanisms that provide finance in different ways for LLA such as constituency-governed funds, devolved grants programs, and microfinance. These initiatives should be scaled out to support more communities where possible. However, a key finding from the analysis of civil society LLA mechanisms is that for many CSOs, the duration of their financial support for local groups has tended to be short-term due to their small operating budgets and short donor timeframes. CSOs should explore options to embed LLA initiatives in longer-term work programs—for instance, by developing concrete decade-long program frameworks for adaptation and capacity development of local institutions. Such program frameworks could bring in different donors to top up finance as the program progresses. This model would contrast with the current approach where CSOs regularly develop new projects to align with donor funding timelines. Constituency-governed organizations like SDI have demonstrated that this type of long-term commitment is possible.

Large-scale NGOs that deliver finance through traditional international financing modalities should aim to mainstream the LLA Principles into programming in order to improve accountability for local constituents

A significant amount of global adaptation finance is delivered by international NGOs through initiatives that are designed at national and global levels. These programs may be based on an understanding of local context and staffed by national experts, but they do not necessarily put local actors in the driver's seat on the design or implementation of the programs. Given that this finance is likely to remain part of the global climate finance architecture for some time, particularly in countries with weak governance contexts, international NGOs should aim to embed the LLA Principles in their operations. In particular, this should focus on more concerted co-design of adaptation interventions so that investments are truly based on local needs. International NGOs should take an approach that builds local institutional structures to drive decision-making for the duration of projects, so that these structures can continue to lead on adaptation initiatives after NGO support concludes.

Recommendation for Increasing Private-Sector Investment in LLA

The private-sector contribution to LLA remains under-researched and there is a need to better understand how this vitally important group of stakeholders can support LLA

This requires exploring the incentives that can drive private-sector action in this domain (say, through the development of cost–benefit metrics or return-on-investment calculations); analyzing how existing domains of adaptation action where the private-sector is active (e.g. hazard insurance, agricultural technology, waste management, energy solutions) can be made more "locally led"; and conceptualizing the policy environment that could "nudge" this sector toward investments and engagement in LLA.

Box 2. Future Research Questions for LLA

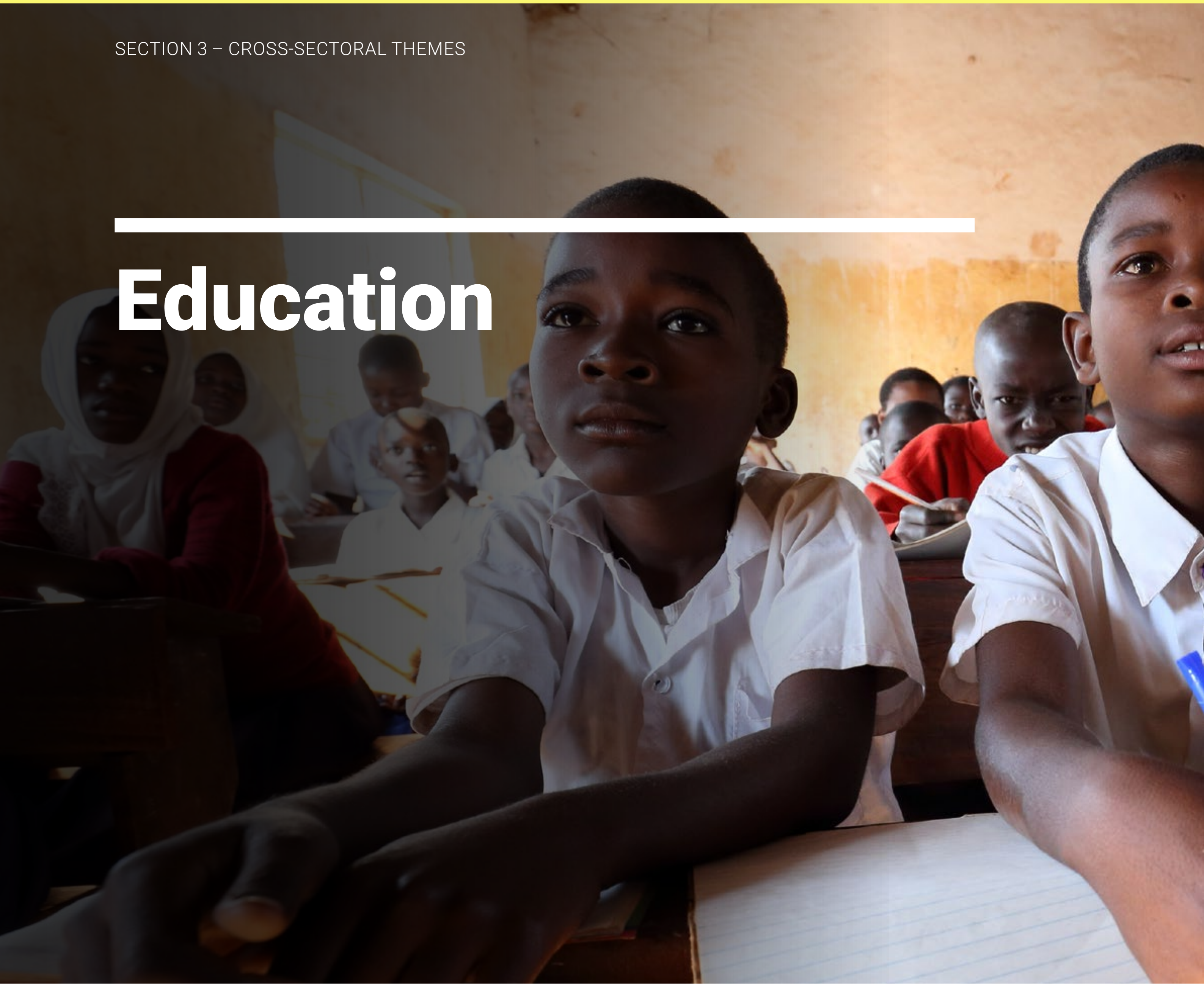
LLA practice in Africa still has many unanswered questions that require further research. For example:

What are the most effective mechanisms for subnational institutions (e.g. local governments, cities, CSOs, network-based organizations, MFIs) to deliver more efficient and streamlined access to finance from IFIs and global climate funds in a way that delivers better results?

What are the best methodologies to conduct cost–benefit analysis that are specific to LLA and can help to understand the differences with traditional delivery models and their effectiveness?

What are the most effective delivery models for the private sector to scale up the delivery of products and services that support local adaptation?

The answers to these questions are at the core of scaling up LLA practice in Africa.



Education

KEY MESSAGES

- Education is a heavily climate-impacted sector in Africa. It is also a key building block of adaptive capacity. However, investment in education is low in Africa, creating a significant barrier for climate adaptation. Despite growing evidence about the synergies between education and adaptation, education has also not been central to climate and adaptation strategies.
- Climate-related disruptions to the education sector have far-reaching negative effects on the adaptive capacity of climate-vulnerable populations in Africa. 25 of the 33 countries where children shoulder extremely high vulnerability to climate shocks are located in Africa.
- The indirect impacts of climate change also impair educational attainment, especially for girls. The Malala Fund estimates that climate disruptions will mark an abrupt end to schooling for at least 12.5 million girls every year globally.
- Climate-adapted educational infrastructure can help sustain learning during climate-related emergencies, while strengthening the resilience of communities to climate impacts. A climate-adapted education workforce is critical to delivering education that unlocks adaptation solutions in other critical sectors in Africa, not to mention generations of empowered climate-adapted citizens.

Photo: Dietmar Temps/Shutterstock

- Education is itself a key adaptation solution for Africa. More education is correlated with strengthened adaptive capacity and reduced climate vulnerability. Climate change education is vital to the development of climate literacy, which is itself vital for improved adaptation. Education also helps to build a breadth of green skills to fuel a just transition to green jobs for adaptation and resilience for all of Africa.
- To make progress on using education as a lever of climate adaptation, a global effort in the form of an "Education for Adaptation Accelerator (E4AA)" Alliance is urgently needed. Africa, as the continent with the fastest-growing youth population, could lead this Alliance.

"

Every day that we delay adapting to climate change is another day wasted. Another day when we're delaying investment now, but paying the cost later. Failure to capitalize on the economic benefit of adaptation through high-return investment now will result in the loss of trillions of dollars in potential development. ... Education is vital for building a climate-resilient future."

Ban Ki-moon
8th Secretary-General of the United Nations and Chair of the Global Center on Adaptation

INTRODUCTION

Underlying the climate and adaptation crisis in Africa is a human crisis. This includes a silent crisis in education, with unacceptable rates of learning and skills poverty, which threaten the prosperity of individuals, communities and nations. A low level of human development makes people more vulnerable to the impacts of climate change and prevents them from becoming a much needed and critical part of climate solutions.

The relationship between climate change, adaptation and education is complex and bi-directional. Climate change undermines educational attainment in Africa by damaging already fragile infrastructure and increasing the vulnerability of educators and learners, negatively affecting their ability to educate and learn. But education is also a key climate adaptation solution for Africa because it enhances the adaptive capacity of people, and especially children, by building critical green skills for adaptation action.[1]

Photo: CECIL BO DZWOWA/Shutterstock

Around the world, there is growing recognition of the relationship between climate change and education. Article 12 of the Paris Agreement recognizes the critical role of education in empowering all members of society to engage in and take climate action—both adaptive and mitigative. Education is also a part of the 2030 Agenda for Sustainable Development, and climate action is a critical thematic priority of UNESCO's (2020) global framework on Education for Sustainable Development. In Africa, the Coalition for Education and Training on Climate Change acknowledges the role education plays in reducing the impact of climate change.[2] Similarly, the African Union's Climate Change and Resilient Development Strategy and Action Plan (2022–2032) and the Southern African Development Community (SADC)'s 2015 Climate Change Strategy and Action Plan both recognize formal and informal climate change education as key elements in enhancing responses to climate change and seizing opportunities in both mitigation and adaptation.[3]

Despite its strategic importance to adaptation efforts, however, education has been overlooked by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), and more broadly in the formulation of climate and adaptation strategy on all levels. The annual UN Climate Change Conference did not feature education in a high-level official discussion until COP26 in Glasgow in 2021, when ministers of the environment engaged ministers of education in a first-ever joint ministerial dialogue on education for climate action.[4] The global education community has also de-prioritized education for adaptation; it was sidelined, for example, at the Transforming Education Summit—the first-ever meeting of heads of state on the topic of education at the UN General Assembly meetings.[5]

At the time of writing, only 40 of the 133 nations that have submitted an updated, revised, or new Nationally Determined Contribution (NDC) mention climate change education as an adaptation (or mitigation) strategy in their NDC.[6] Out of the 43 African countries that have submitted their updated, revised, or new NDCs, 16 mention climate change education.

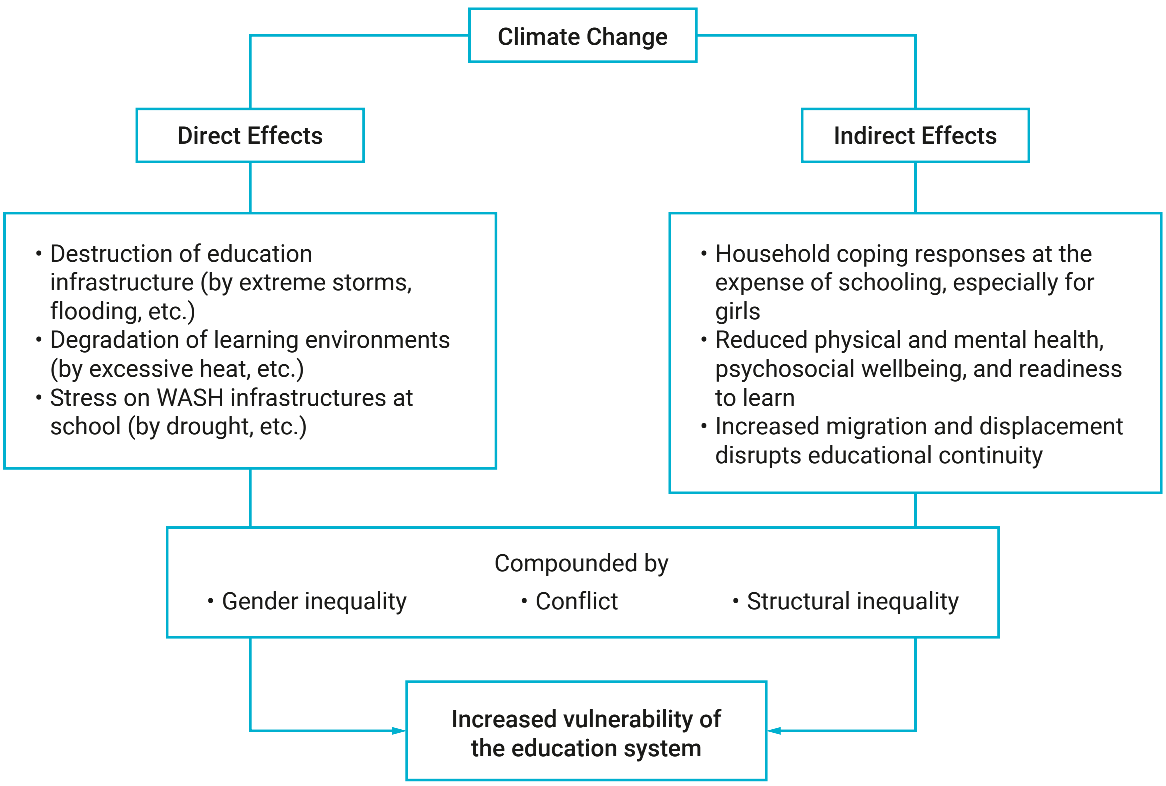
Acting on the greater integration of education in adaptation is urgent. Africa's population is young and growing. In 2050, more than half of Africans will still be under the age of 25,[7] and the continent will boast a workforce of over 1 billion.[8] Yet if Africa continues at its current pace of educational investment, the continent will not be able to respond to the climate crisis. On current trends, a UN and African Union Commission report estimated that it would take another 100 years to reach universal primary education, and another 235 and 280 years to reach universal lower secondary and universal upper secondary education. Progress on climate resilience is similarly slow: The authors of the ND-GAIN Country Index estimated in 2013 that it would take the world's poorest countries, many of which are in Africa, a century to achieve the climate readiness of the richest countries.[9]

This chapter argues for a greater recognition of the need to adapt education systems themselves, but also to recognize education itself as a critical and central strategy for climate adaptation in Africa. Section 1 highlights the challenges faced by the education sector in adapting to climate change impacts and the need for greater investment in education to fully realize its potential as an adaptation solution. Section 2 assesses the state of education in Africa today and makes a case for education as an important building block of adaptive capacity. Section 3, the most substantial section of this chapter, maps out four strategies to accelerate the project of education for adaptation in Africa. Section 4 concludes with recommendations, including a proposal for an "Education for Adaptation" global Alliance to be led by Africa.

Challenges to Education from Climate Change

A wide range of impacts of climate change on education infrastructure, educators, and learner outcomes have been observed.[10] This section breaks down these impacts into three categories: direct, indirect and compounded. The relationship between these effects is diagrammed in Figure 1. However, access to consistent, reliable, and comprehensive data that links climate and education is often anecdotal and related to specific events. This affects our ability to assess the scope and scale of the impacts across Africa.

Figure 1. The Relationship between Climate Change, Vulnerability, and Education



Direct Effects

The direct impact that climate change has on African education systems is most visibly manifested in the destruction of education infrastructure by sudden-onset impacts such as storms and floods. For example, Cyclone Idai, which hit southeast Africa in 2019, demonstrated the extensive vulnerability of education infrastructure in Africa. The damage ranged from the complete collapse of school buildings to the destruction of teaching and learning material. In Mozambique alone, the cyclone destroyed 3,400 classrooms and left 305,000 children without conducive places of learning.[11] Moreover, school premises that withstood the cyclone provided shelter to 142,000 displaced people,[12] which prolonged the time children were left without spaces for learning and increased dropout rates, especially among girls.[13] Such destruction is costly for already tight education budgets. In Zimbabwe, the total cost of educational infrastructure destruction reached nearly US$7 million.[14] With the frequency and intensity of heavy precipitation events in Africa on the rise, this type of destruction and educational disruption is only expected to get worse.[15]

Another direct impact of climate change on education is the degradation of learning environments by temperature rise and extreme heat. Poorly ventilated spaces, including school buildings, have been reported to present desperate conditions during extreme heat and common sandstorms in North Africa, resulting in children missing class days,[16] but exact numbers are unclear, as countries do not appear to be proactively tracking such data. Evidence from other countries suggests that hotter temperatures affect student concentration and performance. For instance, evidence from the United States shows that without air conditioning, an increase in average annual temperature by 1°F (about 0.56°C) reduces that year's learning by 1 percent.[17] With air conditioning, that impact is reduced by 78 percent.

Drought is another major challenge directly impacting education in Africa by stressing water, sanitation, and hygiene (WASH) infrastructure that is already unevenly developed. This is especially the case in poorer urban areas and in rural areas. Nearly 295 million children in Sub-Saharan Africa lack access to water for drinking and hand washing at school.[18] These conditions are a significant deterrent for children to attend school, especially for menstruating learners and teachers.[19] With drought conditions expected to worsen access to water at schools across the continent, climate change will only worsen school attendance.[20]

Indirect Effects

Climate change triggers a set of indirect effects on education by triggering household coping responses that often come at the expense of schooling—especially for girls. This is most prominent in the context of slow-onset and prolonged climate-related disasters, such as droughts, that have a high impact on climate-sensitive sectors such as agriculture and fisheries. For instance, rural agricultural households in Zimbabwe that experienced a loss of farming income during drought are left without enough money to pay for food, school fees, learning materials, or transportation.[21] Drought-affected households without access to credit facilities are especially at risk of withdrawing their children, especially girls, from school—some to engage in income-generating activities and others to be married off.[22] Such maladaptive coping responses further entrench the next generation in a vicious cycle of poverty and climate vulnerability.

Climate change also impacts the health and wellbeing of educators and learners, reducing their readiness to teach and learn. Climate-related events generate a variety of public health challenges, from the increased burden of waterborne disease caused by flooding and poor sanitation to the shifts in vector-borne diseases brought on by rising temperatures, to hunger and malnutrition caused by drought-induced food shortages.[23] For children, especially those in the first 1,000 days of life, health challenges such as malnutrition can lead to stunted growth, which negatively impacts their later cognitive abilities in vocabulary and mathematics, especially in households with low literacy levels.[24] Indeed, research suggests that children exposed to harsh climatic conditions in early life are likely to attain 1.5 fewer years of schooling than children from places with favorable climatic conditions.

Both sudden-onset and prolonged climate disasters can also affect access to essential menstrual and sexual reproductive health products,[25] with impacts on health, including potential pregnancy, as well as on school attendance and learning outcomes.[26]

In addition, the physical destruction of school infrastructure, along with the significant loss of human life, including colleagues and classmates, can also lead to post-traumatic stress, anxiety, and other long-term mental health challenges for teachers and learners.[27]

Lastly, climate-related migration and displacement disrupt access to education. While families with the means to migrate can move to places with better availability of resources such as food and water, often their children are forced out of school as a result, with girls at heightened risk. At the end of 2021, 27.2 million people in Sub-Saharan Africa were internally displaced, according to the Internal Displacement and Monitoring Center (IDMC)—mainly due to conflicts and violence, but more than 2 million due to disasters.[28] Among them, 7.3 million were children between the ages of 5 and 14, and 4.4 million were under 5. The largest numbers of displaced children were in the Democratic Republic of the Congo, Ethiopia, Nigeria, Somalia, and Sudan.

Combining data from the IDMC and the ND-GAIN Country Index (2020), our analysis found that in Somalia and Sudan, there is a particularly large confluence of high climate vulnerability and high child displacement. Both countries also have low adaptation readiness, indicating a great need for investment in adaptation and education.

Compounding Effects

The vulnerability of education systems to climate change are also compounded by, and in turn exacerbate, ongoing systemic challenges in society, including gender inequality, conflict, and historical structural inequality.

Gender inequality exacerbates the effects of climate change on education, especially for adolescent girls. For instance, adolescent girls spend more time walking long distances and waiting for long periods of time to collect water in times of drought, exposing them to greater risk of sexual violence while also causing them to miss school or show up too tired to

Photo: Riccardo Mayer/Shutterstock

learn.[29] Indeed, globally, girls with no education have been found to be at three times the risk of marrying before the age of 18 than those who have completed high school;[30] uneducated girls are also at heightened risk of engaging in transactional sex for food and basic necessities.[31] This puts them at increased risk of HIV infection, which has already been observed in Malawi and Lesotho, and further impairs their resilience and adaptive capacity.[32] The Malala Fund estimates that climate disruptions will mark an abrupt end to schooling for at least 12.5 million girls every year.[33]

Conflict magnifies already tenuous environmental conditions for the safe delivery of education. Only about 65 percent of children in conflict-ridden countries reach the last grade of primary school, compared with 86 percent across low-income countries in general.[34] Children in conflict settings are most affected by death, injuries, increased vulnerability to abuse, lower health, and a loss of school time.[35] Of the 33 countries that UNICEF has identified as bearing extremely high climate risks for children, 29 are also considered to be fragile contexts.[36] Such environmental conditions will no doubt amplify long-standing challenges of governance, increase socioeconomic inequalities, trigger civil wars over increasingly scarce natural resources, and increase conflict-induced displacement, all ultimately disrupting children's access to school.[37]

Structural inequality not only exposes learners in Africa to uneven quality of education, but also heightens the risk of exposure to climate risks for some more than others. For example, the April 2022 floods in South Africa claimed 435 lives, including nearly 70 pupils from Black and poor communities in KwaZulu-Natal.[38] The uneven loss of life has been attributed to the legacy of the apartheid government's 1913 Land Act and 1950 Group Areas Act.[39] Through spatial planning, both pieces of legislation confined Black and "colored" communities to low-lying densely populated areas unconducive to the delivery of essential services. A combination of historical legacies of oppression and contemporary discrimination heighten the exposure of historically marginalized populations of children not only to intergenerational trauma, but also to an excess of environmental hazards that limit their opportunities to quality education.[40]

HOW THE EDUCATION DEFICIT IMPEDES CLIMATE ADAPTATION

The potential for education to be a key instrument to help countries and communities adapt to climate change is severely hampered by the lack of investment in education, and indeed by the limited recognition and understanding of education as a key adaptation strategy. This section presents a broad overview of the education deficit, both in quantitative terms and in quality, in Africa. It then proceeds to show that education is often positively correlated to increased adaptive capacity, suggesting that an increase in human capital could deliver very positive outcomes for adaptation.

Education in Crisis

Investment and progress in education in Africa have been painfully slow. Over the period 2010–2017, only 20 African countries in a sample of 42 provided the minimum education funding recommended by the UN: at least 4 percent of GDP and 15 percent of the government budget. Seven met only one of the criteria, and 15 met neither.[41] Globally, the Education Commission estimated in 2016 that annual aid to education stood at approximately US$16 billion, leaving a US$44 billion shortfall.[42] The education financing gap is projected to get much worse as result of the COVID-19 pandemic's impact on countries' fiscal position.[43]

Average years of schooling are the lowest in Africa compared to other regions, and over half of the world's out-of-school children of primary school age (34 million) are in Africa.[44] Progress in enrollment in secondary and tertiary education in Africa is slow, and enrollment in primary education has stagnated after experiencing a period of rapid progress around the turn of the millennium.[45]

Yet a deeper and more structural problem lies in the quality of education in Africa. Millions of those who go to school emerge without basic literacy and numeracy skills. In Sub-Saharan Africa and the Middle East and North Africa region, only 11 percent and 23 percent of all youth aged 15–24 have basic secondary literacy and numeracy skills, respectively.[46] COVID-19 related school closures resulted in children losing a collective 1.8 trillion hours of in-person learning globally,[47] with those from marginalized communities suffering the most.[48] Before the pandemic, the global learning crisis was already alarming, with 87 percent of children in Sub-Saharan Africa living in learning poverty—meaning they are unable, by the age of 10, to read and comprehend simple text in the language of instruction.[49] Post-pandemic, this figure is expected to increase globally at least by 10 percentage points if active measures for remedial learning and increased investments in education are not taken by governments.

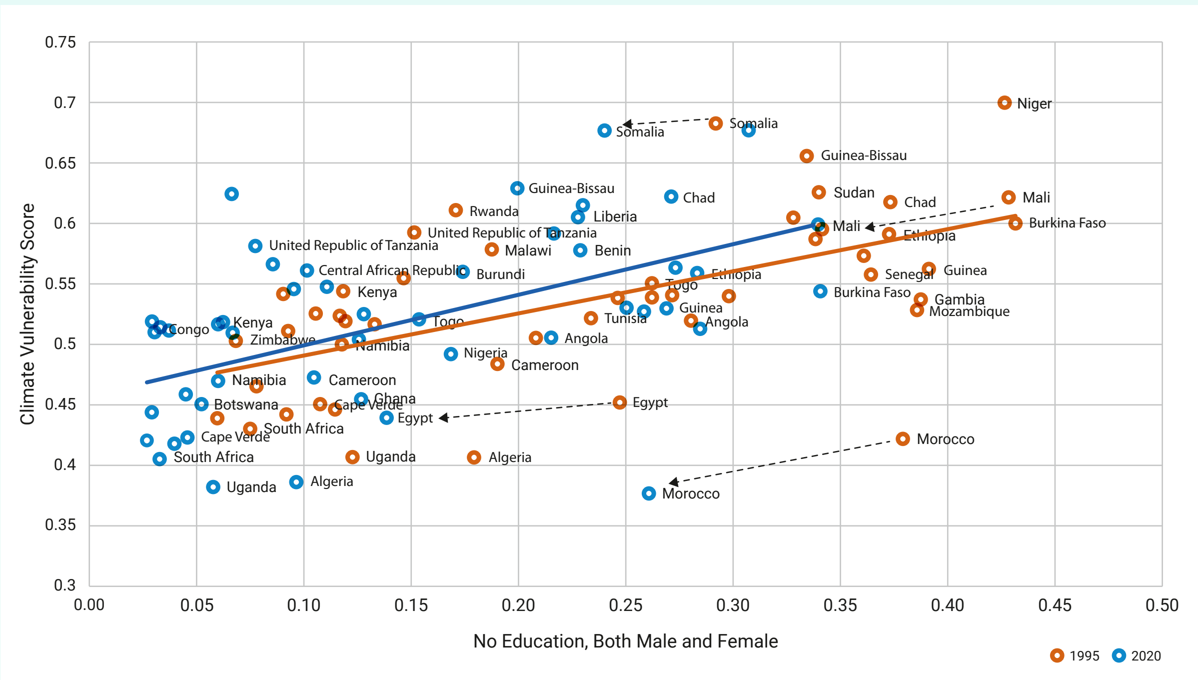
The Impact of Education on Adaptive Capacity

While the evidence on the impact of education on countries and people's adaptive capacity is still emerging, available data points to a strong positive relationship. UNICEF estimates that improving educational outcomes could reduce the climate risks borne by 275 million children globally.[50] New analysis for this chapter combining education data with the ND-GAIN Country Index also confirms the importance of education, especially secondary and higher education, for adaptive capacity.[51] That is, no education is associated with higher climate vulnerability, and more education—specifically at the upper secondary and tertiary levels—is associated with higher adaptive capacity (Box 1). What this and other analyzes indicate is that education is an important building block of adaptive capacity.[52] Research suggests that these foundations can be built in direct and indirect ways.

Box 1. Higher Levels of Education are Associated with Higher Levels of Adaptive Capacity

Over the past two and a half decades, the climate vulnerability score in Africa has, on average, decreased, but only marginally (Figure 2). This small change may be accounted for by improvements in education, both in the decline in the population with no education and the increase in the share of the population with upper secondary and tertiary education. Figure 2 suggests a positive correlation between the lack of education and climate vulnerability scores.

Figure 2. The Relationship Between Climate Vulnerability and Population with No Education, Both Male and Female, in 1995 (Red) and 2020 (Blue) in 49 Countries in Africa

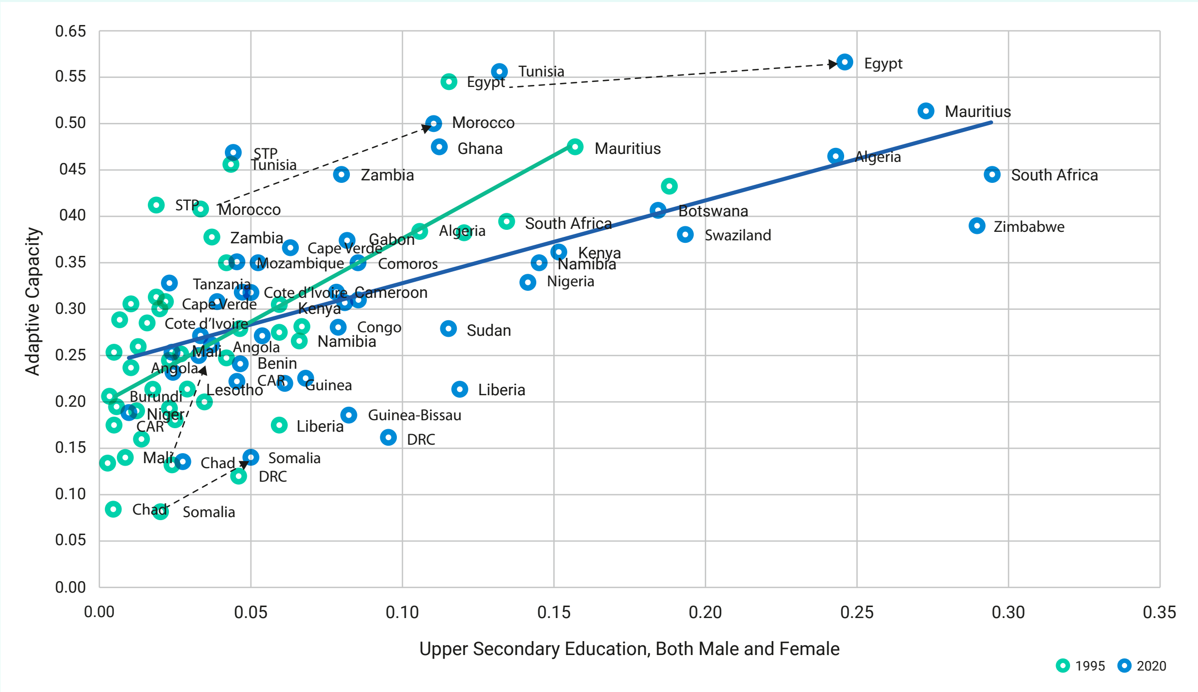


Note: The dashed arrow indicates the direction of change from 1995 to 2020 for Egypt, Morocco, Somalia, and Mali. Pearson correlations are positive and range from r = 0.598 in 1995 to r = 0.554 in 2020.

Data sources: ND-GAIN Country Index and Wittgenstein Centre Human Capital Data Explorer[53]

Similarly, there is a positive correlation between the level of secondary education and the adaptive capacity score[54] in Africa (Figure 3). Of course, improved education may also correlate with other variables (e.g. health, gender equality, better nutrition and improved energy access, etc.) which in turn affect adaptive capacity. The graph below establishes correlation not causation. Further work to analyze this relationship is needed.

Figure 3. The Relationship Between Adaptive Capacity and Population with Upper Secondary Education, Both Male and Female, in 1995 (Green) and 2020 (Blue) in 49 Countries in Africa



Note: Pearson correlations range from r = 0.631 in 1995 to r = 0.618 in 2020. The dashed arrow indicates the direction of change from 1995 to 2020 for Egypt, Morocco, Somalia and Mali.

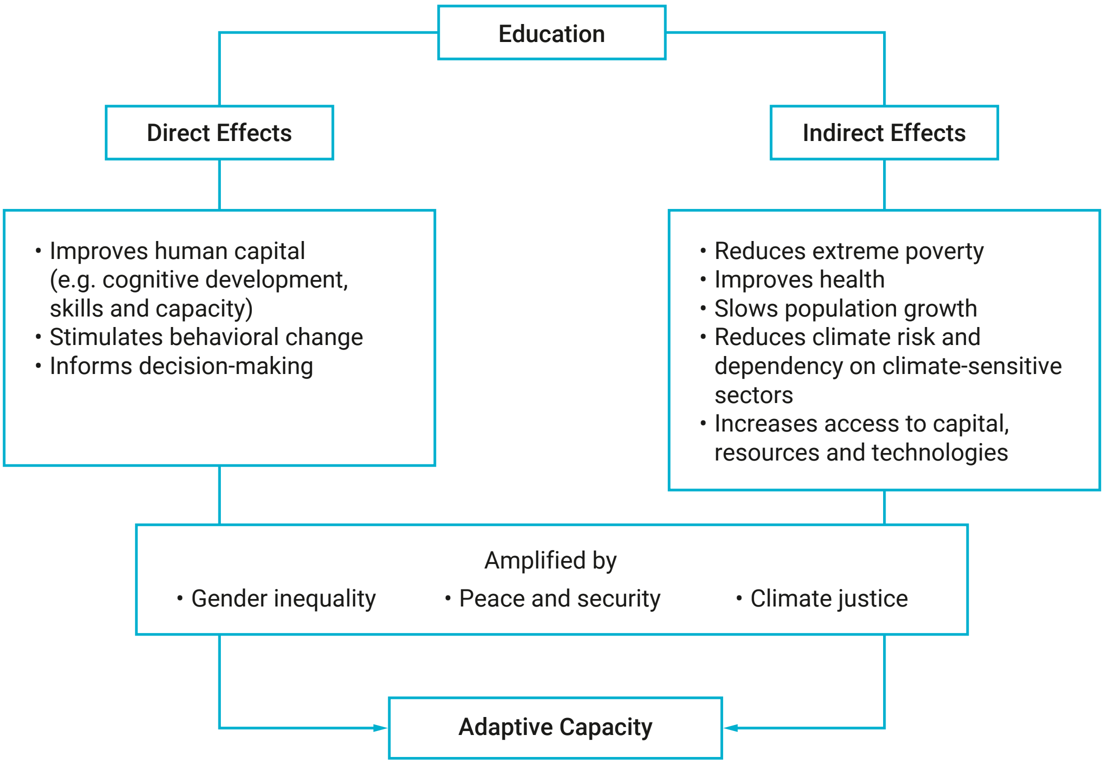
Data sources: ND-GAIN Country Index and Wittgenstein Centre Human Capital Data Explorer[55]

Several studies have underlined the potential symbiotic relationship between human capital—and, specifically, education—and adaptive capacity.[56] Figure 4 outlines the direct and indirect elements of this relationship, in a manner analogous to the direct and indirect impacts of climate change on education described in Figure 1. Pre-primary to post-secondary education allows for cognitive development and builds important skills and capacities. Education about climate change, its impacts, and adaptation solutions can also help to stimulate behavioral change and enable individuals and society to make informed decisions about climate adaptation.[57] More indirectly, education helps to reduce extreme poverty, improves health, and slows population growth, thereby strengthening adaptive capacity of individuals, communities, and states.[58]

With more education, individuals and households can better prepare for and respond to climate shocks through risk reduction, migration, and/or the adoption of climate-resilient technologies, practices and behaviors;[60] they are also more flexible to learn new skills, take on new jobs, or find new livelihoods.[61] With more education, individuals and households can better perceive and reduce their risk, diversify their income, and become less dependent on climate-sensitive sectors. The increased access to capital, information, and resources gives them more agency in the face of crisis, opening up options to respond or adapt to the impacts of climate change.

The effect of secondary education on adaptive capacity has been observed to be highest for women,[62] reinforcing the urgent need to ensure girls

Figure 4. How Education Contributes to Enhanced Adaptive Capacity



Source: Adapted from Figure 1 in Muttarak and Lutz (2014)[59]

Photo: Alfredo D'Amato/Panos Pictures

have access to 12 years of quality and empowering education.[63] This is especially the case for the 22 African countries where girls' education is expected to be disrupted by the effects of climate change the most.[64] Indeed, the effects of education on the empowerment of women and girls and youth not only amplifies the impact of education on adaptive capacity, but also contributes to reducing gender inequalities and addresses development gaps that put these groups at heightened climate risk in the first place.[65]

And finally, the achievement of climate justice through education—that is, educating learners to redress and transform the systemic inequities and injustices that drive climate vulnerability and generate the unequal and uneven burden borne by some more than others—is critical to closing the loop between education, empowerment, and adaptive capacity.[66]

FOUR WAYS TO ACCELERATE EDUCATION FOR ADAPTATION

In Africa, schools and other learning institutions are synonymous with developmental progress. They represent possibilities for children and provide nations with the human capital needed to drive toward a better future—even a future under climate change.[67] Indeed, schools connect people and places and offer hope, shelter and humanitarian assistance in a time of disaster. They are pathways for knowledge, skills and cultural exchange across diverse African communities, and thus they are essential in efforts toward strengthening climate resilience and adaptation.

Making education systems climate-adapted and ensuring that investments in education can in turn drive adaptation will require action across four distinct areas. First, data, diagnosis, and improved planning must underpin greater integration of education in adaptation strategies. Second, education infrastructure must be adapted to be more resilient itself and to act as a driver of resilience. Third, the education workforce must be supported and strengthened to play its role in educating young people and preparing them to be the climate-adapted workforce of the future. Fourth, education content and pedagogy must be oriented toward instilling climate literacy and a breadth of green skills for adaptation in all learners.

Monitor, Diagnose, and Plan for Integrated Education and Adaptation Strategies

It is clear that an investment in education does not present tradeoffs for African countries, but rather a multitude of co-benefits or win–win solutions when it comes to improving the climate resilience of essential social services and infrastructure, as well as strengthening the adaptive capacity of individuals and communities. However, data is a key challenge for adequately diagnosing the extent of disruption on education caused by climate change and for estimating the potential impact that greater investments in education could have on adaptation efforts.

More data is needed on a regular basis to better monitor, diagnose, and address local climate vulnerabilities of and local climate impacts on the education sector across the continent, including but not limited to data on school infrastructure, vulnerable groups of learners and teachers, days of learning lost, and "green" learning outcomes for climate adaptation. Importantly, this data must be user-friendly if it is to be integrated into adaptation policies.[68]

In addition to more data and analysis of the relationship between education and adaptive capacity,[69] greater efforts should be made to include education in adaptation policies and to investments that give priority to the most climate-vulnerable communities and those that are least ready to adapt. This is especially critical in the face of intense climate injustice across the continent.[70] Climate adaptation should not increase or result in new inequalities.[71]

Invest in Climate-Adapted Infrastructure

As a large subset of public infrastructure, government schools across Africa could play a big role in helping African communities adapt to the impacts of climate change. Schools could be designed to be capable of withstanding and/or adapting to climate-related shocks. African countries should avoid further investments in traditional "gray" education infrastructure that is vulnerable to damage or destruction or place the people inside them at higher risk of exposure to climate-related hazards. "Gray" education infrastructure refers to schools built with iron roofs, corrugated asbestos sheeting, or from shipping containers—unsustainable materials that are known for their poor ventilation and insulation.

Photo: Avatar_023/Shutterstock

Air temperatures inside classrooms constructed with these materials often exceed 30°C, causing heat stress and other heat-related symptoms, including thirst and drowsiness. Many of these structures are easily destroyed during flooding or windstorms.

In contrast, "green" infrastructure is both sustainably constructed and built with sustainable materials, allows for natural temperature regulation, produces its own electricity, uses less water, reestablishes endemic flora and fauna thus conserving biodiversity, incorporates herbal and animal corridors, includes space for growing fruit, vegetable, and medicinal gardens on campus, and uses in-house solar panels and/or hydroelectricity generators.

To some, climate-resilient, "green" public schools may be a futuristic vision for Africa, but it is desirable and realizable with international support.[72] African countries can tap into locally available renewable energy and material resources to build green, climate-adapted infrastructure that is both feasible and cost-effective. Evidence suggests that US$1 invested in resilience could save US$4 in post-disaster reconstruction.[73] Investing in climate-resilient infrastructure has been found to be 12 times more cost-effective than disaster relief assistance.[74] Failing to ensure that education infrastructure is resilient, in contrast, is both unsustainable and cost-ineffective, as climate change will cause further disruptions, shorten the rehabilitation life cycle, and increase repair and rehabilitation costs. In low- to middle-income countries, infrastructure disruptions, many of them caused by natural hazards, impose costs estimated at between US$391 billion and US$647 billion per year, putting extra strain on already limited budgets.

Building a climate-resilient education infrastructure in Africa could take three forms:

First, **public schools could be designed to naturally fit in the landscape**. Adapting education infrastructure must go beyond simple "climate-proofing" to consider ways of harnessing nature's capacity to reduce risks and build resilience, making schools practical examples of sustainability for learners and surrounding communities.[75] Such "green" climate-adapted schools can also create important opportunities to connect learners to Indigenous land practices and to nature, supporting both learning and learners' psychosocial health. Indeed, evidence outside of Africa suggests that increasing learners' access to such green space actually improves cognitive functioning, reduces stress, and improves wellbeing.[76]

CASE STUDY 1: School Water-Harvesting Project in Seychelles

The Republic of Seychelles is a Small Island Developing State off the coast of East Africa that has struggled to meet its people's water and sanitation needs. The low-lying archipelago is threatened by rising sea levels, and highly variable precipitation, with short, intense rainy seasons alternating with long, dry seasons and droughts.

Heavy rainfall strains water storage facilities and sewer reticulation systems, leading to increased likelihood of water pollution and disease outbreak.[77] At the same time, despite significant progress in providing clean water access, the country struggles with persistent water scarcity, which has been exacerbated by socioeconomic and demographic growth; on the main island, Mahe, demand was projected to rise by 130 percent from 2015 to 2030.[78] Schools' water consumption is also increasing, and the cost puts a large strain on their budgets.[79]


Photo: UN Women/Ryan Brown/Flickr

In 2010, the Climate Change and Development—Adapting by Reducing Vulnerability (CC DARE) project, funded by the Danish International Development Agency, began a rainwater-harvesting project in schools around the country.[80] The project takes advantage of the extremely wet rainy season to capture water that would normally have been lost through runoff and stores it for use during dry seasons. Along with providing water for the schools, the project teaches schoolchildren and the community about climate change and its effects on water resources, as well as about rainwater-harvesting as an adaptation strategy. Children have also had the opportunity to investigate their own water consumption patterns at school and have identified which activities consume more water than necessary. As a result of both water-harvesting and greater awareness of water consumption, the project has seen school water bills reduced by US$250 monthly. The cost savings are directed to other uses, including teaching and learning resources.

The harvested water has been used for organic garden projects at school that contribute to combating hunger and act as spaces for climate change education.[81] The involvement of learners throughout the planning and installation of water tanks equipped them with vocational skills, including welding, masonry, and painting, that can be applied elsewhere. And the project also led to improved public awareness of climate change in communities surrounding the schools.[82] The project partnered with several NGOs and government and has since been implemented nationally and has been incorporated into the national climate change adaptation strategy. The rainwater-harvesting system is part of building codes for new schools, government buildings, and communal infrastructure, with the larger aim of equipping all households with a rainwater-harvesting and water treatment system.

Second, **public schools in Africa can be the sites of government investment in renewable energy, new sustainable building materials, and sustainable design**. Extended roof surface areas and open grounds in African schoolyards can be utilized to set up solar systems, for example, to provide power to schools, enable more time for instruction and learning, and create living laboratories to study renewable energy and sustainability.[83] In South Africa, the introduction of solar-powered classrooms by Samsung generated nine hours of electricity per day per classroom, access to internet-based learning and teaching material, and led to improved pass rates from 66 percent to 96.5 percent.[84] Similarly, evidence from Ethiopia showed that investments in solar energy for school lighting led to more learning hours, including evening classes.[85] Research suggests that adapting education infrastructure in Africa does not have to be costly but can actually help countries save money while improving the quality of learning environments and learning outcomes. For instance, the solar energy firm Lumos estimates that adopting solar systems can reduce school expenditure on electricity and generators in Sub-Saharan Africa by US$55 a month, from US$70 down to US$15.[86]

Finally, as in other regions of the world, **public schools in Africa can be designed and built with multiple climate adaptation functions in mind beyond providing education**.[87] As a center for communities, schools can also improve resilience by providing shelter to communities (both people and livestock) during a climate-related event, serve as food distribution sites and conduct other post-disaster humanitarian assistance (especially if designed to help minimize post-disaster school disruptions), and can also provide land and utilities to enhance community resilience.

Invest in a Climate-Adapted Education Workforce

Strengthening the climate resilience and adaptive capacity of the education sector's human resources is critical to supporting the readiness of African education systems to respond to climate impacts. Importantly, a climate-adapted, climate-resilient education workforce—including teachers, trainers, facilitators, counselors, staff, administrators, school leaders, and others—is key to unlocking broader efforts across countries in Africa to build present and future generations of a climate-adapted, climate-resilient workforce across economic and social sectors.

Building a climate-resilient workforce requires action in four areas.

First and foremost, **Africa must overcome its teacher shortage**. The UNESCO Institute for Statistics estimated in 2016 that 70 percent of countries in Sub-Saharan Africa faced acute shortages of teachers at the primary level, rising to 90 percent at the secondary level.[88] This amounts to approximately 6.3 million additional primary school teachers and 10.8 million additional secondary school teachers needed through 2030. For African countries to tap into the power and potential of education for adaptation, they will need to invest in empowering and resourcing the teaching profession.

Second, **teachers and other members of the education workforce in Africa, especially those in rural areas, must be better and more consistently compensated,** so they can avoid having to engage in additional livelihood activities, including subsistence agriculture, to make ends meet.[89] Such occupational precarity leaves teachers and educators vulnerable to climate shocks and creates high teacher turnover, further weakening the education sector's resilience to climate-related disruptions. Unfortunately, there is very little research or data beyond anecdotal evidence on how climate shocks impact teachers and their retention. More attention is urgently needed.

Third, **teachers and other members of the education workforce have a strong desire to help prepare learners for a climate-impacted world, but they need time, training, resources, and support to do so effectively.**[90] Indeed, research suggests that quality education for climate action, including for adaptation, rests on employing experiential, project-based learning approaches that build skills such as critical thinking, futures thinking, and systems thinking.[91] Approaches to teaching and learning also need to be responsive to the traumatic impacts of climate change as they unfold across the continent in real time. And educators must themselves have a minimum understanding of climate adaptation, local adaptation needs, local resilience practices, and adaptation solutions—which many still lack.[92] Moreover, many education systems in Africa struggle to implement student-centered pedagogies.[93]

Photo: Giacomo Pirozzi/Panos Pictures

CASE STUDY 2: Sustainability Starts with Teachers

Sustainability Starts with Teachers (SST) is a capacity-building program with the objective of providing support to educators in implementing action-oriented transformative learning that integrates sustainability into all areas of education.[94] The program supports educators in 11 Southern African countries, targeting teacher educators in 118 teacher education institutes (TEIs), and covers early childhood, primary, secondary, and technical and vocational education and training.

The content covered in the program is anchored in all 17 Sustainable Development Goals, but guided especially by Goal 4, Target 4.7, which focuses on instilling in learners the knowledge and skills needed to promote sustainable development. It recognizes the role of teachers in translating climate change, environmental issues, and biodiversity conservation as informed by regional and global protocols into locally relevant educational content and pedagogical approaches. The program also recognizes teachers' role in shaping the worldviews and attitudes of learners, as well as their skills to engage in climate adaptation in their communities and beyond. Teachers are guided by a 5-Step Action Learning Programme Framework to develop contextualized climate change lessons and to create transformative learning environments.

Participation in the program is free of charge and obstacles to participation have been removed. For instance, participants in the program have zero-rated internet access to course material, including videos on climate change, impacts and climate adaptation. E-material can also be downloaded for reference and use by educators after the program. The program builds on the achievements of the UNESCO Global Action Program on Education for Sustainable Development and is implemented in partnership with Rhodes University's Environmental Learning Research Centre, Southern African Regional Universities Association (SARUA) and the Swedish International Centre of Education for Sustainable Development (SWEDESED).

Photo: Richard Juilliart/Shutterstock

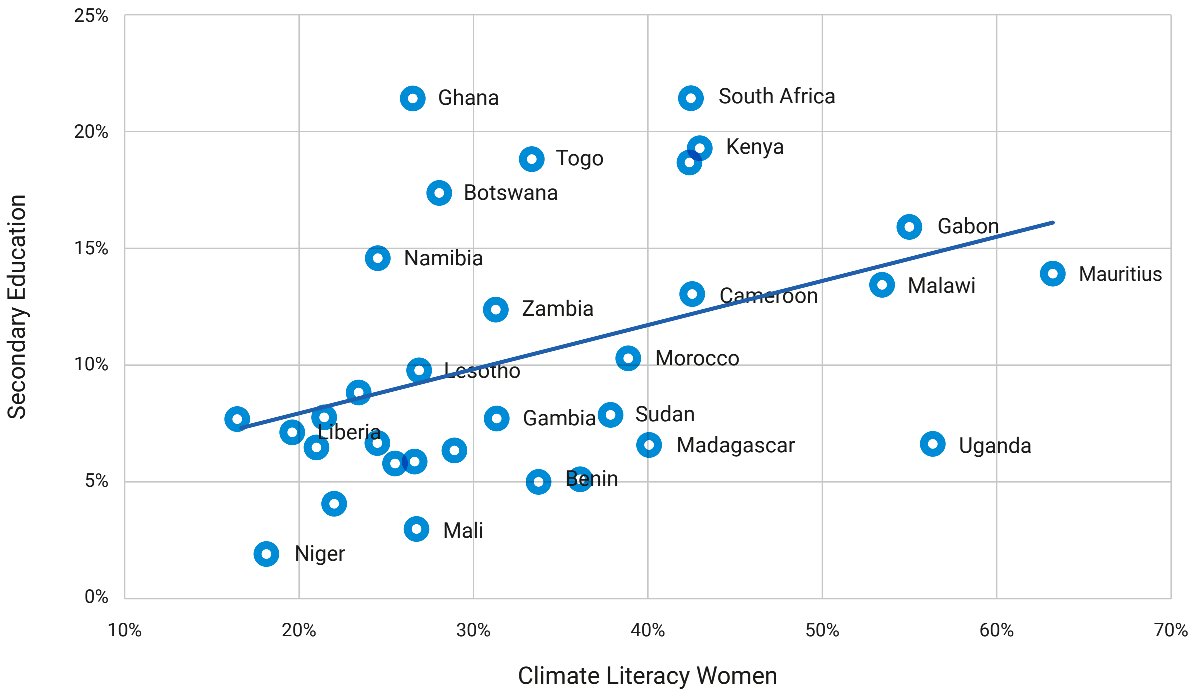
Finally, **cross-sectoral climate resilience teams could help climate-proof education systems, including teaching and learning.** To enable effecti design of climate-adapted education systems, a new form of workforce collaboration will be required that reaches across sectoral boundaries. These cross-sectoral climate resilience teams should include those working in climate; WASH; energy; agriculture; health; construction; gender; and social protection—not to mention teachers who can ensure learning connections. Indeed, learning teams that engage different ministries (including but not limited to education), trade unions and employer networks can help to ensure that adaptation investments are in sync with available skills and unlocked with new skills.[95] The concept of learning teams is relatively new in education, but it is gaining increasing momentum as a win–win solution for education and climate action.[96] Such cross-sectoral teamwork requires a change in mindset: from consolidated practices by relevant sectors, to integrated expertise in service of building climate adaptation and resilience through education.[97]

Invest in Climate Literacy and a Breadth of Green Skills for Adaptation

Education for adaptation creates the building blocks of adaptive capacity, which is especially important for climate-vulnerable countries across the African continent. Importantly, climate change education must integrate Indigenous technical knowledge and universalistic science, and it must reflect local practices in its approach to adaptation responses.[98]

At minimum, all learners must first acquire basic foundational and secondary skills, including literacy and numeracy, to support climate adaptation efforts across every sector of the economy.[99] But in addition to basic skills, all learners must achieve **climate literacy**—or an understanding of the anthropogenic causes of climate change and the role that individuals, communities, and societies can play in adopting systems and behaviors that both mitigate against further environmental damage and adapt to present and future impacts of climate change.[100] Climate literacy enables informed decision-making about local adaptation by increasing the ability to comprehend climate information. Higher climate literacy is associated with reduced injuries and death from climate disasters, as well as higher community resilience.[101] And, unsurprisingly, higher climate literacy is positively correlated with higher levels of education—especially secondary education, and especially among women (Figure 5).

Figure 5. The Relationship Between Climate Literacy (2016–2018) and Secondary School Attainment Among Women (2015–2020) in 30 African Countries



Data sources: Wittgenstein Centre Human Capital Data Explorer and Simpson et al. (2021)[102]

Photo: Corrie Wingate Photography/SolarAid/Flickr

All learners will also need to build a breadth of green skills for adaptation to navigate the technical needs, socioemotional dynamics, and transformative potential of green jobs for adaptation and resilience.[103] This includes specific skills that green jobs for adaptation and resilience might require, from project management to product development, from ecosystem management to disaster risk reduction, from sales and marketing to science, technology, engineering, and math (STEM) to support adaptation innovations. Green skills for adaptation also include "portable" or transferable skills like critical thinking, decision-making, communication, empathy, flexibility, and adaptability that can facilitate climate-adapted thinking, being, and doing, regardless of one's occupation. And finally, transformative skills like working within complexity, coalition building, collective action, solidarity, agency, and justice-oriented civic skills will be vital to supporting deeper systems change for long-lasting, equity-oriented, and equality-producing adaptation for transformation.[104]

CASE STUDY 3: Building a Breadth of Skills to Support Adaptation in Agriculture

Despite their limited contribution to climate change, women are on the frontlines of climate change in Africa because of their gendered roles and responsibilities. To address this, the Campaign for Female Education (CAMFED), an international non-governmental organization working on issues of girls' education and women's empowerment across Africa, has started to equip thousands of female Agriculture Guides (former beneficiaries of CAMFED scholarships) with a breadth of green skills for adaptation to support their and their communities' adaptive capacity and climate resilience.[105] The program builds their technical knowledge and skills in climate-smart agriculture to improve the productivity, sustainability, and profitability of their agricultural enterprises. And the program uses its life skills focus to strengthen girls' critical thinking, decision-making skills, leadership, confidence, and sense of agency. Further, the program's attention to systems change builds girls' solidarity, collective action, and advocacy skills to transform social norms and harmful gender practices that have traditionally held girls back.

Photo: Marcel Crozet/Flickr

The Agriculture Guides then pass on the fruits of their education through training and mentorship to build the skills of smallholder farmers and parent support groups that grow food in school gardens to feed vulnerable children in their communities. The project is instrumental in mitigating against school interruptions for girls, especially those whose education is under threat from the indirect effects of climate change on their households. The program also helps young women build climate-smart livelihoods, enhance the food security of their communities, and build their individual leadership and collective resilience.

In Zambia, the project was boosted by the allocation of 304 hectares of multipurpose agricultural land to young women leaders to establish large-scale climate-smart demonstration farms led by the Agriculture Guides. The project's first phase benefited 40 CAMFED Agriculture Guides, who then cascaded their knowledge and skills to reach more than 8,500 women. Together, they were able to achieve significant yield improvements, up to three times compared to baseline. Additionally, each Agriculture Guide went on to support three more girls to go to school and created an average of four paid jobs in her climate-smart agricultural enterprise.

CAMFED has over 7,000 government partner schools across more than 150 districts in Ghana, Malawi, Tanzania, Zambia and Zimbabwe, and has supported nearly 5 million children to go to school since 1993. CAMFED has a five-year ambition to scale this project to help 50,000 young women transition into productive and sustainable agricultural enterprises, to reach 750,000 more community members through the mentorship of CAMFED Agriculture Guides, and to create 150,000 new climate-smart jobs.

In short, effective climate adaptation means educating the workforce with the knowledge and skills needed to power the jobs that will support whole-of-economy adaptation efforts. This will require educating the present and future workforce to understand how climate change impacts their profession or livelihood and how their profession or livelihood might impact climate change. In some cases, education may also be required to build the capacity of those most vulnerable members of society in climate-impacted livelihoods to move to climate-adapted ones. In Africa, this is more than just climate-smart agriculture; it also includes climate-resilient infrastructure (including adapting education infrastructure), natural resource management and nature-based solutions, climate information services, as well as adaptation-oriented micro, small, and medium enterprises that promise to create job opportunities while building climate resilience across Africa.[106]

Photo: Laurent Weyl/Panos Pictures

RECOMMENDATIONS

To make progress on the four levers described in the previous section, a regional effort in the form of an "Education for Adaptation Accelerator (E4AA)" Alliance is urgently needed. The proposed objectives of the Alliance would be threefold: to bring stakeholders together to establish an irresistible case for education for adaptation; to support countries to identify and activate effective education for adaptation efforts across the four areas identified above that could be localized and scaled; and to build a global movement that champions education for adaptation. Africa, as the continent with the fastest-growing youth population, could lead this Alliance. More specifically, the Alliance could formulate an agenda encapsulated by the slogan "Analyze, Act, Amplify":

Analyze: Establish an Irresistible Case and Evidence-Based Narrative

Spotlight the case around education's impact on building the adaptive capacity and climate resilience of individuals and communities. Building on existing education, workforce, and climate science datasets, the E4AA Alliance should not only work to fill critical data gaps on education for adaptation, but also create a first-of-its-kind model for calculating the transformative potential of education in building the specific and adaptive capacities for climate resilience.

Bring together evidence of effective adaptation programs that put education at the center of climate adaptation efforts across the four areas identified above. Working together with partners across the African continent and beyond, the E4AA Alliance should build a set of adaptation education case studies to help the global community and African decision-makers develop tools and resources for implementing education that can unlock short-term and long-term adaptation, transition, and transformation.

Act: Support Countries and Communities to Invest in Education for Adaptation

By 2025, the E4AA Alliance could work with 10 of the most vulnerable countries (members of the Climate Vulnerable Forum, with an initial focus on Africa) to ensure adaptation education and adapted education systems are a key part of their National Adaptation Plans.[107] The E4AA should support countries to coordinate and build domestic and global coalitions of organizations to provide technical assistance and build local capacity along all four acceleration pathways identified above. In addition, the E4AA should support countries to leverage international and domestic expertise, including youth, to conduct adaptation education needs assessments and to develop national adaptation education strategies or other relevant policy support.

By 2025, the Alliance could work with 10 education providers with community reach and expertise across Africa and a coalition of youth in Africa to develop localized adaptation education tools and content based on climate change education design principles and Indigenous knowledge. The E4AA should develop global climate resilience and adaptation education tools that can be localized to support implementation of education for adaptation. Importantly, such efforts should redress entrenched systems of injustice and inequality, including gender inequality, and should twin the goals of climate literacy and climate justice by building individual and collective agency for civic empowerment.[108]

Amplify: Build a Movement for Climate Adaptation Through Education

Establish a High-Level Advisory group, including youth representation, to steer the work of the E4AA Alliance and to help mobilize national and global champions of education for adaptation. Such a network should work to direct attention to education for adaptation at high-level events like COP, UNGA, and the Global Education Forum in order to mobilize resources to education as a key pillar of adaptation efforts.

Develop a communications and engagement strategy to create visibility and uptake for the knowledge work of the E4AA Alliance. This could include the publication of a flagship report, guidance notes, technical briefs, and an annual synthesis of best practices in adaptation education; the dissemination of web-based calculator tools to support decision-making; a global social media campaign that raises the visibility of locally led programs; and the facilitation of peer-to-peer learning.

Institutional Arrangements for Adaptation

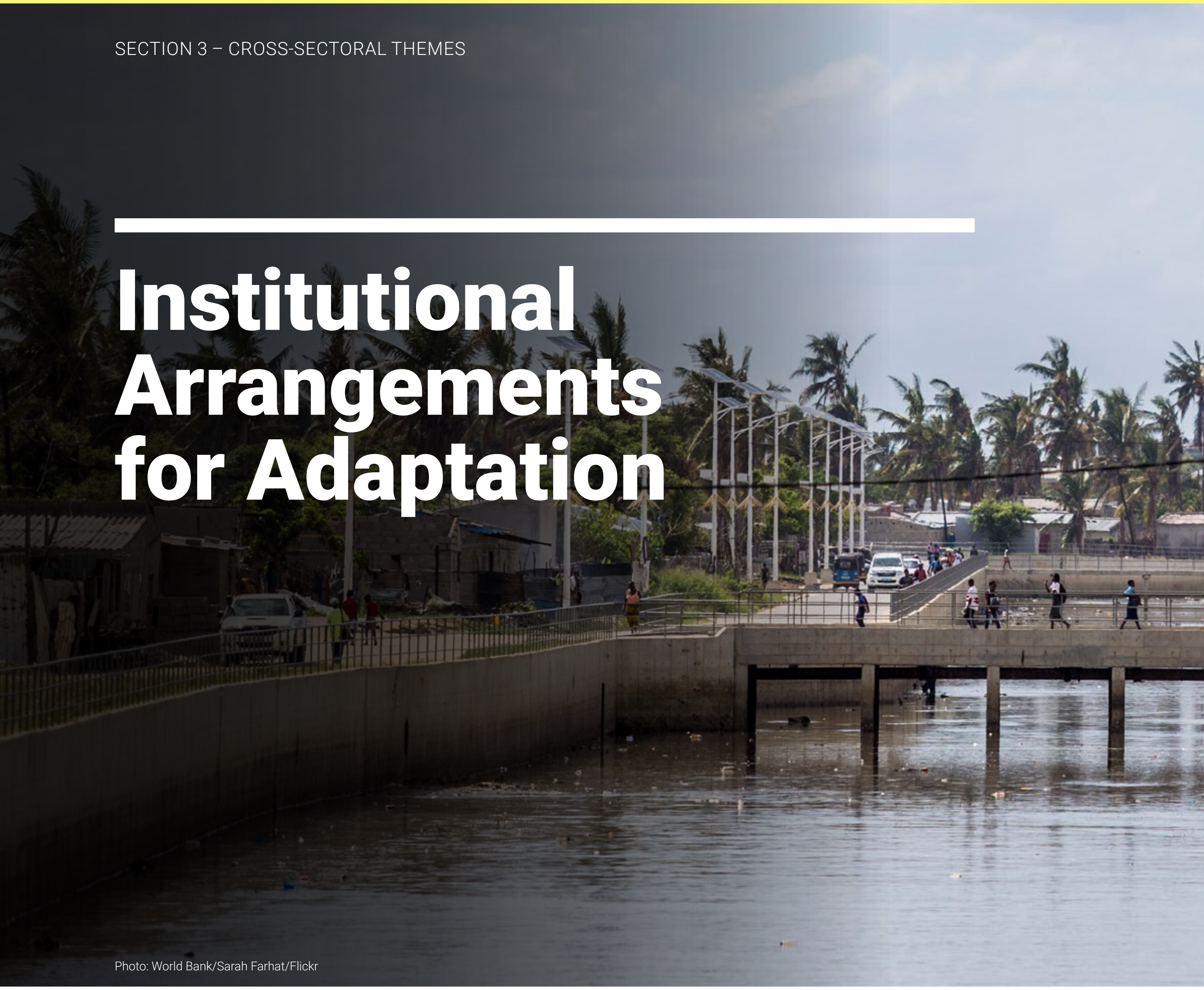


Photo: World Bank/Sarah Farhat/Flickr

KEY MESSAGES

- Setting up an institutional framework for climate governance is crucial to plan, legislate and manage the implementation of adaptation actions in a country. For Africa, progress has been made in setting up the institutional arrangements, but challenges remain when it comes to setting clear roles, mainstreaming finance, and disaster risk reduction considerations throughout the process, and having a monitoring system in place for measuring progress and contributing to transparency, among others.
- The Nationally Determined Contributions (NDCs) enhancement mechanism provides an important opportunity for African countries to establish clear institutional arrangements to support the successful implementation of adaptation actions and to increase the transparency of their climate adaptation communication. Nevertheless, some countries still state the need for capacity building and finance to support the process.
- Seven African countries have submitted an Intended Nationally Determined Contribution (INDC) and 46 have submitted updated NDCs. Of these, 25 describe their institutional and governance framework in a more detailed manner, 11 do not explicitly mention an institutional framework in place, and 17 signal the intent of developing, adapting, or reinforcing an existing one that is not described with details.

- Joint responsibility between the leading institution of climate change adaptation activities and finance ministries can reinforce alignment with national budget frameworks and help attract international climate finance. For Africa, finance ministries are generally included in some parts of NDC or National Adaptation Plan (NAP) institutional arrangements as budget holders and financing procurement institutions rather than as co-leads.
- Aligning disaster risk policy frameworks with climate adaptation institutions and frameworks instruments is imperative, especially for African countries, which are hardest hit by climate-related disasters.

"

Africa is staring down the pillars of this global crisis of the climate. But you have shown the courage to set the resilience agenda at the center of your development efforts. And you have put your own money to use in the fight against the climate breakdown. Together, you are leading the African Union, the Climate Vulnerable Forum, the pre-COP to Sharm el-Sheikh. Together, you are an extraordinary coalition for a new way forward for Africa and for the world."

Ban Ki-moon
8th Secretary-General of the United Nations and Chair of the Global Center on Adaptation

INTRODUCTION

The 2015 Paris Agreement put forward a global goal of "enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change" (Article 7.1).[1] Parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed to submit Nationally Determined Contributions (NDCs)—non-binding climate action plans including domestic and international actions to mitigate and adapt to climate change. This provided countries with a new opportunity to communicate how they intend to contribute to enhancing adaptive capacity and building resilience. In line with the Paris Agreement, Parties were asked to submit enhanced NDCs in 2020.[2]

Photo: peeterv/iStock

One crucial element of the enhancement process is establishing clear institutional arrangements to support the successful implementation of adaptation actions.[3] Parties of the UNFCCC are encouraged to set institutional arrangements that provide transparency to the process through their NDCs.[4] "Institutional arrangements," as referred to in this chapter, include the policies, systems, and processes that governments use to plan, legislate, and manage their activities to fulfill their climate mandates and international commitments.[5]

A 2019 report on enhancing NDCs by the World Resources Institute and the United Nations Development Programme (UNDP) suggested that when establishing institutional arrangements during the NDC enhancement process, countries identify a lead institution and ensure intra-governmental coordination that accounts for the inclusion of all relevant ministries, other non-governmental stakeholders, and parliament, as also alignment with other development and sectoral processes.[6] Furthermore, governance practices for climate-resilient development are expected to be most effective when both formal (e.g. the law) and informal (e.g. local customs and rituals) institutional arrangements are integrated, thereby enabling ongoing coordination across levels of governance.[7]

For Africa, of the 53 UNFCCC-affiliated countries, seven have submitted only an Intended Nationally Determined Contribution (INDC) and 46 have submitted updated NDCs.[8] GCA's analysis of African NDCs revealed a wide variation in the details provided by individual countries of institutional arrangements for the implementation and tracking of their climate actions: 25 describe their governance framework in a detailed manner, 11 do not explicitly mention an institutional framework in place, and 17 signal the intent of developing, adapting, or reinforcing an existing one that is not described with details. The National Adaptation Plans (NAPs) also provide detailed information on country governance for adaptation, though these are considered more a national planning process than an international communication process.[9] Only nine African countries have developed and submitted a NAP since 2020.[10]

GCA's State and Trends in Adaptation 2021 (STA21) report examined the institutional arrangements for finance and the efforts to mainstream climate change in national planning and finance in five African countries. The STA21 analysis found that while significant strides have been made in integrating climate adaptation and resilience into long-term planning, there is still room for improvement. Many institutional arrangements for the NDCs do not include the Ministry of Finance as

a co-lead in the UNFCCC process, but mostly as budget provider.

This chapter first describes and highlights the utility of toolkits for assessing institutional arrangements, namely the World Bank's Climate Change Institutional Assessment (CCIA) and the Capacity for Disaster Reduction Initiative's Digital Tool for Disaster Risk Reduction Capacity Diagnosis and Planning. It then presents an analysis of the institutional arrangements described in 10 selected African country NDCs or NAPs, first outlining a general emerging pattern and then drawing out specific country examples related to implementation, finance, and institutional arrangements for Monitoring, Reporting, and Verification (MRV) systems. The final section highlights the benefits of embedding disaster risk reduction (DRR) and disaster risk management (DRM) into a country's institutional framework, focusing on the case of Malawi as a good example. Lastly, policy recommendations are provided for the way forward.

INSTITUTIONAL ASSESSMENT TOOLS FOR ADAPTATION

The Climate Change Institutional Assessment (CCIA)

Climate change creates short- and long-term impacts on several sectors of the economy, environment, and society. These challenges need to be met with effective coordination between multiple public and private actors for action to be planned, implemented, and sustained over time.

The World Bank has developed the CCIA as a tool to identify the strengths and weaknesses of a country's institutional framework for addressing the governance challenges that climate change poses.[11] The assessment tool is for government officials participating in policy, planning, implementation, and finance. It can be used by governments at any stage of the development of their climate change institutional framework.

The CCIA is being used in the World Bank's new Country Climate and Development Reports (CCDRs). These are core diagnostic reports that integrate climate change and development considerations that will help countries prioritize the most impactful actions that reduce greenhouse gas (GHG) emissions and boost adaptation.[12] The CCDRs build on data and rigorous research and identify main pathways to reduce climate vulnerabilities, including the costs and challenges as well as benefits and opportunities from doing so. The reports suggest concrete, priority actions to support the low-carbon, resilient transition. CCDRs will feed into other core World Bank Group diagnostics, country engagements, and operations, and will help attract funding and direct financing for high-impact climate action.

CCIA focuses on five pillars crucial to consider when designing and planning the institutional arrangements for climate governance of a country, which are: organization; planning; public finance; subnational governments and state-owned enterprises; and accountability.

The organization pillar focuses on assessing the way a country's institutions in charge of climate change policy are organized. CCIA appraises the regulatory framework, functional mandates, government coordination, and technical capacity of government agencies to support and carry out climate change policy. The pillar aims to understand the scope of framework legislation (long-term targets, risk and vulnerability assessments, climate strategies and plans, etc.), the assignment and implementation of core mandates, the scope of horizontal coordination arrangements, and in-house climate expertise, among others.

The planning pillar focuses on evaluating a country's systems for climate change risk and vulnerability assessments, strategies, and plans—assessing the consistency of goals with policies. It considers the long-term strategies (i.e. country long-term objectives and targets for resilience and adaptation, forward-looking development strategies), medium-term strategies (consistency of a country's NDC with sector targets, adaptation goals, cost estimates), availability of climate risk and vulnerability assessments, integration of adaptation into national development plans, and assignment of MRV functions, among others.


Photo: BinyamTeshome/World Bank/Flickr

The public finance pillar focuses on how a country has integrated its climate strategies, plans, and policies into the fiscal and public financial management systems and its practices and mobilization of resources for climate action. The pillar considers the integration of climate change into fiscal risks and expenditure plans; the integration of climate change considerations into infrastructure governance regulation, strategies, and planning; green procurement regulation; and the institutional framework for mobilization of climate finance, among others.

The pillar on subnational governments and state-owned enterprises focuses on the management of climate change within the intergovernmental system and state-owned enterprises, as well as incentives for climate action and the capacity of subnational governments. The pillar includes functional assignment coordination and capacity, subnational climate finance, and strategic and land-use planning.

The accountability pillar focuses on transparency and stakeholder engagement mechanisms for civil society, the private sector, and other stakeholder involvement in climate change policy processes. It also considers the roles of expert advisory and oversight institutions that ensure accountability and transparency. The pillar considers the availability and effective communication of key information, requirements for engagement with diverse stakeholders (e.g. the private sector, civil society, the scientific community) in the planning process, the mandate and authority of independent expert advisory bodies, audit institution reviews of government climate change policy, and the authority of courts to review compliance with the regulatory framework for climate action, among others.

The World Bank emphasizes that the government institutions should coordinate to carry out climate change policy based on medium- and long-term plans and goals. Additionally, vertical and horizontal intergovernmental coordination arrangements, alignment of national policy with international commitments, and a solid accountability system are crucial factors for a well-structured institutional framework.

The CADRI Digital Tool for Disaster Risk Reduction Capacity Diagnosis and Planning

The Capacity for Disaster Reduction Initiative (CADRI) is a global partnership integrated by 20 humanitarian and development organizations that give countries access to expertise in DDR and climate change adaptation (CCA).[13] It was launched in June 2007 at the Global Platform for Disaster Risk Reduction. CADRI seeks to advance knowledge and good practices in DDR and implement a more coherent approach to capacity development across the humanitarian and development realms.

CADRI's newest tool, the CADRI Digital Tool for Disaster Risk Reduction Capacity Diagnosis and Planning,[14] was designed to support countries in their efforts to strengthen their national and local capacities for reducing disaster and climate-related risks. A core component is the question bank, reflecting the collective DDR and CCA experience and knowledge of the CADRI partnership members. This is a live document that users have the opportunity to contribute to by recommending adjustments to existing questions or adding new ones.

Registered users have access to the tool functionalities with which design, planning, and implementation capacity assessments can be made. These assessments can be comprehensive or focused on specific sectors and hazards. Non-registered users have access to the question data bank and can perform customized searches for specific guidance on key issues to consider when building DRR and CCA capacities at national and local levels.

The tool allows users to:

- Draw up capacity reports on: DRR and Capacity Diagnosis, Disaster Preparedness Capacity Diagnosis, CCA Capacity Diagnosis, Risk Information Capacity Diagnosis.
- Create projects and teams: The tool functionality allows for a global database of DRR and CCA experts. The profiles can be used during the design and planning phases to identify suitable experts.
- Customize questionnaires using the question data bank to match the scope of the capacity diagnosis they are planning to carry out.

NDC AND NAP—AN ANALYSIS OF INSTITUTIONAL ARRANGEMENTS

NDCs and NAPs are considered valuable resources to understand how the institutional arrangements in different countries in Africa work. Nevertheless, Global Center on Adaptation (GCA) analysis shows that they only capture a limited part of the formal and informal governance setting in the countries.

For the analysis, the NDCs or NAPs of 10 African countries from the UNFCCC registry were used, where such documents were considered to demonstrate clear institutional arrangements and were written in English. There was also an attempt to make the selection regionally balanced (ideally two institutional frameworks analyzed per African sub-region). The 10 countries selected for this study are: Egypt, Liberia, Tanzania, Namibia, Rwanda, Sierra Leone, South Sudan, Malawi, Angola, and the Democratic Republic of the Congo (DRC).

This section first outlines general patterns of institutional arrangements emerging from the analysis, followed by a closer look at the elements of NDC/NAP implementation, MRV, and finance. The section ends by highlighting the role of DRR and DRM components within a country's institutional framework. Throughout, we provide country-specific examples and showcase examples of good practice. It is important to note, however, that a deeper analysis of the full body of NDCs is necessary to draw more concrete conclusions and generalizable recommendations.

General Patterns

Generally, the role of the supreme institutional body responsible for climate change is given, by a decree or law, to a specific ministry, government office, or institution. The process of creating a mandate to set up the institutions in charge of climate governance is agreed upon by a parliament or congress or comes directly from the President or Prime Minister. Supreme institutional bodies can be either a National Climate Change Steering Committee chaired by the Vice-President's Office (as is the case in Egypt, Liberia, and Tanzania, among others), or a Ministry of Environment, which might be the supervisor or chair of a Directorate, Steering Committee, or management authority (this is the case in Sierra Leone, South Sudan, Malawi, Angola, and the DRC, among others).

The supreme institutional bodies are often supported by a technical secretariat or committee that aids in providing technical assistance and building capacity. The technical secretariat can be embedded within the Directorate, Steering Committee, or management authority, or a separate committee can be established to ensure the implementation of its daily activities. For Sierra Leone, for example, consultative committees provide policy and implementation advice to the Steering Committee on relevant issues and support the NAP implementation through research, capacity building, and awareness-raising.

An institution is set as the focal point for the UNFCCC processes and oversees the reporting commitments of the progress of the NDC and NAP actions. In some cases, the supreme institutional body, the technical secretariat, and the institution in charge of being the focal point for the UNFCCC process can be the same (e.g. in Namibia).

Countries often report having aligned their NDC or NAP actions to general development, climate change, or environment mid- and long-term strategies and policies—allowing the institutions to coordinate climate actions and avoid policy misalignment. Examples of this are Liberia's National Policy and Response Strategy on Climate Change (2018), Tanzania's National Climate Change Response Strategy (2021), and Angola's National Strategy for Climate Change (2017, amended 2021), among others.

To ensure transparency, MRV systems are planned or are set up to guarantee countries can track the progress of their NDCs and NAPs and communicate their results. The institution in charge of this process can be the same as the focal point of the UNFCCC, but in some cases, organizations from outside the government can oversee tracking progress (e.g. in Tanzania, this is done by the National Carbon Monitoring Centre at the Sokoine University of Agriculture).

Financial issues, such as resource mobilization and reporting on finance of the countries, are made by financing bodies that can be the Ministry of Economy or Finance (e.g. South Sudan, Rwanda, Malawi, DRC, among others) or the local government, although in some instances this is not clearly stated. The integration of the Ministry of Finance with the Ministry of the Environment as co-leads that provide policy oversight, coordination, and resource mobilization has been observed in the case of Sierra Leone.

Finally, to connect the national to the local level, national-level government bodies and ministries can act as implementing entities, with local-level government bodies responsible for executing adaptation interventions on the ground (e.g. Tanzania, DRC, South Sudan). Details of this matter are not always mentioned in the NDCs or NAPs.

Next, we highlight some of the patterns of NDC/NAP implementation, MRV, and finance that emerged from the analysis.

Implementation

Generally, implementation of the NDC is overseen and/or coordinated by an overarching committee or governmental body, while execution of the interventions or actions is undertaken by relevant sectoral or provincial ministries. The overseeing committee for implementation is often the supreme institutional body, although this was not the case for all. Some NDCs reported implementation plans that were already in place, while others outlined plans for NDC implementation that were still to be formalized. For those that reported plans already in place, the sectoral or provincial ministries with which responsibilities lie are generally articulated and named; whereas for those communicating future implementation plans, the roles and responsibilities of specific ministries tend to be less clear. Tanzania and the DRC are two examples of countries with NDC/NAP implementation plans in place, with a clearly defined coordinating body and local sectoral/provincial ministries in charge of implementation. Angola and Liberia are two examples of countries still at the planning stage.

In Tanzania, the National Climate Change Steering Committee (NCCSC) and Zanzibar Climate Change Steering Committee (ZCCSC) are responsible for guiding the coordination and implementation of the NDC. They also ensure cross-sectoral participation. Sector ministries, in collaboration with Local Government Authorities, are responsible for implementing the adaptation interventions and are responsible for preparing sector-specific initiatives. The Tanzanian NDC stipulates that initiatives should detail each action to be undertaken and how they will be achieved; a timeframe for their implementation;

the means of tracking their progress; the source of funding; and alignment with other national and international policies and strategies to attract international climate finance.[15]

In the DRC, the National Committee on Climate Change coordinates climate efforts with relevant ministries and governmental bodies, as well as with local governments through its engagement with the Provincial Committees on Climate Change. Additionally, the DRC has a Working Group on Adaptation Measures, which coordinates the implementation of adaptation-specific measures in the country with all relevant ministries and the Ministry of the Environment and Sustainable Development.

In Angola, the coordination oversight of implementation will lie with the Ministry of Culture, Tourism, and Environment (MCTA), while implementation will be undertaken by ministries in charge of core adaptation contributions. Angola created the National Commission on Climate Change and Biodiversity (CNACB) in 2012 with the mandate to create enabling conditions for the execution and implementation of the National Strategy for Climate Change and to develop a national investment plan for climate change, drought, desertification, and biodiversity. Angola's NDC outlines a proposed redefinition of the Commission's responsibilities, functions, and objectives.[16] It was remarked that extending participation in this commission to provincial governments is crucial for the decentralization process. In light of this, it is proposed that the composition of the Commission incorporates other ministerial departments and public institutions relevant to the implementation of NDC, and that coordination and cooperation efforts across different sectors of NDC initiatives are increased.

Liberia's updated NDC outlines the consultative process through which the country's first NDC was reviewed to inform the updated NDC.[17] With support from the NDC Partnership, Liberia has initiated the process of developing an NDC Implementation Plan. The plan will detail short- and long-term actions required to reach the climate adaptation goals outlined in the revised NDC. It will define the roles and responsibilities of relevant institutions and institutional arrangements for implementation, coordination, reporting, support, and finance. The implementation plan also describes an MRV system to track progress toward the achievement of the NDC targets.

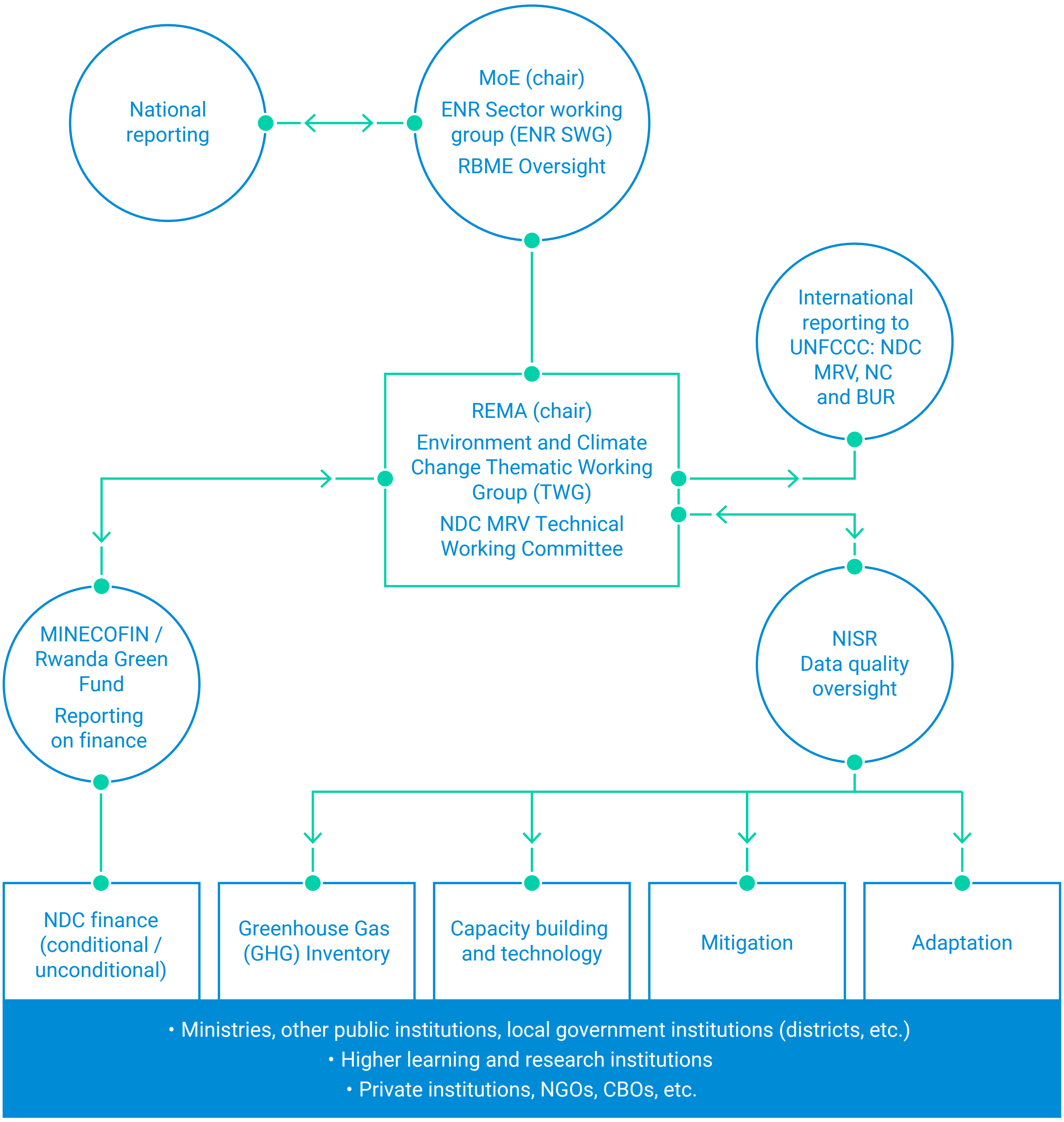
Monitoring, Reporting and Verification Systems

An effective MRV system is necessary for successfully implementing adaptation measures outlined in the NDCs, monitoring their effectiveness, and crucially attracting and facilitating access to climate finance. Some countries outline a robust MRV system, while others signal intent to develop one or report the need to strengthen an existing one. Our review indicates that all countries recognize the importance of MRV for NDC transparency and accountability.

Rwanda outlines a robust MRV system with a coordinated institutional framework and clearly defined ministry roles and responsibilities. The Rwanda Environment Management Authority (REMA) has the overall responsibility for and chairs the Environment and Climate Change Thematic Working Group, which hosts a national planning forum. This forum hosts a core team that forms the NDC MRV technical working committee with the following responsibilities: creating guidelines and common standards, templates, and formats for reporting MRV results; defining common data sources and methods for compiling NDC MRV results; endorsing the NDC MRV and communicating results for upstream NDC MRV-based policy and strategic decision-making; and institutional strengthening and capacity building.

Primary data is generally collected at the local/district level, which has direct linkages with sectors and institutions for sourcing relevant sector or priority action-specific data. This is done with support from multiple district-level stakeholders through the Joint Action Development Forum, which facilitates the engagement of NGOs, the private sector, and development partners to provide inputs into the NDC MRV process. The Ministry of Local Government (MINALOC) provides coordination oversight, and the National Institute of Statistics Rwanda (NISR) validates national statistics. Rwanda's NDC outlines line and lead ministries responsible for monitoring and/or reporting specific adaptation indicators. It also outlines high-level national or global indicators in place to harmonize reporting on climate adaptation and resilience.

Figure 1. Institutional Arrangements for Tracking Rwanda's NDC MRV Implementation



Source: Reproduced from Figure 7.1 of Republic of Rwanda (2021)[18]

Namibia mentions current efforts to strengthen its existing institutional arrangements for a robust MRV system. A conceptual MRV was presented in its Biennial Update Reports 1 (2014) and 2 (2016), with the intent of its implementation. Namibia reports that some progress has been made, but that this progress is still insufficient to meet reporting requirements. One major gap identified is the inability of the system to effectively aggregate the cumulative effects of individual adaptation actions.

Liberia has an MRV system in place for mitigation actions. For adaptation, the country has a monitoring and evaluation (M&E) system. Plans for an MRV system that tracks the progress of NDC implementation further than mitigation elements are under way, which will build upon the existing structures for M&E and inter-sectoral coordination. The country stipulates that it will require support to ensure the strengthening of this MRV system, including institutional arrangements and responsibilities, developing indicators, and methodologies.

Finance

The STA21 analysis showed the importance of the commitment of countries like Kenya, Rwanda, Ethiopia, Uganda, and South Africa to integrate climate change considerations into planning, budgeting, implementation, and decision-making at the national and county levels, and across all economic sectors. Ensuring joint responsibility between the leading institutions of CCA activities and finance ministries can strengthen alignment with national budget frameworks.

In the case of Sierra Leone, an Inter-Ministerial Committee (IC) and a Parliamentary Committee (PC), were created to gain the political and legislative support needed for implementing the NAP. The IC is co-chaired by the Ministries of Environment and Finance, which in collaboration provide policy oversight, coordination, and resource mobilization for the NAP. With some other countries, the Ministry of Economy or Finance is responsible for the procurement of resource mobilization and reporting on finance of the countries, but they do not seem to co-lead the process with the supreme institutional bodies (e.g. South Sudan, Rwanda, DRC, among others). These ministries can establish which actions are conditional to international finance and which ones can be committed through internal sources (i.e. national, provincial, local governments, or private institutions).

In some cases, finance ministries are provided with more roles and responsibilities. For instance, Rwanda's Ministry of Finance and Economic Planning (MINECOFIN), in addition to reporting on finance, is involved in the overall coordination of M&E activities (including NDC MRV) from planning, data collection, and reporting at all levels, among other responsibilities.

It appears that institutional arrangements for finance, similarly to almost all other elements explained here, usually consider mitigation and adaptation jointly and do not report individualized institutional arrangements for each type of climate action.


Photo: Graham Montanari/iStock

EMBEDDING DISASTER RISK REDUCTION AND MANAGEMENT IN INSTITUTIONAL ARRANGEMENTS FOR ADAPTATION

The importance of DRR and DRM institutional frameworks, policies, and processes is being increasingly recognized at national and international levels.[19] There is also a strong consensus on the urgent need to move from response strategies to disaster preparedness and risk reduction. International commitments on DRR are reflected in the Sendai Framework for Disaster Risk Reduction (2015–2030) and its predecessor, the Hyogo Framework for Action (2005–2015).[20] Aligning policy frameworks with international instruments and enhancing national DRR strategies and coordination efforts is imperative, especially for African countries, which are hit very hard by disasters, particularly in terms of impact on livelihoods, physical and natural resources, and ecosystems.[21]

The water chapter in STA21 presents an analysis of the linkages between DRM and climate adaptation within the water sector in Africa.[22] It shows that Integrated Water Resource Management (IWRM) and DRR generally do not have coordinated actions and programs under different institutions. The analysis shows that the growing urgency of climate adaptation actions makes this coordination even more critical. The water chapter in STA21 goes into further technical detail about this analysis.

DRR and DRM together constitute a dynamic process that needs continuous adjustments, decision-making, and cooperation at multiple levels among a wide range of institutions and actors, including government, non-governmental organizations, private agencies, communities, households, and individuals. Optimal institutional management requires flexibility to adapt response measures according to the unique and ever-changing features of the current disaster.[23] Greater participation in public decision-making can improve efficiency, equity, and resource management in the context of DRM. Decentralizing government decision-making, through having clearly defined stakeholder roles to inform or control the process, may increase public sector accountability and effectiveness.[24] Autonomy in decision-making of local agencies during a disaster is central to timely and effective disaster response.[25]

Thus, there is clear value in integrating DRR and DRM into national institutional arrangements for increased coordination and more effective disaster response and preparedness efforts. The importance of this is recognized by countries, as presented in their NDCs, to varying extents, and is also integrated into broader country institutional frameworks to varying extents. For example, Namibia presents DRM as an adaptation priority area of which the Ministry of Urban and Rural Development (MURD) is the leading ministry and includes one targeted action within this priority area of improving information flow and communications between formal structures at the national, regional, and community levels. Liberia's Environmental Protection Agency (EPA) coordinates with the National Disaster Management Agency on the fulfillment of its NDC and provided inputs to the

consultative process when designing the NDC. Egypt states alignment of its NDC to its National Strategy for Adaptation to Climate Change and Disaster Risk Reduction.

Malawi presents a good example of integrating DRR and DRM into the country's institutional arrangements, as outlined in its NDC (Figure 2).[26] The Malawi Government has a national planning process that involves a pillar, enabler, sector, and district-level coordination structure. Medium- to long-term plans are coordinated by the National Planning Commission (NPC). The Ministry of Economic Planning, Development and Public Sector Reforms (MOEPD&PSR) tracks the short-term implementation of sectoral priorities through sector working groups (SWGs).

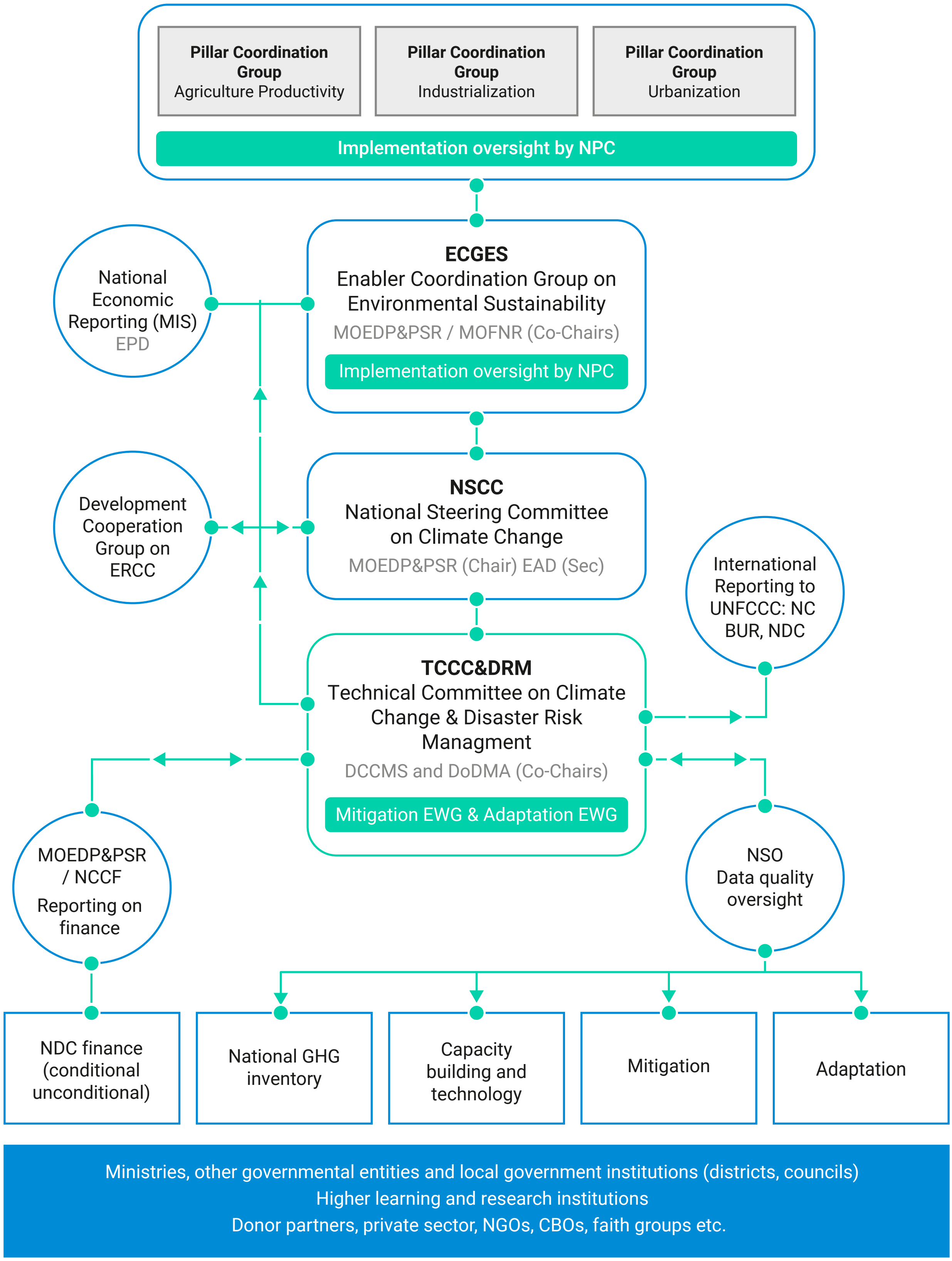

Photo: Tommy Trenchard/Panos Pictures

Three Pillar Coordination Groups (PCGs) are responsible for spearheading implementation and reporting progress and are supported by the Enabler Coordination Group on Environmental Sustainability (ECGES). The PCGs and ECGES work closely with the existing National Steering Committee on Climate Change (NSCCC) and the joint Technical Committee on Climate Change and Disaster Risk Management (TCCC&DRM) to define multi-year priorities and to advise the Government on the resources required for meeting these priorities. The NSCCC and TCCC&DRM receive policy and implementation oversight from the NPC through the ECGES.

The TCCC&DRM provides technical guidance to the NSCCC on all DRM and resilience issues in Malawi. It includes representatives from government entities, as well as from civil society, the private sector, and donors. The committee is co-chaired by the Department of Climate Change and Meteorological Services (DCCMS) and the Department of Disaster Management Affairs (DODMA). Expert Working Groups (EWGs) provide technical guidance and report to the TCCC&DRM. These working groups are established according to requirements and include adaptation and climate finance. Through the Adaptation EWG, the TCCC&DRM serves as the national coordinator for all national institutions that implement sectoral adaptation measures, receive finance and other support, and oversee NDC tracking and reporting at the national level. The TCCC&DRM also ensures that Malawi's NDC MRV system links adaptation, mitigation, and finance, as well as support for capacity building and technology transfer.

Further, Malawi showcases good institutional arrangements, specifically for implementing and reporting on adaptation priorities. The NDC outlines 10 strategic adaptation options relating to three pillars: institutional framework; knowledge, technology, and financing; and resilience of the most vulnerable. Strategic adaptation actions under the institutional frameworks pillar include the establishment of institutional arrangements for multi-sector coordination of climate change actions, as well as testing and institutionalization of mechanisms to integrate CCA into national and sectoral plans and planning instruments, including annual sectoral budgets and guidelines.

Figure 2. Institutional Arrangements for Tracking Malawi's NDC Implementation



Source: Reproduced from Figure 7-1 in Republic of Malawi (2021).[27]

RECOMMENDATIONS

Based on the review of strategic documents and institutional arrangement for climate adaptation action in Africa, the following policy recommendations emerge:

1. The climate adaptation institutional frameworks in Africa have, for the most part, set up institutional arrangements. There is still work to be done on mainstreaming finance and DRR considerations throughout the process. It is also important to clarify roles of different agencies. As African countries improve their NDCs, clarifying the institutional arrangements would be an important area.
2. Ensuring joint responsibility between the lead institution of CCA activities and finance ministries can strengthen alignment with national budget frameworks. Integrating climate strategies, plans, and policies into the fiscal and public financial management systems can allow countries to maximize resource expenditure and their impact.
3. An effective MRV system is crucial for NDC transparency and accountability. It is a necessary tool for countries to successfully implement adaptation measures, to monitor their effectiveness, and for attracting and facilitating access to climate finance.
4. Strengthening the five CCIA pillars when designing and planning the institutional arrangements for climate governance can help to establish clear institutional arrangements to support the implementation of adaptation actions.
5. Aligning disaster risk policy frameworks with climate adaptation institutions and frameworks instruments is imperative, especially for African countries, which are hardest hit by climate-related disasters.

Photo: Terry J Lawrence/iStock

Youth and Entrepreneurship

Photo: GCA

KEY MESSAGES

- The African Youth Adaptation Solutions Challenge (YouthADAPT Challenge) is an annual competition and awards program for youth-led enterprises jointly organized by the Global Center on Adaptation (GCA) and the African Development Bank (AfDB) under the YouthADAPT pillar of the Africa Adaptation Acceleration Program (AAAP).
- The first winners of the YouthADAPT Challenge were presented at COP26 during a dedicated award ceremony. Over 2,000 applications were received from which 10 winners were awarded. Winners receive seed funding of up to US$100,000 to develop their innovation and receive tailored business development training through a 12-month incubation and acceleration program.
- The awarded enterprises target crucial environmental, social, and economic sectors affected by climate change, and present clear value propositions to scale up for higher impact as well as to create employment opportunities across Africa. The challenge also has a strong focus on women, with at least 50 percent of selected businesses being women-owned.

- The challenge aims at being the beginning of a revolution of young business entrepreneurship on adaptation. By 2025, the YouthADAPT Challenge is expected to have reached 300 young innovators and youth-led enterprises.
- Reflecting on the challenges and barriers they have faced in launching and growing their businesses, the winners provided their insights into how African governments can support young entrepreneurs through policy actions and programs.

"We are here to appeal that the adaptation agenda should be a youth agenda, that youth dominate in Africa. And we are requesting that finance should target young people, youth-led initiatives and youth entrepreneurs. We are also requesting that global leaders should include young people in the planning, the design and the implementation of adaptation programs."

Desmond Alugnoa
Co-Founder, Green Africa Youth Organization;, GCA CEO's Youth Advisory Panel

OVERVIEW AND DESCRIPTION OF THE YOUTHADAPT CHALLENGE

Introduction: Youth and Employment in Africa

Micro, small and medium-sized enterprises (MSMEs) are leading engines of job creation in Africa and account for a large part of economic output for the continent.[1] SMEs constitute 95 percent of Africa's private sector[2] and provide an estimated 80 percent of jobs across the continent.[3] At least 44 million formal MSMEs existed in Sub-Saharan Africa alone in 2018. Their growth, however, is considerably constrained by a lack of access to finance and markets, with 51 percent of the businesses requiring more finance than they have access to.[4] Climate change also poses a threat to business growth and employment in Africa, with negative impacts already seen in the form of job losses, destruction to business assets, forced migration, disruptions to transportation routes and access to markets, risks to occupational safety and health affecting labor productivity, and reduced demand resulting from economic shocks and instability.[5]

Climate adaptation responses can, however, protect existing jobs, drive green job creation for adaptation, support the provision of other employment-related benefits such as healthcare and social protection, and provide opportunities for new economic activity and investments.[6]

There lies a considerable opportunity in mobilizing private-sector actors for adaptation efforts in Africa. The Private Sector chapter in the State and Trends in Adaptation 2021 report showed that collaboration and partnerships within the private sector (and with other stakeholders) can not only build resilience within the private sector, but can generate adaptation and resilience benefits for society at large. This is especially true of MSMEs, given that they make up a significant part of the continent's private sector.[7] Further, MSMEs are uniquely positioned to develop locally relevant and effective adaptation solutions, which in turn can significantly build the resilience of the communities in which they operate.[8] Identifying potential business opportunities, incentivizing MSMEs, and promoting local entrepreneurship is thus crucial for creating employment opportunities and generating economic and social output in Africa.[9]

As the most educated generation ever in Africa, African youth today have high economic ambitions and provide an untapped potential to build resilience through their innovativeness, energy, and entrepreneurship. Indeed, Africa's large and growing young population, estimated at over 1.4 billion in 2022 is one of the continent's most valuable assets for growth. (The median age in Africa today is 18.7.[10]) Capitalizing on this presents an unparalleled opportunity for harnessing social and economic development in Africa and driving transformative adaptation at scale across the continent.[11]

Despite market and investment opportunities, a lack of soft and hard skills, in addition to skills mismatch, limits the capacity of youth to take up evolving economic opportunities. Businesses run by young people also face major constraints to development from infrastructure deficits and lack of access to finance.[12] The Youth chapter in the State and Trends in Adaptation 2021 report offers a detailed analysis of the nexus of youth, employment and climate change adaptation in Africa.

Unlocking the untapped potential of youth in Africa to build resilience through innovative solutions and entrepreneurship can drive transformative adaptation at scale across Africa. It is important to engage and support young people in key investments and adaptation policies, increase accessibility of financial instruments, increase the visibility of private-sector adaptation action in Africa, and incentivize MSMEs through policies and by creating an enabling environment for entrepreneurship.[13]

African Youth Adaptation Solutions Challenge

In 2020 the Global Center on Adaptation (GCA) and the African Development Bank (AfDB) launched the Africa Adaptation Acceleration Program (AAAP), which aims to mobilize US$25 billion over five years to drive adaptation and resilience efforts in Africa through four pillars (see the Africa Adaptation Acceleration Program chapter for more information on the AAAP and its progress). Recognizing the need and opportunity for promoting the creation of green jobs for adaptation for youth, the Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience (YouthADAPT) pillar aims to prepare a new generation of African youth for the transition toward green and climate-resilient development, as well as to combat poverty, promote sustainable job creation at scale, and improve the quality of life for young people in Africa.


Photo: GCA

The African Youth Adaptation Solutions Challenge (YouthADAPT Challenge) is an annual competition and awards program for youth-led enterprises jointly organized by GCA and AfDB under the YouthADAPT pillar of the AAAP framework. The challenge aims to strengthen inclusive growth and broaden investment and economic opportunities for youth in Africa, through strengthening and supporting youth-led enterprises to accelerate and scale up innovative solutions for climate adaptation and resilience.

The awarded enterprises target crucial environmental, social, and economic sectors affected by climate change and present clear value propositions to scale up for higher impact as well as create employment opportunities across Africa. The challenge also has a strong focus on women, with at least 50 percent of selected businesses being women-owned.

Winners receive seed funding of up to US$100,000 to develop their innovation and receive tailored business development training through a 12-month incubation and acceleration program. Here selected enterprises are supported to build their institutional capacity, help make their business commercially viable, position themselves to effectively utilize grants offered, and to also mobilize additional private capital. This is undertaken through training workshops tailored to provide practical skills in entrepreneurship and climate adaptation mainstreaming, and professional mentorship to enable the entrepreneurs to execute their business plans, boost the creation of green jobs for adaptation, and thereby support Africa's continental effort toward climate resilience.

By 2025, the YouthADAPT Challenge is expected to have reached 300 young innovators and youth-led enterprises.

An Overview of the Application Process, Evaluation Criteria and Selection of the Winner

The competition targets young entrepreneurs between the ages of 15 to 35 and MSMEs in Africa that have demonstrated proof of concept, offer innovative solutions to climate adaptation and resilience, and have been operational for at least two years with a potential to scale up operations. Young entrepreneurs can respond to a call of expression of interest by submitting a for-profit business plan, from which those with the highest potential for driving adaptation efforts are identified. In 2021, the African Youth Adaptation Solutions Challenge had 1600+ applications (Figure 1). Most businesses that applied were based in either East Africa (684) or West Africa (722). In East Africa, a considerable percentage of the applications were in Kenya (392), and in West Africa, most of them were in Nigeria (516).

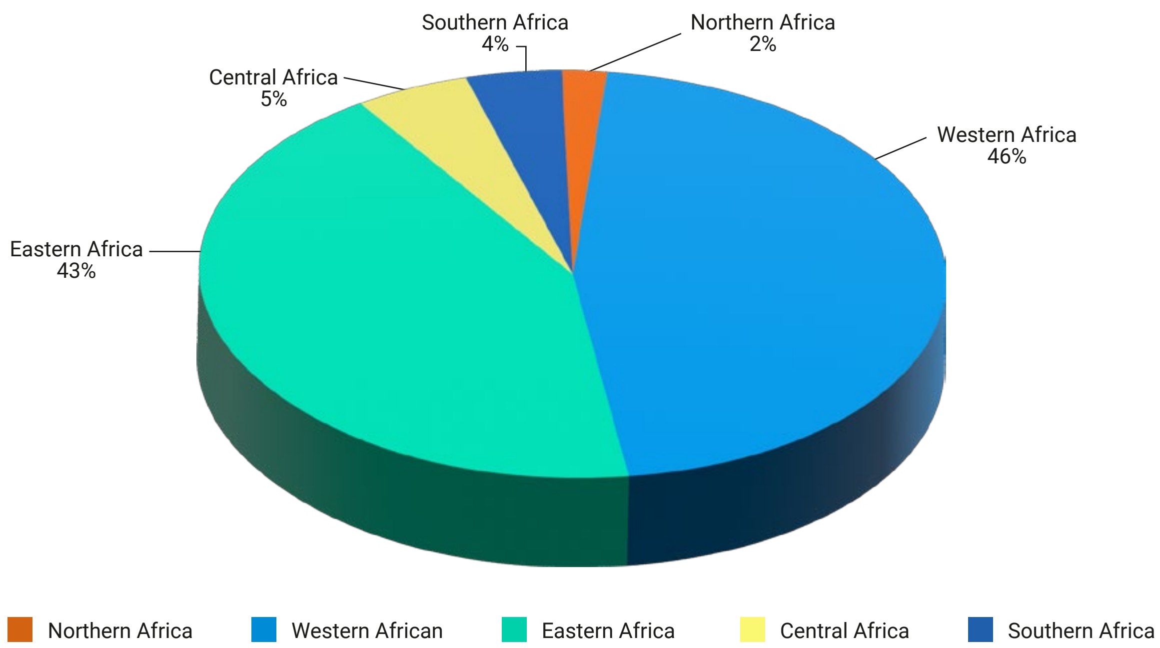
After careful deliberation, 20 shortlisted businesses were requested to submit a three-minute video of their business idea. Of these, 85 percent focused on the adaptation of the agricultural sector and the remaining 15 percent on waste management to prevent waterway clogging and floods.

The adaptation solutions delved into the topics of:

- Providing high-quality drought-resistant seedlings to farmers
- Providing climate-smart agriculture advisory systems
- Providing early-warning systems to avoid waterway clogging
- Providing capacity-building activities in the use of drought-resistant seedlings, irrigation systems, etc.
- Collection and upcycling of plastic waste to avoid waterway clogging
- Agroforestry and land conservation as a protection from drought, strong winds, etc.
- Vertical farming hydroponics for agri-efficiency
- Post-harvest loss prevention through produce dehydration
- Solar-powered smart irrigation technology to avoid water waste
- Organic fertilizer production and cultivation improvement to enhance nutrient retention

Then, the submitted videos were screened by a distinguished jury nominated by GCA and AfDB and showcased at the Conference of the Parties (COP26) in Glasgow in the Africa Pavilion.

Figure 1. Applications to the Youth Adaptation Solutions Challenge by Region



Box 1. Highlights of the YouthADAPT Challenge Award Ceremony at COP26

The first winners of the YouthADAPT Challenge were presented at COP26 during a dedicated award ceremony for the challenge. Over 2,000 applications were received from which **10 winners were chosen**. The event was led by a distinguished panel comprising of GCA's CEO Prof. Dr. Patrick Verkooijen, CEO of the Climate Investment Funds (CIF) Ms. Mafalda Duarte, President of the AfDB Dr. Akinwumi Adesina, Cabinet Secretary for Environment in Kenya Mr. Keriako Tobiko, and the Regional Director for GCA Africa Prof. Dr. Anthony Nyong.

The panelists stressed the importance of turning Africa's demographic advantage into an economic dividend by transforming the continent's young and dynamic population into **innovative business leaders and climate change adaptation solution providers**. The panelists also urged the winners to share their visions of success with other emerging business leaders following them, because the challenge aims at being the beginning of a **revolution of young business entrepreneurship on adaptation**. The winners highlighted that the grant would allow them to scale up their innovations by increasing their production capabilities (such as through the introduction of machinery, more staff, greenhouse construction, etc.) and training capacities (e.g. training with farmers and their own training with experts in business development), expanding their technology acquisition capacity, broadening their service provision, creating more jobs, and extending their networks to impact even more people.

Photo: Ayekpa Guy-Roland Tayoro/African Development Bank

"The world is at its best when it taps into the innovation and the creativity of the younger generation. Their ingenuity has always been at the forefront of every industrial revolution"

Dr. Akinwumi Adesina

The Accelerator Program

A comprehensive gap analysis of each of the winning enterprises was undertaken by the Kenya Climate Innovation Center (KCIC), with the collaboration of GCA and AfDB, to identify individual needs and provide targeted incubation and mentorship support. The gap analysis was done by conducting interviews, reviewing business plans, and using KCIC and AfDB gap analysis and climate adaptation tools. Some of the most frequently mentioned needs included making the businesses ready to attract investors, the need for digital marketing, and climate risk management.

During the implementation phase, training is provided as a bundled service, allowing for networking and information sharing among the enterprises on the best practices with a pan-African view, which then integrates into their respective business processes. To provide the entrepreneurs with the necessary tools for scaling up their businesses, training workshops were given on the topics of cash flow management, budgeting, fundraising, and digital marketing. Later, to mainstream adaptation into their businesses, training workshops were conducted on understanding climate change, adaptation fundamentals, adapting MSMEs to a changing climate, and the adaptation finance landscape.

The accelerator program is implemented alongside grant provisions released in tranches determined by milestones achieved. The YouthADAPT Challenge provides the winners with a sustainable funding model and an expert mentorship component—allowing them to access funding and training to support their short-term goals while also creating an environment for accessing funds that will help them unlock their long-term goals (Figure 2).

Figure 2. The Sustainable Funding Model for the African Youth Adaptation Solutions Challenge Enterprises

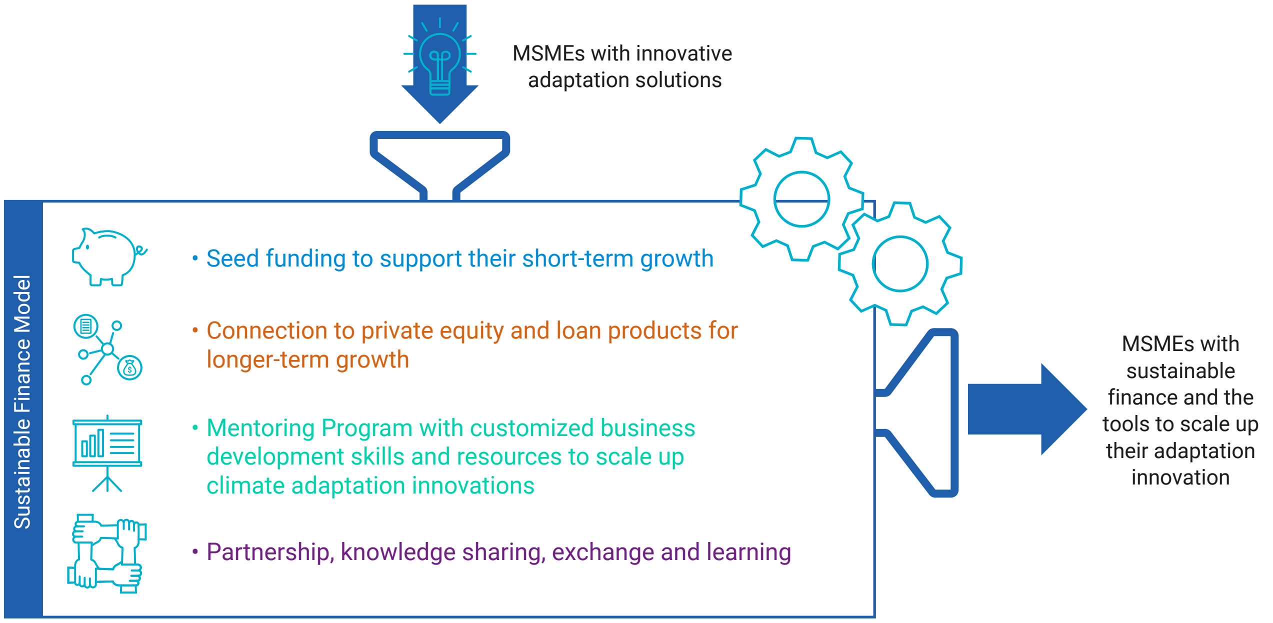


Photo: GCA

YOUTHADAPT WINNER PROFILES

Interviews with the ten YouthADAPT Challenge winners were conducted to learn what impact the grant and accelerator program have had on their businesses thus far. The winners were asked about the challenges they faced in launching and growing their businesses, about the impacts of the climate change adaptation and resilience and social elements of their businesses, and about their recommendations for how governments in Africa can support young adaptation entrepreneurs through policy actions and programs.

The winning enterprises provide climate adaptation and resilience solutions in critical social and economic sectors affected by climate change, including agriculture, waste management, water resources and sanitation, renewable energy and energy efficiency, and ecosystem restoration.

Bleaglee Waste Management, Bamenda, Cameroon

Overview: Projections show that Cameroon is at risk of potentially damaging and life-threatening river floods, which are expected to occur at least once every 10 years.[14] Poor waste disposal can exacerbate this by clogging drains. Other consequences of poor waste management include respiratory issues when waste is burned, shortened animal lifespans when they consume waste, and the contamination of water bodies when waste is dumped into canals, oceans, and wetlands.

To help communities mitigate the risk of flood, Bleaglee Waste Management first identifies waste in drainage channels and waterways using drones that can quickly inspect and detect the type of waste that is clogging water systems. In parallel, the company identifies and works with individuals and businesses that want to dispose of waste. The company targets individuals and households, businesses, government and non-governmental organizations, and vulnerable communities. It communicates with them directly through social media and text messages. The company works with informal waste collectors and youth environmental groups (eco-groups) to pick up and collect waste. This waste is sorted and sold to recycling companies in the national and international markets. Plastic waste is then converted into fuel and sold to clients.

Revenues and Costs: The company generates revenue from providing drone services to waste management and recycling companies in the detection of waste in waterways (34.34 percent), digital and recyclable waste collection and sorting (22.26 percent), and selling fuel from converted waste (43.38 percent) (as per the 2020 financial statement). The highest costs for the company's operations come from salaries, infrastructure/warehouse costs, and waste sourcing and transportation.


Juveline Ngum Ngwa

"The grant will help us to create jobs for over 10,000 young informal waste collectors, especially young women."

Exposure to climate change impacts

Challenges: The development and implementation of the project required extensive research and interviews with local communities. These efforts revealed that raising awareness of the impact of waste on floods was key to the project, as poor waste disposal is a major factor for drainage clogging in Cameroon. Future challenges identified are navigating governmental regulations on drone usage, advocating for the proper design of drainage systems, and keeping people motivated to continue reducing their waste. In response, Bleaglee is implementing a reward system to motivate continued waste reduction behaviors.


Photo: GCA


Photo: GCA


Photo: GCA

Contribution to Adaptation and Resilience:

Early-warning Systems: The company provides early-warning systems for multiple hazards such as flooding, water contamination, and potential respiratory illness. Currently, Bleaglee, with the help of their drones and over 300 part-time waste collectors, has been able to clear 3,000 tons of waste from waterways, reducing the risk of flooding for nearby communities.

Protection of Wetlands: The company protects wetlands through clearing poorly disposed of waste in drainage channels and waterways. The company also works with municipal councils to design better drainage systems and policies that protect wetlands. Further, the company is mapping recycling centers to create a toolkit to guide people on where and how to properly dispose of their waste.

Social Impact: The company contributes to social-economic empowerment of vulnerable communities through enabling behavioral change and inspiring intrinsic motivation for environmental stewardship. The company achieves this through practical learning on proper waste disposal and the value and use of segregated waste. Bleaglee currently employs 20 workers (12 women, 8 men), all of which are youth, and works with 19 casual workers (13 women, 6 men). Bleaglee also allows for waste collectors to receive 45 percent of the recycling revenue, providing them with an alternative source of income.

YouthADAPT Grant: The grant awarded under this program will help expand Bleaglee's capacity to remove waste from waterways and to increase revenue generated from waste by enhancing their recycling facilities. The grant will also allow the company to continue offering their training programs on waste management. The company aims to train and give jobs to over 10,000 informal waste pickers by 2026.

Sustainable Builders, Northern Province, Zambia

Overview: According to the World Food Programme, in 2022, 48 percent of the population in Zambia is currently unable to meet their minimum calorie requirements.[15] The country has 1.5 million smallholder farmers, who produce most of the country's domestic food supplies and are also extremely vulnerable to climatic shocks.

Sustainable Builders addresses this issue by focusing over the last 10 years on three areas in the agriculture sector: small business development, testing digital solutions, and offering structured markets in the supply chain. The company targets smallholder farmers and communicates with them directly through member organizations such as cooperatives and marketing unions. The business links and improves the functionality of the agriculture supply chain, and supports the development of a conducive environment for farmer behavior change toward a more diverse range of production options. This results in increased output and productivity while addressing critical food security issues. Over the 10 years that it has been operational, the business has grown from offering capacity building to organizations and cooperatives, into a project implementer, and now operates as a fully sustainable enterprise.

Revenues and Costs: The company's revenues come from selling seeds (70 percent), providing training services (20 percent), and seed export (10 percent). The most important costs of the company are operational. While salaries for management and rentals insurance costs are constant, others costs such as wages and logistics change depending on the season.

Weluzani Joseph Thole

"We are trying to provide transparency in the agriculture sector, where profits are shared equitably with all the participants of the value chain."

Exposure to climate change impacts

Challenges: The company had to gain the trust of its clients and grow from being a company that offered training for farmers to being a fully established sustainable enterprise trusted by investors. It has had to deal with unstructured markets within the agricultural supply chain, which decreases profit margins for farmers, deters farmers from diversifying their crop production, and poses logistical challenges for the business.

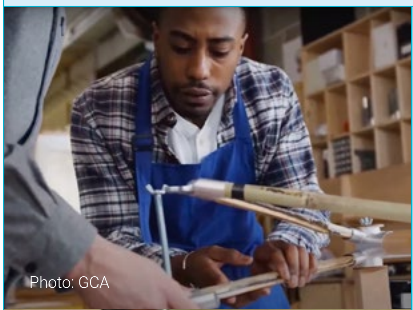


Photo: GCA

Photo: GDNet-Global Development Network/Flickr

Photo: CIMMYT/Flickr

Contribution to Adaptation and Resilience:

Drought-resistant Seeds: The company supplies smallholder farmers with drought-resistant legume seeds that are manufactured based on regional climatic conditions and rainfall patterns. It focuses on groundnuts, cowpeas, and pigeon peas. The company also provides farmers with training and technical efficiency services focused toward building their adaptive capacity, the need for which has become especially apparent in recent years. Specifically, training and support are provided on crop diversification and good agricultural practices to ensure that farmers increase their yields even during periods of drought.

Digital Solutions: Sustainable Builders works with engineers and rural farmers to identify, co-design, and test digital solutions that can potentially create efficiencies and improve commercial relationships between all levels in the agricultural supply chain.

Social Impact: Sustainable Builders provides social impact through jobs and livelihood creation and promotes food security among communities. By offering structured markets the company contributes to increased transparency in the agriculture sector, thereby allowing farmers to sell their crops at fair and profitable prices, promoting equity within the supply chain. Further, improved storage practices will attract bulk buyers who offer better market prices and provide income to the farmers during off-seasons. To date, the company has captured 2.25 percent (13,500 farmers) of the serviceable market in the northern parts of Zambia. It currently operates within one district and is planning to expand to two more districts. The company has 9 staff (5 women, 4 men), all of which are youth, and 17 casual workers (5 women, 12 men).

YouthADAPT Grant: With the YouthADAPT Challenge funds, the company aims to secure digitalized warehouses for grain storage to reduce post-harvest losses caused by poor storage practices. Winning the YouthADAPT challenge has helped Sustainable Builders establish itself as strong competitors within the agriculture sector and it has increased the company's autonomy as a business. The funding also enables the company to test and introduce more agricultural digital solutions, which in turn increases profits for the farmers. The company also envisages expanding its operations from one region to three by the end of the year.

Global Farms and Trading Company Limited, Tamale, Ghana

Overview: According to projections, Northern Ghana is at a high risk of experiencing river floods, water scarcity, extreme heat, and wildfires,[16] all of which will have a severe impact on agricultural systems. These impacts make it essential to work on adapting the agricultural system in Ghana.

Global Farms is a producer of grains (maize, rice, and soybeans) promoting adaptation and resilience among smallholder farmers in the northern parts of Ghana. The company seeks to increase food security, reduce poverty, empower women, and safeguard ecosystem services through the practice of conservation agriculture. The company's three main operational strategies are: to organize and build capacities of smallholder farmer groups to become climate adaptation and resilience-oriented out-growers; to increase the volume of commodities traded through an increase in production yields while ensuring ecosystem services are protected; and to provide an efficient and sustainable market system to smallholder farmers while ensuring company profitability.

Revenues and Costs: The company targets processing companies, smallholder farmers, food vendors, and individuals. It communicates with its customers directly through social media platforms, local radio stations, and registration. The company generates its revenues from selling maize (30 percent), soybeans (32.55 percent), and rice (37.47 percent) (as per its 2020 financial statement). The main costs are operational, related to training smallholder farmers, farm inputs, human resources, and acquiring machinery and farming implements.

Mahama Suleman Saamani Elisha

"With the funds from the grant, we have been able to expand our coverage from 500 to 1,500 smallholder farmers."

Tahiru Jamila

Exposure to climate change impacts

Drought | Land degradation | Flood

Challenges: Challenges with production processes include decreased availability of inputs and cash flow interruptions as a result of COVID-19, as well as disturbances caused by climate risks such as drought and flooding. Insufficient financial resources to expand and champion climate action strategies, and lack of expertise in climate resilience strategies for the dissemination of climate information, are other challenges.

Photo: TG23/Shutterstock

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Contribution to Adaptation and Resilience:

Integrated Farming: The company works with the forestry commission to provide training to smallholder farmers that focuses on intercropping their grain with trees around their farms. This enables farmers to adapt to effects of climate change as the trees act as wind breakers for their crops and reduce the soil erosion that can result from heavy rain and flooding.

Conservation Agricultural Practices: The company, through the support of Savanna Zones Agriculture and Implementation Project (SAPIP), provides training to the small farmers they work with on good conservation agricultural practice. This includes training on zero or minimum tillage; measures to control soil erosion, flooding and bushfires; and methods of pest control that do not have an effect on the environment.

Social Impact: The company enables smallholder farmers to increase their household incomes and create employment opportunities in their communities. The company also enhances the availability and affordability of high-quality food. Global farms also creates social impact through women and youth empowerment: of the 500 smallholder farmers, 341 are females, and 334 are youth. The company focuses on expanding the coverage of smallholder farmers from 500 to 10,000 over the next five years. The company currently employs 13 permanent workers (5 women, 8 men), all of which are youth, and 60 casual workers (35 women, 25 men).

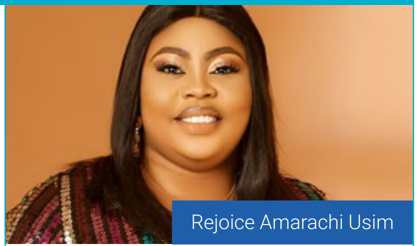
YouthADAPT Grant: Through the grant, Global Farms will enhance its capacity to provide training to smallholder farmers on the adoption of agricultural conservation practices, as well as assist them in accessing quality and climate-tolerant seeds to improve production yields. The funds will also help Global Farms to transport, store, and sell the produce to bulk buyers and negotiate better prices for the farmers while reducing the cost of transport and marketing for the farmers.

Simkay Green Global Ventures, Kaduna State, Nigeria

Overview: The agricultural sector in Nigeria is projected to be heavily impacted by flooding and drought.[17] Natural hazards have also resulted in land and infrastructure degradation from erosion, direct crop failure from floods and heavy rains, and nutrient leaching, all of which puts a heavy burden on the Nigerian agricultural system.

Simkay Green Global Ventures is an agro-processor of tomatoes and potatoes, working on the adoption of improved cultivation techniques for smallholder farmers in rural Nigerian communities to avoid off-season shortages and high levels of post-harvest waste among tomato farmers. The company facilitates training on vertical sack farming and provides implementation support. This type of farming does not rely on rain, optimizes land use, and increases crop productivity and yield for farmers. It also protects farmers from damages caused by flooding. The resulting yield is transported to a factory where the vegetables are sorted, washed, dehydrated, and ground. After production, the packed product is distributed through physical direct purchases, social media handles, and a network of the retail distributor. The company targets students, working professionals, and food vendors. It communicates with its customers directly through sales representatives, online sales channels, and indirectly through distributors.

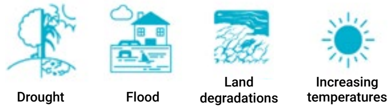
Revenues and Costs: The company generates its revenues from selling tomato powder (58.69 percent) and potato powder (41.30 percent) (financial statement 2021). The main costs are attributed to operations, mainly the costs of machinery procurement, raw material procurement, marketing, human resources, and production overhead costs.



Rejoice Amarachi Usim

"Before YouthADAPT we had engagement of 10,000 farmers. We are now looking at, all things being equal, 100,000 farmers engaged by the end of the year."

Exposure to climate change impacts



Challenges: The short seasons of tomato cultivation (four months of the year) posed a challenge for Simkay as it saw decreased levels of engagement and interest from farmers during off-season production cycles. This was overcome by introducing climate-smart farming techniques to farmers that enabled year-round production. Another challenge faced in growing the business was securing funds to move from fabricated to mechanized machinery.

Photo: Kate/iStock

Photo: Anna Frank/iStock

Photo: Andre Polvan/iStock. Inset: GCA

Contribution to Adaptation and Resilience:

Vertical Sack Farming: The company promotes the use of vertical sack farming for smallholder farmers, which is a low-cost technology for planting crops into the sides and tops of large sacks of soil. The type of farming does not rely on rain, optimizes land use, and increases crop productivity for farmers. On average, a single sack contains 50 to 70 vegetable plants. The vertical sacks use less water compared to vertical farming, allowing farmers to grow crops even during periods of drought. It also protects the farmers from damages caused by flooding. The company has successfully trained 400 farmers in vertical sack farming thus far.

Post-harvest Losses: The company offtakes produce from the farmers, thereby cutting out intermediaries, increasing farmers' income, and reducing post-harvest losses. It then dehydrates, grinds, and packages the vegetables and sells the powder to the Nigerian market. Dehydration enables farmers to adapt to changing crop-growing seasons caused by dry spells, increasing income during off-seasons and contributing to food security.

Social Impact: Simkay provides social impact by creating jobs and improving the livelihoods of the farming communities involved. The company currently employs 10 workers (6 women, 4 men), all of which are youth, and works with 53 casual workers (38 women, 15 men). It currently has 25 young people working in production areas and aims to have 80,000 workers by the end of the year. It has a current engagement of 22,000 smallholder farmers and aims to work with 100,000 farmers by 2023. Through selling tomato powder during the off-season, the company contributes to combating food scarcity and improving health in Nigeria, as the powder retains 100 percent of its nutritional quality during the dehydration process.

YouthADAPT Grant: The grant will aid Simkay in promoting climate adaptation through the acquisition of a 5,000-ton processing machine (4,000 tons more than its current machine), which can produce 80kg of tomato powder daily. Funds will be invested in the construction of a cold storage facility, which will greatly increase the institution's capacity to lengthen the shelf life of perishables and create a sustainable food system for better food security. The grant will also help the enterprise expand its engagement with farmers from 22,000 to 100,000 by 2023. Before the YouthADAPT challenge, Simkay was working in four states. It now predicts that, with the funds and increased capacity gained through the program, it could have 20 states in its database by the end of the year. The company's customer base has also increased, and it is now looking at exporting to international markets. The mentorship has helped the company to draw up business strategies, improve marketing strategies and operational processes, and increase its investor readiness.

Soupah Farm-en-Market Limited, Nigeria

Overview: Projections show that parts of Nigeria are at risk of extreme heatwaves resulting in heat stress, which is expected to occur at least once in the next five years.[18] Significant impacts are expected as well on the country's water resources, which will impact the agricultural systems in Nigeria.

Soupah Farm-en-Market Limited is a women-led agro-producer and distributor based and operating in Ibadan, Nigeria, that leverages controlled-environment agriculture practices and resource-smart growing technology to change the way food is grown and distributed. The company reduces the impact of weather conditions on the production and transportation of food in the community by growing vegetables such as lettuce, kale, leafy greens, and herbs using hydroponic systems. The company also innovatively operates its farm from the rooftop of a building within the city to grow, harvest, and sell directly to consumers at affordable prices. Unlike traditional farming, hydroponics is simply planting food on water and nutrients. This allows the company to plant with 95 percent less water and eliminates the need for harmful fertilizers and chemicals, and also machinery. By farming on rooftops in cities, the company does not require any new land to farm, reduces CO_2 emissions from long-distance food transportation, and ensures that the product reaches consumers quickly and in its freshest form. The company's resource-smart growing technology can grow up to 3 tons of fresh produce within a 650-square-meter area. By utilizing controlled-environment agricultural practices, the company can grow produce all year round. The grant will allow the company to hire more permanent staff and increase productivity.

Revenues and Costs: The company targets individual customers who go directly to the company's urban farm to buy produce. The company also sells to institutional customers such as hotels, restaurants, and schools. By percentage, the company generates its revenues from selling fresh produce (25 percent), tea and spices (39 percent), and juice and smoothies (36 percent) (financial statement 2021). The major costs come from the company's operations including payroll, cost of goods sold, electricity and telephone bills, and rent, among others.


Ifeoluwa Olatayo

"The YouthADAPT grant will help us to increase our production capacity five times, and the training has helped reduce the knowledge gap in-house."

Exposure to climate change impacts


Drought


Heat Stress

Challenges: Hydroponics is a capital-intensive venture, and it was difficult to secure funding for it, which led to the founder, Ifeoluwa Olatayo, selling personal assets to kickstart her business. Further, there was a knowledge gap in Nigeria about the technical needs of hydroponics, which made her delve into a variety of resources on hydroponics to try to replicate it in the Nigerian context. She managed to get a tutor through the International Institute for Tropical Agriculture, who supported her to address the knowledge gap.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Contribution to Adaptation and Resilience:

Hydroponic Farming Systems: The company uses a hydroponic system of farming. Unlike traditional farming, this requires fewer resources (including those needed for sustainable farming) by using 95 percent less water, no machinery, no new land, and no harmful fertilizer. Hydroponic farming techniques also ensure higher yield by up to 30 percent than the traditional methods of farming and reduce the growing time by half. The hydroponic farming system is also grown indoors in controlled environments, thus protecting the crops from harsh weather conditions due to climate change.

The reduced water level required ensures that the crops can be grown year-round even during periods of drought. The company's hydroponic farming system also has climate mitigation benefits due to its localized production on rooftop farms, and the company produces its products in urban areas cutting down the amount of fossil fuel needed to produce and transport food. So far, Soupah Farm has reduced malnutrition for 4,000 consumers within its impact area by making high-quality food accessible and affordable.

Social Impact: The company makes a social impact through creating jobs and livelihoods. It currently employs 16 permanent workers (11 women, 5 men). Furthermore, the company works with two casual workers, a man and a woman. The company impacts 317 smallholder farmers, 224 men and 93 women, of whom 52 percent are youth as off-takers of their products. The company also supports them by providing agronomy services, which translate to better yields and more household incomes for the farmers.

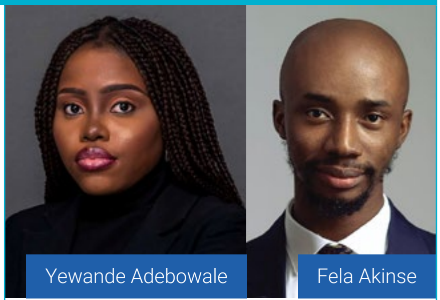
YouthADAPT Grant: The grant will promote climate adaptation by improving the water-use efficiency of the hydroponic farming model, helping communities cope with water scarcity and drought. Before the YouthADAPT award, the production was around 150kg per production cycle (26 days), and the company envisions it going up to 650kg with the construction of new farms to a total of four. The processing capacity to produce herbs and juices using produce is projected to be scaled up from 200kg per week to 600kg. Furthermore, the grant will allow the company to increase its staff to 30 permanent workers, of whom 70 percent will be women.

Salubata Technological Innovations Limited, Nigeria

Overview: Plastic pollution has become one of the most pressing environmental issues in Nigeria, impacting communities by clogging drainage systems and contributing to flooding. Water waste also has many cascading effects, one example being environmental pollution that causes health problems. About 90 percent of plastic waste in Nigeria is not recycled,[19] and this has resulted in over 5 trillion items of plastic floating in canals and oceans.

Salubata Technological Innovations Limited is a shoe design and manufacturing company based and operating in Nigeria since 2018. The company seeks to convert plastic waste into affordable footwear, simultaneously generating income and reducing waste. The company uses recycled plastic taken out of waterways and the sea as raw material to make shoes. Its operations help reduce floods caused by clogged drainage systems and potential health problems caused by water waste, as well as reduce the global carbon footprint by avoiding the need for newly produced plastic. The company targets individuals and the mass market through its B2C customer segment, and retail and franchise through its B2B segment. It communicates with customers directly through direct calls, email, and meet-ups. It is currently working to scale its operations beyond Africa, to Europe and North America.

Revenues and Costs: The company generates 41.66 percent of its revenues from its B2B operations and 58.33 percen from its B2C operations. The most important costs for the business operation come from rent, human resources, material acquisition, logistics, and maintenance.



"Companies that promote a green and circular economy have higher chances than before of attracting investors because this is the age of sustainability."

Exposure to climate change impacts

Challenges: In its early stages Salubata had difficulties accessing funding. It is currently facing challenges in building strategic partnerships, particularly B2B partnerships.


Photo: ewg3D/iStock


Photo: swaag/Shutterstock


Photo: Salubata

Contribution to Adaptation and Resilience:

Plastic Waste Management: Most of the waste that clogs drainage systems and waterways is plastic waste. By reducing this plastic waste through recycling and upscaling, the company protects drainage systems and waterways, reducing flooding in urban areas where the waste affects communities the most. Recycling of plastic waste also significantly reduces its impact on the environment and wetlands. So far, Salubata has processed 1 million tons of plastic waste. The company is planning to introduce blockchain technology to increase transparency in the sourcing of the plastic waste.

Social Impact: The company's social impact is through creating jobs and livelihoods. It currently employs 10 permanent staff (5 women, 5 men) and works with 4 casual workers (3 women, 1 man), all of whom are youth. Additionally, Salubata works with about 50 waste collectors, mostly women, by offering payment for waste collected. It has designated 5 percent of its profits to empowering women in local communities.

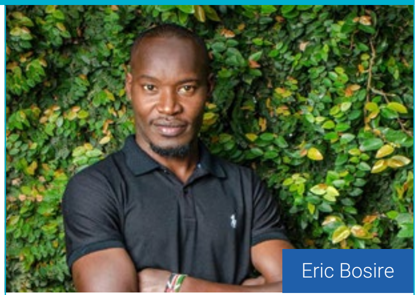
YouthADAPT Grant: The grant funds will be used to support Salubata's production capacity, which will increase its waste removal efforts from canals and dumpsites, thereby minimizing the effects of floods caused by extreme rainfall. The training received through the accelerator program has helped the team with structuring the business, including training on tax, accounting, filing annual returns, getting the business ready for investment, and ensuring all documentation and paperwork is up to date. The mentorship has helped to improve business management and to link Salubata with potential B2B customers who are exploring the sustainability aspect of their business.

Irri-Hub Ke Limited, Kenya

Overview: Kenya is projected to experience increased short-term crop failures and long-term production declines due to changes in precipitation patterns.[20] Furthermore, production losses may be intensified by indirect impacts of drought and flooding (increased insect, disease, and weed infestations; soil degradation due to soil erosion and runoff).

To address these issues, Irri-Hub Ke supplies and installs climate-smart irrigation technologies that promote water security and mitigate the effects of drought, extreme heat, and changing rainfall patterns on crops. Irri-Hub's activities include supplying farmers with drip irrigation options, greenhouse technology, eco-friendly water-harvesting options, and mulching technology. The drip irrigation systems are powered by green energy such as solar power. The company targets smallholder farmers in arid and semi-arid areas and communicates with its customers directly through social media, farmers' forums and expos, and training activities. The company also offers farm planning services provided through field teams, and remote digital support through the company's digital platform. By using Irri-Hub's products and services, customers benefit from sustained weather resistance, affordable energy, an alternative to rainfed agriculture, modern technology, and water conservation through water-harvesting.

Revenues and Costs: The company generates its revenues from its provision of climate-smart irrigation systems to smallholder farmers (financial statement 2020). The main costs are attributed to inventory purchase, rents and rates, wages, travel expenses, and repairs and maintenance of the irrigation systems.



Eric Bosire

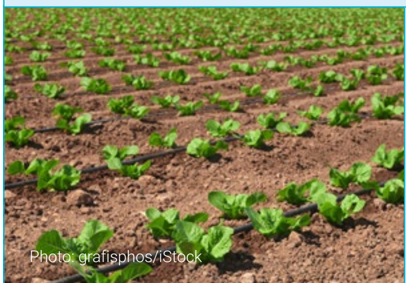
"We have been able to install more than 1,862 irrigation systems and serve over 15,000 farmers across the country."

Exposure to climate change impacts

Water scarcity

Drought

Challenges: Awareness of the availability of technologies and their usage among farmers. The cost of technologies also posed a challenge when establishing the business.



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Contribution to Adaptation and Resilience:

Irrigation Technology: The company offers climate-smart irrigation systems ranging from sprinklers to drip systems. The smart irrigation systems enable farmers to sustainably increase productivity and climate resilience by reducing reliance on rainfed agriculture. The water storage component enables the farmers to effectively adapt to drought-related challenges by ensuring water is available throughout the year, and in turn increasing food security. Irri-Hub has helped set up 1,862 irrigation systems benefiting 15,000 farmers.

Greenhouse Technology: Irri-Hub's greenhouses protect crops from climate change effects such as very heavy rain, very high and low temperatures, and high wind intensity. Farmers can produce crops under a controlled environment to support year-round production. The company sells greenhouses to NGOs and cooperatives, each of which works with groups of between 15 and 25 farmers. Since inception, it has installed 136 greenhouses.

Water Harvesting: The company's water-harvesting products enable farmers to harvest excess water during the rainy season and store it for use during periods of drought. The technology also offers flood protection as water is directed to storage dams, reducing flooding on farms. The company has installed 152 water-harvesting products to date, translating into the conservation of 10 million cubic liters of water.

Mulching Technology: Mulching paper reduces water loss from the soil through evaporation. During periods of drought, the mulching paper assists farmers in conserving moisture already in the soil and reduces the amount of water used. The mulching technology also prevents soil erosion, thereby protecting crops from excess rainfall. The company has thus far set up 100 items of mulching technology across the country, which amounts to approximately 4,132 m² of mulching paper.

Social Impact: Irri-Hub's social impact is through job and livelihood creation. The company empowers and supports farmers to increase their adaptive capacity, improve yield, and enable year-round production, resulting in increased household income for farmers and allowing them to create employment opportunities in their communities. The company currently employs 8 permanent workers and 5 casual workers, all of which are youth. Combining all technologies installed, the company has been able to reach 15,000 farmers country-wide.

YouthADAPT Grant: The grant has allowed the company to acquire more inventory and expand its implementation of climate-smart irrigation systems. The funds have been used to invest in R&D with the aim to automate irrigation systems and create a pay-as-you-go system for farmers. The accelerator program has helped Irri-Hub to redefine its business model, streamline and align company policies to the company's mission, adjust pricing systems, and improve marketing strategies. The company will soon open a second branch to help reach more remote farmers.

Mumita Holdings Limited, Cameroon

Overview: In Cameroon, agriculture is largely rain-dependent. With increasingly unpredictable rainfall patterns together with changes in pest status and dynamics, planning for farmers is complex. Climate variability can strain production capacity, impose extra business costs, and cascade into market prices.[21]

Mumita Holdings produces African indigenous vegetables using greenhouse technologies and the implementation of irrigation systems to support year-round production. The company implements innovative technological and group-focused interventions within the African vegetable supply chain to ensure sustainable production; quality and quantity of vegetables; and efficient post-harvest handling, transportation, processing and conservation, marketing, and distribution. The company targets female farmers in rural areas engaged in African indigenous vegetable production, convenience shops, supermarkets, and individuals. The company communicates with farmers through partnerships with traditional councils and regional/division delegations of agriculture, and with its other customers directly through radio campaigns and in-person meetings. Mumita has two overall objectives: to build sustainable and empowered vegetable farmer networks armed with modern sustainable production tools to support year-round production; and reduce food insecurity by processing fresh vegetables into semi-finished dehydrated nutrient-rich vegetable products that meet consumers' expectations and market standards.

Revenues and Costs: The company generates its revenues from the provision of low-cost greenhouses (54 percent), solar-powered irrigation systems (33 percent), and selling dehydrated vegetables (13 percent). The most significant cost for the company's operation is the vertical integration cost of building its raw material supply chain. Other costs include maintenance of machinery, logistics, capacity building, packaging, and customer acquisition.

Matiedje Nkenmayi Gislaine

"Investors are ready to bet on us because of our youthfulness and vision for agriculture. The grant will help us to improve the livelihoods of many more rural women engaged in vegetable farming."

Exposure to climate change impacts

Challenges: Challenges include accessing farmer networks and working against the mindset that its members are too young to run a business. Side sales of farmers may pose a challenge to the company in the future.


Photo: SilvaPinto1985/iStock


Photo: UN Women/Ryan Brown/Flickr


Photo: kitz-travellers/iStock

Contribution to Adaptation and Resilience:

Greenhouse Technology: The company offers low-cost greenhouse technology solutions to vegetable farmers, which protect crops from climate change effects such as very heavy rain outpours, very high and low temperatures, and high wind intensity. Crops are protected from these extreme elements and enable the farmers to produce crops under a controlled environment, supporting year-round production. The company has set up five greenhouses through cooperatives.

Irrigation Systems: The company also offers solar-powered irrigation systems, ranging from sprinklers to drip systems, to support farmers' production activities. The irrigation systems enable the farmers to produce year-round without depending on seasonal rainfall. The irrigation systems also help the farmers adapt to drought conditions by allowing them to farm even during periods of severe drought. The company has sold 15 irrigation systems to cooperatives and hired out another 5.

Post-harvest Losses: The company dehydrates vegetables to increase the shelf life of fresh produce, thereby reducing post-harvest losses. Increasing the shelf life of fresh produce also contributes to increased food security. The company currently supplies supermarkets with up to 50kg of dry vegetables weekly during the dry seasons.

Social Impact: The company enhances social resilience by creating jobs and improving livelihoods, especially for rural women farmers, though education on climate-smart agricultural practices, enabling access to equipment, and facilitating market access. The ability to produce and consume vegetables year-round increases income levels of the farmers and contributes to maintaining cultural heritage. The company currently employs 30 workers (18 women, 12 men), all of which are youth, and works with 40 casual workers. It is currently working with 20 cooperatives of between 15 and 40 people, with a network of anywhere between 1,500 to 4,000 smallholder farmers.

YouthADAPT grant: The grant will contribute to the construction of a cooling plant, the purchase of new machinery to increase production of dehydrated vegetables, and a warehouse for operation space. The funds will also help to purchase packaging in store, thereby cutting the total cost of final product prices to customers, supermarkets, and retailers. The challenge has already helped build capacity within the company and to increase and identify new networks that will allow access to new markets.

Maima General Dealers, Zambia

Overview: For Zambia, rainfed agriculture accounts for most of the planted area, and is practiced largely by smallholder farmers.[22] Climate variability and natural phenomena like drought can have an impact on the vegetation available for open grazing livestock production. Maima's hydroponic millet fodder offers a solution to this problem because production uses only water in a controlled environment, reducing the impact of climate variability.

Maima General Dealers Limited is an agribusiness enterprise operating within the small livestock sub-sector in Mwembeshi in the Central Province of Zambia. It runs a small livestock processing facility for chickens and goats. The company keeps capacity of commercial chicken layers to a maximum of 5,000 birds, broilers to a maximum of 5,000 birds, and local free-range chickens to a maximum of 2,000 birds. The company buys chickens and goats from surrounding farmers to process and sell to established markets. The initiative provides farmers with a stable market and helps them become climate-resilient. The company targets local retailers for its products including shops, restaurants, hotels, lodges, and supermarkets in Lusaka, Zambia. It also supplies its products to the Democratic Republic of the Congo through a partner organization called Mbombo Investments Limited. The company communicates with its customers directly through physical interactions by visiting their business premises.

Revenues and Costs: The company generates its revenues from selling eggs (54.75 percent), chicken meat (41.64 percent), and goat meat (3.61 percent) (financial statement 2021). The highest costs for the company's operation are for the chicken feed.


Mpulu Kabani

"This award means that we will be able to establish company processing plants and enable us to create new jobs."

Exposure to climate change impacts


Drought


Increased rainfall variability

Challenges: Awareness gaps in the areas of climate risk and management approaches. There is a need for access of information on how to mainstream and track progress of the adaptation solutions that the business is providing.


Photo: Africanway/iStock


Photo: struvictory/iStock

Contribution to Adaptation and Resilience:

Hydroponic Fodder: The company produces and promotes the production of hydroponic millet for smallholder farmers to feed their livestock. The hydroponic millet fodder is grown using millet seeds that have low water requirements and are broadly available in Zambia. This offers solutions to farmers who do not have large pieces of land for open grazing and feed production and can aid those affected by poor vegetation growth due to land degradation and climate change.

Social Impact: The company currently employs 23 workers (7 women, 16 men). All permanent employees are youth. The company supports smallholder farmers by providing them with parent stock for free-range chickens as well as training to improve their yield through the usage of hydroponic fodder to feed their livestock even during periods of drought. This translates to improved household incomes and livelihoods for farmers. The company works with 1,250 smallholder farmers clustered in 25 cooperative societies consisting of 50 farmers each.

YouthADAPT Grant: The grant will be utilized, firstly, to expand the company's greenhouse facility, increasing the production of hydroponic fodder that can act as a safety net for those impacted by climate variability. Secondly, the grant will also help Maima to expand its training provision to farmers on high-quality hydroponic fodder production to improve the health of their livestock. Finally, the YouthADAPT grant will help the company in the construction of a cold room, preventing post-harvest food loss and a loss of income for the farmers. Furthermore, with the award, it will be able to go from providing 18 direct jobs to 200, with a focus on being 70 percent women and 30 percent men.

Kimplanter Seedling and Nurseries Limited, Kenya

Overview: Kenya is highly exposed to droughts and floods. Droughts affect the highest number of people and have the greatest economic impacts in the country. Droughts are often country-wide, but generally the most severe impacts are in the country's arid zones. In the past 100 years, 28 droughts have been recorded and appear to be increasing in frequency.[23]

Kimplanter Seedlings and Nurseries Ltd (Kimplanter) operates from Ruiru Sub-County, Kenya, and has three branches across the country. The company specializes in vegetable, fruits, and tree seedling propagation. The company buys certified seeds from reputable seed companies, sows them in propagation trays, takes care of them during the nursery stage and, when ready, sells them to farmers as ready-to-transplant young crops. The seedlings are drought-resistant and can grow in harsh climatic conditions. They are selected varieties that can adapt to dry and hot conditions and low soil moisture content. The company also provides farmers with inputs on the best crop management practice such as plant spacing, crop protection and post-harvest practices to improve production, maintain quality, and generate some income from yields. The company targets large-, medium-, and small-scale, and subsistence farmers. It communicates with its customers directly through farm visits, telephone calls, text messages, and social media platforms.

Revenues and Costs: The company generates its revenues from selling vegetables (69.42 percent), fruit seedlings (22.96 percent), herbs (4.5 percent), and trees (3.1 percent). The most important costs for the company's operation are production, research and development, wages, sales and marketing, and logistics.

Carolyne Mukuhi Mwangi

"I am a strong advocate of good policies supporting youth and women in agriculture. I am passionate about accelerating this agenda further in my country."

Exposure to climate change impacts

Challenges: Challenges include accessing quality seeds, the cost of these varieties, capital for propagation units, accessing loans as a young person, acquiring the needed expertise, marketing logistics.

Photo: GCA

Photo: Simplice/Shutterstock

Contribution to Adaptation and Resilience:

Drought-resistant Seedlings: The company propagates and sells drought-resistant seedlings to farmers, which helps them improve productivity even in periods of drought. The seed varieties are aligned with the regional climatic conditions to which they are distributed. The company currently has a holding capacity of 1.5 million seedlings every month and aims to increase this to 2.2 million seedlings by the end of 2022.

Climate-smart Agriculture: The company trains farmers in climate-smart practices and techniques, which increases their adaptive capacity in the face of climate change impacts such as rising temperatures and floods.

Social Impact: The company provides a social impact by creating jobs and livelihoods. Kimplanter currently employs 24 permanent employees and works with 21 casual workers, all of whom are youth. The company ensures that 60 percent of all workers are women. The company currently engages with 18,000 smallholder farmers annually and aims to increase this number to 72,000. These smallholder farmers can generate household income and create employment within their communities.

The YouthADAPT Grant: The grant has helped Kimplanter improve its documentation and marketing outreach, as well as better business management through business advisory services. The grant will help the business undertake research to develop new varieties of seedlings that are both drought-resistant and high in nutrition, with the aim to increase its product range from 15 to 25 products. The business will also offer after-sales service training support to the farmers who buy its products to ensure optimal production and to strengthen marketing of the new varieties. The grant will also help the company expand the Kimana branch of the business to allow it to reach more farmers.


Photo: GCA

BUSINESS CHALLENGES AND THE YOUTHADAPT INTERVENTION

Key Challenges Faced by the Winning Entrepreneurs in Launching and Growing Their Adaptation Businesses

Based on the interviews conducted, there emerged six main challenges that the young entrepreneurs faced while launching and growing their businesses.

Limited financial resources and difficulties in accessing and securing funding: Access to finance is essential to be able to fund adaptation innovations. This was a challenge, particularly for the more capital-intensive ventures that required costly technologies, machinery, or inputs. Young entrepreneurs had difficulty navigating loan systems that require collateral at levels that are unfeasible for them. Further, loan interest rates require constant payments over a year. This does not consider periods in which the company is not making revenues: for example, agribusinesses during production and pre-sale seasons.

Need for business development and operational skills: The second challenge commonly faced across the group was creating and establishing the business activities and protocols necessary for running a company and optimizing effectiveness and efficiency in its operations and service delivery. Winners expressed the need for in-house capacity building for business development skills such as project management, financial management, tracking daily activities, bookkeeping, budgeting, writing, implementing company policies and procedures, and marketing, to name a few.

Knowledge gaps: Several entrepreneurs expressed the need for climate experts trained on adaptation and resilience strategies, which would help them disseminate climate knowledge to their customers, smallholder farmers, local municipalities, and the wider community in which they operate. Hiring these experts is costly; thus this challenge is perpetuated by having limited financial resources.

Uncertainty of climate impacts: The winners have already experienced negative impacts of climate risks on their business, both directly and indirectly. Floods have caused disturbances in production and distribution processes through, for example, damage to infrastructure such as greenhouses and irrigation systems, as well as to roads, which affects access to farmers and markets. Heat stress decreases the number of working hours for farmers and results in crop losses. Rising temperatures also affects seedling storage and growth in greenhouses. With increasing variability of rainfall patterns and increasing frequency and unpredictability of extreme climate events, there is great uncertainty surrounding how climate risks will impact their businesses in the future. Potential impacts may disrupt operations, affect their supply chain, damage infrastructure and equipment, hinder service provision, and overwhelm their clients, thereby diminishing the effectiveness of their solutions. This is particularly true for young entrepreneurs in the agriculture sector, which in Africa is predominantly rain-dependent and highly vulnerable to climate impacts. This makes the implementation of adaptation strategies even more critical.

Changing farming and customer behavior: Being agents of behavioral change is challenging in itself. Some winners reported initial reluctance from the communities in which they operate in first accepting and then implementing new behaviors, such as adopting new technologies. Sustaining long-term behavioral change is another challenge requiring interventions and strategies that maintain motivation.

Operational context. Other contextual conditions that posed challenges for the winners to launch and grow their businesses include receiving little help from local municipalities, lack of infrastructure such as poorly constructed roads and unreliable access to electricity, difficulties obtaining the necessary certificates and licensing, government regulations such as on drone usage, and not having structured markets.

How the YouthADAPT Challenge Has Helped the Winning Entrepreneurs Address Challenges

The YouthADAPT challenge has helped the winners address some of the challenges they have faced since the inception of their enterprises. The grant, training sessions, and mentorship have all contributed to unlocking new possibilities for scaling up their businesses and impacting the lives of more people in their communities. The three main ways the YouthADAPT accelerator program has helped them are:

Funding for scaling up: The grant has enabled the entrepreneurs to grow their businesses through hiring more permanent and seasonal staff, purchasing the required machinery and technologies to increase their production capacity and service delivery, investing in research and development for developing new innovative adaptation solutions and expanding their product range, expanding their outreach for increased farmer engagement, building a greater network of clients and partners, and connecting to funding from other institutions for longer-term growth.

Training for impact: The training sessions combined with ongoing expert mentorship have provided the winners with concrete and customized business


Photo: GCA

development skills, including business management, strategic insights, marketing logistics, dealing with climate change impacts, financial management and tracking of finance flows, cash flows, monitoring of expenditures, and budget creation. Further, these training sessions allow the entrepreneurs to share knowledge, learn from one another, and build their networks.

Investor readiness: The winners generally perceive improved levels of investor readiness resulting from the accelerator program. Winners report that the training and mentorship has enabled them to improve their business documentation, increase the commercial viability of their enterprises, and better position themselves during the application and pitching process, thus making them more attractive to investors and partners. Ultimately, this means the entrepreneurs are better equipped to take advantage of emerging market and investment opportunities. Winning the challenge has also helped to establish their business reputation and gain competitive advantage among other businesses in their respective sectors.

RECOMMENDATIONS ON HOW GOVERNMENTS IN AFRICA CAN SUPPORT THESE YOUNG ENTREPRENEURS

Reflecting on the challenges and barriers they have faced in launching and growing their businesses, the winners provided their insights into how African governments can support young entrepreneurs through policy actions and programs. Elements of an enabling environment for young entrepreneurs included improved infrastructure and connectivity (such as energy access and transportation routes), inclusive policies, access to funding and knowledge programs, easing lengthy bureaucratic processes, encouraging business through tax incentives, and more. Crucially, youth should have a seat at the table during policy formation. The three main recommendations were:

Access to funding: Make access to financial capital easier for young entrepreneurs. This includes simplified loan systems and processes; making grant and funding opportunities more visible; lowered interest rates that are flexible and adjusted according to revenue at different periods; and more flexible and feasible collateral requirements.

Create tax incentives: Encourage youth entrepreneurship by lowering tax barriers that severely inhibit growth. This could include providing early-stage tax cuts until the company starts making a profit; offering adaptation tax rebates; reduced or zero-rate taxes on farm inputs such as seeds and equipment; and tax holidays or exemptions.

Facilitate access to knowledge and capacity building: Equip young people with tools to successfully implement their adaptation innovations through training and mentorship programs; business incubators; training in digital technologies; access to networks of young entrepreneurs around the world; knowledge exchange between young businesses and established companies; vocational training programs; and climate change awareness-raising campaigns. Create synergies between government, NGOs, and the private sector.

Security

KEY MESSAGES

- As a threat multiplier, climate change exacerbates fragile situations and worsens social tensions and upheaval. Therefore, countries with fragile socioeconomic and political systems are especially susceptible to the security impacts of climate change.
- There can be no adaptation without security, just as there is no security without adaptation. Without effective governance and social and political stability, adaptation projects fall to the wayside, or may even risk exacerbating population vulnerability if they do not consider emergent security risks. Therefore, it is increasingly important to both "climate-proof" security and "security-proof" adaptation efforts.
- A range of early-warning systems (EWS) have emerged in the African context, which effectively warn and inform about dimensions of climate and conflict. EWS should rely on local actors and their knowledge in order to prevent maladaptation and to not enhance or exacerbate existing vulnerabilities of local and marginalized communities.
- Integrating dialogue into the planning and implementation stages of all adaptation projects is important for addressing community


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concerns. Otherwise, adaptation projects could create economic or social winners and losers, increasing instability among the local population. Dialogue programs help to avert these missteps toward maladaptation and establish local partnerships that are more resilient to climate and conflict risks.

- Regional and local security sectors in Africa have a significant opportunity to engage in climate adaptation and climate-security risk reduction. This is because, in many cases, they may be the only existing or best-equipped force to prepare for and respond to disasters.

> **"Without success in Africa, there can be no success in Europe. Our destinies are so intimately intertwined that if we are not collectively responsible for the development of Africa, for Africa being able to use the opportunities it has, we will still be intertwined without doing anything and we will sink together in an ocean of despair."**
>
> **Frans Timmermans**
> Executive Vice-President, European Commission

INTRODUCTION

Climate change impacts create novel security threats and also interact with existing social, political, and economic conditions and vulnerabilities. Climate-security analysis seeks to understand these risks as well as identify opportunities to prepare for and to prevent complex climate-related security risks.[1]

This chapter presents a climate-security adaptation framework to better understand the climate and security nexus and support the "security-proofing" of climate adaptation planning. The framework consists of five steps:

1. Identify areas of climate-security risk through an analysis of climate-conflict pathways;
2. Assess climate-security risk through forecasting and early-warning systems (EWS) that combine security and climate risks;
3. Develop "conflict-proof" adaptation planning;
4. Translate climate-security risk assessments into localized action; and
5. "Climate-proof" the role of local security sectors.

Following the framework's step-by-step logic, in the first section the chapter illustrates the nexus of climate change and security through seven climate-conflict pathways—i.e. potential routes in which climate change can impact violent conflict—and their application across Africa. The next section then shows how this theoretical understanding creates the foundation for developing tools such as EWS to predict where climate change will pose the greatest security risks on the continent. The next section is about making adaptation "conflict-proof"—that is, ensuring that high-level information is integrated into regional and local action on climate adaptation. This can be achieved in several ways: by linking the climate-security information network with information-sharing networks at the local level, conducting climate-security scenario exercises among experts and stakeholders to improve preparedness for conflict, and developing participatory and dialogue-based approaches to climate security. The final section highlights the role of the security sector, from regional institutions to local actors, in the implementation of climate adaptation by setting out the principles of a climate-security governance framework and focusing on specific examples of high- and ground-level security action in Africa.

The overall guiding conclusion from this chapter is that there can be no adaptation without security, just as there is no security without adaptation. Without effective governance and social and political stability, adaptation projects fall to the wayside, or may even risk exacerbating population vulnerability if they do not consider emergent security risks. Conversely, without strong climate adaptation measures in place, climate impacts increasingly damage social, political, and governance structures within society, leading to deteriorating security, particularly for vulnerable states and communities. Therefore, focusing on climate security and climate adaptation in concert is key for creating positive outcomes.

IDENTIFYING AREAS OF CLIMATE-SECURITY RISK THROUGH AN ANALYSIS OF CLIMATE-CONFLICT PATHWAYS

The security implications of climate change are undeniable. As far back as 2009, US President Barack Obama had linked the impacts of climate change to conflict, highlighting the vulnerability of fragile regions to deteriorating environmental conditions in a speech on climate change at the United Nations.[2] If institutions and governments remain incapable of mitigating the shocks of climate change, the fragility of states will increase.[3] Climate change can also act as a "threat multiplier,"[4] exacerbating fragile situations and worsening social tensions and upheaval.[5] Therefore, countries with fragile socioeconomic and political systems are more susceptible to the impacts of climate change than countries where the government can act as a buffer for the fallouts of climate change. Regions that are especially vulnerable to climate-related hazards such as droughts, heatwaves, landslides, tropical storms, and wildfires should be analyzed closely, in order to be able to project future pathways, anticipate emerging challenges, and undertake more timely and effective action.

Lower-resourced nations are more vulnerable to climate change and its impacts due to their lower adaptive and coping capacity to support their populations, and those same factors can also make them susceptible to the emergence of conflict.[6] To manage this vicious cycle, it is increasingly important to both "climate-proof" security and "security-proof" adaptation efforts.

Up to half of all African countries have been identified to be vulnerable to climate change and are regarded as very fragile. Nine of the 10 lowest-ranked countries on the ND-GAIN Index, which measures climate vulnerability and readiness to adapt, are in Africa; four among them—the Central African Republic, Sudan, Niger, and the Democratic Republic of the Congo—experienced high-intensity armed conflicts in 2021, and several others have experienced smaller-scale conflicts.[7] Access to water, food, and energy is threatened by climate change trends such as decreased rainfall, rising temperatures, and extreme weather events, leading to a loss of crop productivity, and leaving the continent exposed to further unrest and even conflict.[8]

For example, multiple regions in Africa have seen an increase in conflict between herders and farmers as climate-induced changes through droughts, wildfires and heatwaves decrease grazing lands and available natural resources.[9] If climate adaptation projects are not implemented in a conflict-sensitive way, it could lead to intercommunal tensions and violence. Poor governance and military state interventions that disregard conflict-sensitive approaches, along with the loss of livelihoods, generate further conflict and instability.[10] These factors make Africa especially relevant when it comes to developing adaptation plans that are both climate- and security-proof.

This section outlines seven pathways that shed light on the linkages between climate change and conflict. Further, it applies the climate-conflict pathways to the African context in order to underscore the need for early-warning mechanisms and climate threat assessments.

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Overview of Climate Change and Conflict Pathways

The 2021 State and Trends in Adaptation (STA21) report presented five causal pathways from climate change to conflict risks in the Sahel and the Horn of Africa. They were reduced livelihood security, increased patterns of marginalization and exclusion, the rise in terrorism and non-state armed groups, competition over scarce resources, and increased migratory movements.[11] Building on this, a 2022 study by The Hague Centre for Strategic Studies (HCSS) developed seven climate-related conflict pathways identifying factors that lead to further conflict.[12] These align well with the STA21 pathways and provide more detailed descriptions of the interacting factors for the individual pathways, delivering new insights to our existing understanding of the climate and security nexus. By building on a large and diverse body of literature, this chapter delivers a comprehensive and novel overview of potential routes in which climate change can impact violent conflict. The seven pathways are summarized in Table 1.

The seven pathways identified in the HCSS study are applicable in different regions of the African continent. Sub-Saharan Africa is especially affected by the interplay of climate change and conflict, in particular the Sahel region and the Horn of Africa. This is due to the high dependence on livelihoods based on agriculture and livestock—climate-sensitive sectors that enhance the impact climate change will have on the region and increase the likelihood for conflict to develop. The Sahel region is affected by rainfall deficits and severe droughts but also by heavy rains and floods, leading to conflict and migration.[14] The Horn of Africa is severely impacted by droughts, encouraging migration and ethnic tensions.[15] Migration, combined with poor integration of new migrants, can cause tensions between different ethnic groups that historically have not interacted with each other, heightening the risk of violent conflict.[16] As documented in Somalia, for example, communities that are displaced internally as a result of climate hazards are more susceptible to identity-related conflicts and recruitment by armed groups.[17]

Table 1. Seven Climate Change and Conflict Pathways

	Pathway description	
1	Climate change-related resource scarcity leads to conflict between pastoralist and sedentary communities	Changes in temperature and precipitation cause forms of scarcity that force pastoralist groups to alter their transhumance routes. This precipitates resource competition between groups, infringes on traditional customary regulations, and increases conflict risk.
2	Climate change-related resource scarcity leads to larger-scale intercommunal violence	Climate change–induced scarcity of water, food, and land resources, in combination with social, political, geographic, and economic variables, can trigger intercommunal tensions.
3	Climate change precipitates (internal) migration, leading to social unrest	Climate change can lead to migration, whether from rural to urban areas or between rural areas. This can spark social unrest by increasing resource competition and exacerbating feelings of relative deprivation, as well as by increasing the severity of intercultural clashes.
4	Climate change-related social unrest empowers non-state armed groups	Climate change interacts with state fragility and contributes to livelihood deterioration, creating fertile ground for the emergence and expansion of non-state armed groups (NSAGs).
5	Policies aimed at mitigating the effects of climate change have adverse effects	Climate change policies can trigger political exploitation and marginalization of groups, aggravating existing grievances and tensions.
6	Climate change-related social unrest precipitates large-scale political movements, provoking a government crackdown	Climate hazards can provoke a window of opportunity for violent and non-violent opposition to further undermine authorities. This erodes state capacity and exacerbates social vulnerability. Conflict arises as a result of the state's (violent) crackdown on dissent.
7	Disputes over transboundary resources cascade into interstate conflict	Climate change can foster tensions over transboundary resources in three main ways: 1) water scarcity raises tensions over transboundary freshwater resources; 2) temperature increases create a new frontier for disputes in the Arctic; 3) diplomatic disputes over climate mitigation measures and responsibility.

Source: Authors' summary of Swejis et al., 2022, analysis[13]

These seven pathways highlight a variety of ways in which climate change could trigger conflict—and depending on the fragility of a state, a different pathway could apply. Projecting how a conflict could materialize provides the opportunity to meet climate-conflict risks with a higher level of preparedness, design more effective interventions, and thus moderate their trajectory to prevent the worst outcomes.

Each pathway shows the interaction between climate change and social, economic, and political factors that can produce violence. The index is meant to highlight the different roads conflict can take, while considering the impacts of climate change and the predisposed fragility of individual states. For Africa, pathways 1–6 of those listed in Table 1 are especially relevant. As mentioned above, multiple pathways can emerge and unfold simultaneously, increasing the risk of conflict even further.

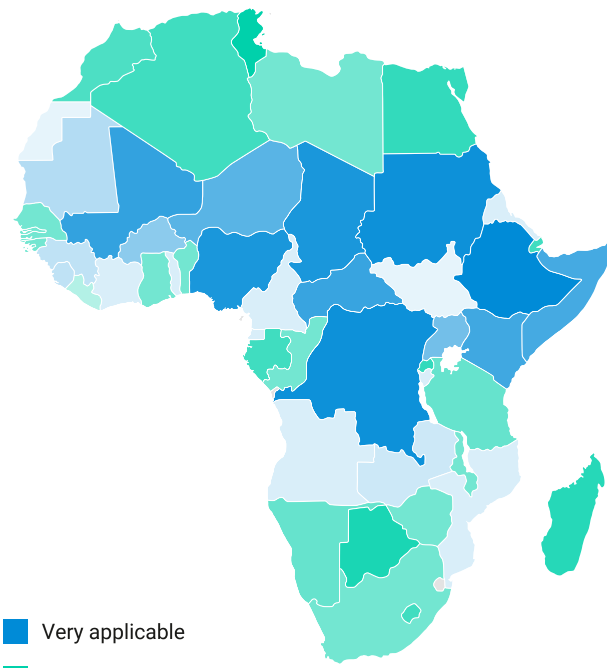
As Figure 1 shows, countries in the Sahel and Horn of Africa are the most vulnerable to climate-conflict pathways. In these regions pastoral societies are forced to migrate into areas with sedentary agriculture and the types of production clash, which allows for conflict to emerge.[18]

For example, Niger is confronted with demographic and climatic pressures that are moving the frontier of cultivation north, affecting pastoralist zones and traditional routes.[19] The conflict between agricultural farmers and mobile pastoralist populations (pathway 1) in Mali have been ongoing since the droughts in the 1970s, which catalyzed the rebellion of Tuareg ethnic groups against others over challenges threatening their livelihoods (pathway 2).[20] The Tuareg groups in the Sahel have been migrating (pathway 3) southwards due to climate change effects like high climate variability with drought and flooding, resulting in conflict.[21]

In Kenya, climate-related conflict is characterized by clashes between sedentary farmers and pastoralists, who have been migrating due to severe droughts, leading to violence.[22] Pathway 2 is also applicable in Mali, which has been plagued by unreliable rainfall and land degradation, resulting in lower crop yield.

In most African countries or regions, more than one pathway is applicable, and it is worth pointing out some of the patterns in which they combine and ramify. The West African Sahel region comprising Mauritania, Senegal, Mali, Burkina Faso, Niger and Chad is plagued by high unemployment rates, weak

Figure 1. Climate-Conflict Pathologies Applied to Africa



governance, political unrest and radical Islamist groups (pathways 4 and 6).[23] Governments in Mauritania, Mali, Niger, Chad and Burkina Faso are all occupied with fighting separatist or minority ethnic group insurgencies as well as Al-Qaeda or Islamic State–affiliated groups, leading to high political turmoil.[24] This could lead to more social unrest and for non-state armed groups to emerge and gain momentum (pathway 4).

In Mali, fragile governance, political instability as well as livelihood insecurity, marginalization and inequality have led to more opportunities for armed groups to find recruits and support (pathways 4, 5, and 6).[25] There is also evidence to link a higher success rate in recruiting for extremist groups during and after low rainfall periods.[26] For example, when the Malian Government implemented land redistribution measures to advance agricultural productivity and combat the challenges of food insecurity, this approach was challenged by the pastoralist population.[27] Such a policy that focuses purely on expanding the amount of available resources may

Photo: yoh4nn/iStock

disregard preexisting intercommunal tensions and aggravate them.[28] This led to intensified conflicts between crop farmers and pastoralist groups, highlighting how the policies aimed at mitigating climate change effects instead increased conflict (pathway 5). With an annual 3 percent population growth, there is increasing competition over scarce resources, and as disputes between farmers and herders in Mali and in the Sahel are endemic, the potential for intercommunal conflict remains high.[29]

Overall, the Sahel and Horn of Africa regions, as well as the countries to the south of these regions (Figure 1), are most vulnerable to climate-induced risks, as they already have a precarious starting point through state fragility and ethnic fractionalization. Understanding these pathways and identifying vulnerable regions can facilitate the development of more specific data tools to predict and anticipate climate-security risks in Africa.

ASSESSING CLIMATE-SECURITY RISK THROUGH FORECASTING AND EARLY-WARNING SYSTEMS

Mapping the climate-related conflict pathways in African regions contributes to the development of effective EWS that can prevent or mitigate conflict risks. EWS are based on the idea that by understanding and assessing climate and security risks in advance, local, regional, and national communities will be able to avoid, prepare for, and become resilient against the insecurities that would otherwise emerge. Much early warning is focused on conflict and climate risks as primary threats to human security. EWS aim first to alert key government decision-makers, as well as community leaders, about existing risks. Second, EWS strive to improve decision-makers' comprehension of the risks' potential impacts. Finally, EWS facilitate preventative and mitigative measures known as early or anticipatory action.[30]

To summarize, EWS constitute the consolidated sets of tools, methods, and practices that allow for the systematic collection of data and information to create early-warning products like risk assessment (through monitoring, forecasting, and prediction), and inform early-action policies.[31] EWS help contextualize the crisis in terms of time, space, and potential tipping points embedded in economic, political, social, and cultural structures.[32]

Early-Warning Systems: Methods and Tools

A variety of methods and tools are available for EWS. Most EWS combine quantitative and qualitative methods but rely more heavily on the former. This can be explained by the wide availability of quantitatively based indices, which capture social, physical, and virtual indicators at various levels.[33] However, desk research of publicly available resources, field monitoring for granular and local-level insight, surveys, and crowdsourcing data are gradually being more implemented, along with new means of using artificial intelligence (AI) to process large amounts of virtual, written, and visual information. Digital tools are further applicable for EWS data analysis; correlational statistical models and machine-learning methods can provide interpretable results about relations between indicators and probabilities of risks. Beyond correlation, successful efforts are also being made to use machine-learning applications to formally identify and assess causal relationships between variables of interest.[34]

Support from qualitative or experimental findings can make predictive and causal models more robust. Expert insights and superforecasting tournaments can also reveal trends in data. These analyses are often embedded in frameworks like game theory, market dynamics, actor–network models, or theories of change.[35] One final information-gathering tool of crucial importance is reliance on Indigenous knowledge. As climate and conflict risks ultimately affect individuals on local levels most directly,[36] using existing and entrenched Indigenous knowledge systems can reveal the most culturally, geographically, and historically relevant indicators of risks and the corresponding ways to prevent it.[37]

It is also important to conduct reviews of the take-up of the information produced by the EWS. If the information is not implemented or does not even reach the target actors, then practices should be revised.[38] Additionally, next-generation technologies will inevitably emerge and improve the accuracy and efficiency of existing systems. Incremental improvements are crucial for EWS to remain relevant.

Combining the above-mentioned elements, a range of EWS have emerged in the African context, which effectively warn and inform about dimensions of climate and conflict. Table 2 offers a snapshot of the most relevant examples.

Table 2. Conflict Early-Warning Forecasting Models Currently Being Applied in Africa

Early-warning system	Origin	Focus	Purpose
Continental Early Warning System (CEWS)	The African Union (AU)	Continent-wide, interstate harmonization on a regional level	Anticipation and prevention of conflicts across Africa
Conflict Early Warning and Response Mechanism (CEWARN)	Intergovernmental Authority on Development (IGAD)	East African regional economic community	Sharing information, cross-border conflict monitoring, regional implementation of CEWS conflict analysis
ECOWAS Warning and Response Network (ECOWARN)	Economic Community of West African States (ECOWAS)	West African regional economic community	Detection and monitoring, regional implementation of CEWS conflict analysis
West Africa Early Warning and Early Response Network (WARN)	West Africa Network for Peacebuilding (WANEP)	West Africa	Enhancing human security through monitoring, reporting, and strengthening ECOWARN
Central African Early Warning Mechanism (MARAC)	Economic Community of Central African States (ECCAS)	Economic Community of Central African States	Data collection and analysis for conflict prevention, interstate network building
SADC Regional Early Warning System (SADC-REWC)	Southern African Development Community (SADC)	Southern African Development Community	Creation and management of National Early Warning Centers for information exchange
Water, Peace and Security (WPS) Global Early Warning Tool	World Resources Institute (WRI), The Hague Centre for Strategic Studies (HCSS), Deltares	Africa, Asia, and the Middle East	Identification of conflict hotspots before violence erupts
Five-country Anticipatory Action Framework Pilot Program	UN Office for the Coordination of Humanitarian Affairs (OCHA)	(pilot in) East Africa	Informing preventative action for humanitarian impact of climate and disease crises
Conflict Prevention and Reconstruction Unit	The World Bank (WB) Social Development Department	Global, Great Lakes Region, West Africa	Informing reconstruction post-conflict and preventing future conflict outbreaks
Global Facility for Disaster Reduction and Recovery (GFDRR)	The World Bank (WB)	Global	Developing and supporting planning and management of projects to develop resilience
Famine Early Warning Systems Network (FEWS NET)	USAID	Global	Providing information about food security and risks

Source: Compiled by authors from numerous international sources

Key indicators	Climate dimension	Method(s)	Term horizon
Political, economic, social, military, humanitarian	Access to scarce resources (land and water) is considered a root cause of conflict in the economic dimension	Structural, actor, and dynamic analysis. Scenario-building. Field research, behavioral analysis. Qualitative and quantitative data.	Long term, 1–4 years
Media, peacebuilding, state collapse, elections, forced migration, human rights and judicial reform, small arms proliferation, environmental degradation	Economic community initially focused on issues of drought and desertification. Focus on pastoralist conflicts including those caused by land depletion.	Bottom-up, process-oriented approach, local information collection networks, field monitors. Qualitative and quantitative data.	Live updates and long term, 1–4 years
Shared indicators with CEWARN	Natural disasters as amplifiers of conflict	Citizen and civil society cooperation. Statistical modeling. Field research.	Live updates and long term, 1–4 years
Shared indicators with CEWARN	Prediction of human-caused and natural disasters	Grassroots information, community-based surveys	Live updates and long term, 1–4 years
Existing indicators and rankings on peace, governance, security, human factors	Consolidating climate as a dimension of peace and security	Decentralized correspondents, qualitative and quantitative	Medium scale, several months
Socioeconomic, climate, poverty	Food and nutrition security, prevention of famine, drought warning	Qualitative and quantitative modeling and forecasting tools	Monthly forecasting
Community, conflict, economy, food, governance, and water	Water-related variables are assessed and correlated with conflict outcomes. Causal models provide insights into the interactions between variables.	Machine-learning–based methodology, employing a random forest (RF) model type	12-month forecasts
Climate, environmental, human security	Droughts and floods considered as large-scale natural hazards	Field research, quantitative monitoring	12 days (floods), several months (droughts)
Development, economic, social	Access to natural resources as source of conflict	Qualitative, structural and accelerator modeling	Various
Climate, environmental, economic, tangible and non-tangible values	Resilience to climate change, hydromet services and EWS, resilient cities and infrastructure	Modeling and quantification of disaster risk, desk research (Global Rapid Post-Disaster Damage Estimation–GRADE)	Medium to long term
Conflict-based, weather, and economic shocks contributing to famine		Food security classification data, quantitative	Medium scale, several months

Opportunities and Risks of Early-Warning Systems

EWS possess clear advantages. But their inherent complexity means that their use also presents certain risks of suboptimal outcomes, not to mention the risks of transgression of some ethical boundaries related to the use of data. If properly understood and accounted for, these risks can be mitigated with the requisite controls and precautions. This subsection presents an overview of these opportunities and risks, as well as mitigation measures to provide a more secure sense of how EWS work in practice.

Opportunities: There are three key opportunities presented by EWS. First, the use of EWS creates the chance that conflict risk warnings will be provided in a timely manner. If an EWS is further bolstered by extensive research, triangulated data, and past accuracy, then the legitimacy of a warning is amplified. This effect is reinforced by the fact that EWS can exist at and interact across multiple levels. For example, the CEWS provides broad-overview data, while EWS of economic communities (such as ECOWARN or CEWARN) focus on more granular and locally relevant information. As such, it is more likely that policymakers will pay attention to the warning and that better situational awareness will be established between actors possibly affected by and peripheral to a conflict.

Second, EWS increase the likelihood of early action. If the information distilled from EWS data is delivered to the right policymakers, then early action can take place to prevent and mitigate a conflict. Assuming that EWS contribute to shared awareness, EWS especially make it possible to align policy efforts between governments, local and transnational non-governmental organizations, and other stakeholders.[39] In Africa, the CEWS acts as an international hub for information exchange between the various regional initiatives, including ECOWARN and CEWARN, while the latter can support the operationalization of local and transnational findings.[40] This is especially true if EWS integrate Indigenous knowledge, which can serve as a platform of relevant and reliable information.

Furthermore, if local actors contribute to information, there will be a further stake in seeing the success of early action and adaptation. In turn, stakeholders who rely on EWS can gain domestic and international reputational benefits, signaling their commitment to conflict management. The close proximity and collaboration with local stakeholders are some of the main advantages of ECOWARN and CEWARN, making these international examples of effective EWS. Finally, the early-action initiatives brought on by EWS evaluations can have positive spillover effects into other policy domains, for example by promoting digitalization and improved efficiency as well as practices of transparency and bottom-up approaches.[41]

Risks: Yet EWS also present risks. First, like other predictive tools working on the basis of big data, EWS encounter problems of information inaccuracy. EWS could predict “false positives” (e.g. high conflict risk is predicted, but the risk is minor) or “false negatives” (e.g. no conflict risk is predicted, but conflict still occurs). A false positive may have fewer adverse consequences as it could still motivate useful mitigation efforts. However, a false negative reveals


Photo: Katja Tsvetkova/Shutterstock

that the model is faulty and requires revision, leading to reputational losses.[42] A lack of trust in the results negatively affects the likelihood that policy actors will take the desired actions. False results may also be caused by malicious actors, motivated to manipulate results to their favor. Furthermore, even correct results must be presented in clear, understandable, and implementable ways, so as not to alienate policymakers lacking relevant training.

Second, EWS bring unique ethical risks. Data used by EWS is part of the debate on privacy and data ownership. Furthermore, when data stems from the Global South, there are additional concerns about exploitative extraction practices by actors from the Global North. Despite the acknowledged usefulness of Indigenous knowledge, the possible commodification of cultures and insensitivity toward their practices can make it difficult for such information to be accessed and integrated effectively into EWS. Overall, misuse of data can have reputational repercussions for the perceived reliability of EWS.[43] Simultaneously, a big data focus risks neglecting indispensable local perspectives, creating results that are ultimately irrelevant to local populations.

Finally, while EWS aim to warn against conflict, EWS research may aggravate humanitarian issues. The actions that are interpreted as "correct" or "necessary" based on EWS results can worsen and even create new types of conflict. For example, research has repeatedly come to the conclusion that military interventions tend to prolong conflict.[44] Yet, even without military interventions, mitigatory or preventative actions based on EWS can lead to local economic and political imbalances if implemented without a mind for sustainability.[45]

Mitigation: Fortunately, there are ways to mitigate EWS risks. First, it is important to triangulate data and models to minimize inaccuracy issues. The risks of EWS can be resolved by using mixed-method, quantitative–qualitative approaches from the outset. Second, to tackle the risks caused by ethical concerns, EWS initiatives should outline ethical and legal guidelines that address privacy risks, accessibility, and sourcing of data to avoid exploitation. Setting such a bar would mean that EWS draw upon the expertise only of trusted advisors who understand local actors and conflict dynamics, thus minimizing the risks of input manipulation or biased answers. Crucially, any early action that results from EWS should be carefully evaluated to avoid unsustainable choices or escalations of humanitarian crises. And finally, it is necessary to manage expectations about what EWS can and cannot do. Depending on the parameters, EWS are limited in the kind of information they can provide.[46] The stakeholders using EWS should be made aware of this, so they can use EWS to make the most informed choices for the purposes that they were meant for.

MAKING ADAPTATION ACTION "CONFLICT-PROOF"

EWS and other climate-security risk assessment tools provide helpful maps for developing adaptation strategies, yet the mere existence of such tools is not a silver bullet for addressing climate vulnerability. In order to translate quality information into action, climate-security actors require mechanisms to apply these tools on the ground. These actors can adjust existing climate adaptation programs to make them more "conflict-proof" and can create climate-security partnerships that provide new solutions to confront intensifying risks strategically. These programs and partnerships can ensure that high-level information is integrated into regional and local action on climate adaptation.

Given the interconnected nature of climate impacts, social vulnerability, and conflict risks, it is critical that climate adaptation programs be made "conflict-proof". Adaptation initiatives should integrate concerns regarding social vulnerability and include alternative pathways to respond to changing social and political conditions. This is particularly important given the long timescales that are required to design effective adaptation strategies. A 2020 brief from the International Institute for Sustainable Development noted that the timescales required for an effective National Adaptation Plan (NAP) process align well with relevant timescales for peacebuilding.[47] Post-conflict recovery can take decades to achieve long-term stability goals and climate adaptation planning often also requires a generational lens.

National climate policies such as Nationally Determined Contributions (NDCs) can also take into account the interplay between climate variability, extreme weather, land-use pressures, transhumance, and the potential for intercommunal conflict.[48] For example, Mali's NDC states that enhancing and protecting the natural resource base may serve as a good adaptation strategy to minimize conflict between farmers and pastoralists.[49] The country's National Adaptation Programme of Action, in 2007, had recognized that changes in natural flood systems and frequent droughts were weakening and degrading ecosystems, driving migration, which might result in land disputes and conflict.[50] Finally, successful climate change adaptation policies could be scaled up. In the case of Mali, that includes changes in the production and marketing strategies for livestock.[51]

While the extended timescales of NAPs and NDCs provide opportunities for peacebuilding, they also introduce more uncertainty into adaptation planning. Effective adaptation plans should acknowledge and address this uncertainty. Sociopolitical dynamics and conflict conditions can change drastically over the course of decades. Without effective plans in place to adapt existing adaptation programs in the face of disruptions, adaptation initiatives risk disintegrating quickly in the face of conflict, leaving populations vulnerable to both climate and conflict risks. Resilient adaptation planners, including donors, governments, and implementing actors, must prepare to pivot their interventions to remain resilient across a range of potential future scenarios, including conflict. Flexible operational protocols throughout the implementation of the adaptation strategies are necessary to account for changing factors over time.[52]

A final consideration for "conflict-proofing" adaptation programs is to avoid maladaptation, which can entrench or exacerbate the existing vulnerability of marginalized populations. Maladaptive solutions may address short-term climate risks while heightening long-term vulnerability. From a climate-security perspective, maladaptation could lead to risks such as decreased land tenure security; marginalization of minority groups; increased environmental degradation; and the exploitation of climate funding by biased, elite, or oppressive groups.[53]

Given these risks, it is important to understand the complexity of population vulnerability, ensure equitable stakeholder participation in project design and implementation, and implement robust evaluation of the success of adaptation programs in order to avoid maladaptation.[54] Local communities, including marginalized groups, have the most direct understanding of maladaptation risks, which may vary greatly at the subnational level. Therefore, another starting point for more security-proof adaptation policies is Local Adaptation Plans of Action (LAPAs), which can then help to shape broader National Adaptation Plans.[55] Local communities are the best choice for identifying conflict risks and potential solutions, and analyzing the impact of adaptation interventions on conflict dynamics.[56] It is exactly for these reasons that local communities should have a leadership role in responding to EWS. This issue is explored in greater depth in the next subsection.

Integrating Local Leadership into Early-Warning Systems

One major challenge for EWS in Africa is ensuring that the data and information they provide is applied on the ground to increase climate resilience in tangible ways. A lack of localized knowledge and data analysis in addition to challenges to disseminating information to local communities are barriers to effectively responding to climate and security risks. In response to this gap, a series of interviews with the International Military Council on Climate and Security (IMCCS) members based in Africa highlighted the opportunity to integrate information sharing and planning into existing local customs for adaptation to climate-security risks.

Robust systems for information sharing exist at the local level, yet they are often misunderstood or underappreciated by regional or state institutions. However, when those local information-sharing systems are utilized, they can be very effective at mobilizing communities to action and doing so at a low cost. In one example from expert interviews, an Indigenous local community leader in South Sudan was able to convene the community in order to warn them about an incoming flood based on meteorological predictions. In the meeting, the community also discussed the steps they might take to prepare for the incoming disaster. This community leader was able to accomplish information sharing that directly translated to collaborative action on an immediate timescale. In contrast, the expert predicted that the same process would have taken a traditional meteorological team extensive time and financial/personnel resources to accomplish.

As this example illustrates, expanding the opportunities for local engagement is common sense, and can help fill the gaps in traditional information-sharing methods. It can also guard against maladaptation by ensuring that the community's perspectives regarding its own security and climate adaptation are elevated to the highest levels of decision-making.

Active Climate-Security Scenario Exercises

EWS leverage data in order to assess and predict the likelihood of climate impacts and disasters. However, data often fails to predict the impact of less-measurable variables, such as governance decisions or social, cultural, or geopolitical dynamics. For example, in Ethiopia, adaptation planning based on climate predictions has informed the resettlement of pastoralist populations. However, that resettlement has contributed to the further marginalization of those groups in society,[57] a factor that likely could not have been predicted by data alone. Given the human dimensions of these dynamics, it becomes useful to combine data with the experience of practitioners, experts, and stakeholders through serious gaming and scenario exercises.

Climate-security scenario exercises provide participants with relevant background on climate conditions, disaster projections, history, culture, and politics in the country or region of interest. With this background, participants encounter a theoretical future risk, which they must seek to understand and respond to. The goal of these exercises is to bring together experts, practitioners, and stakeholders to address realistic future scenarios in an integrated way.[58] A collection of experts may be able to assess social, cultural, political, and governance dynamics in a way that data cannot. Scenarios can also bolster the preparedness of climate-security practitioners and community members to respond to emerging risks on a local, national, or regional level in Africa and develop effective climate-security adaptation strategies for action.

Box 1. A Case Study in Mobilizing Stakeholders to Action: The Water, Peace, and Security Partnership

The Water, Peace, and Security (WPS) partnership is a case study that illustrates how adaptation tools have been translated into stakeholder engagement and integrated action.[59] The WPS partnership has created a Global Early Warning Tool that seeks to anticipate the emergence of water-related conflicts. For example, the February 2022 quarterly analysis warns of possible emerging conflict in Kenya, Somalia, Ethiopia, South Sudan, and Cameroon.[60] The data analysis lays the foundation for identifying the most pressing risks, but it is only the first step of the partnership's work. The WPS partnership builds on its data tool in order to implement adaptation action through a four-step process: understand, mobilize, learn, and dialogue.

Figure 2. The Water, Peace, and Security Process

Source: Adapted from WPS website[61]

The early-warning tool developed by the WPS partnership synthesizes and analyzes data from around the world in order to help policymakers understand where water/climate risks intersect with political instability and threaten conflict. The publication of quarterly analyses makes complex data across a global landscape accessible to policymakers and humanitarian, peace, and security actors. The available information further drives analysis, engagement, and action on the ground.

The information provided through EWS is then intended to mobilize stakeholders and decision-makers to action. The WPS partnership has found that action to adapt to climate-security risks is more effective when it is integrated, as opposed to siloed. Therefore, adaptation projects should be co-created by a diversity of relevant stakeholders. For example, in Kenya, the WPS partnership has engaged in participatory workshops with government authorities, local civil society organizations, and national and regional organizations to develop a work plan for addressing water-related conflicts in the Turkana basin.[62] Ultimately, participatory processes mobilize diverse actors to reach more effective adaptation solutions.

WPS training programs can help to bolster stakeholder engagement by providing tools to the 4D community (diplomacy, defense, development, and disaster response) to understand and adapt to climate-security threats. This includes skills for identifying climate/conflict risk hotspots and engaging in conflict resolution and community mediation. Additionally, these trainings can include serious gaming and scenarios exercises as a way to build adaptation strategies.[63]

A key pillar of the WPS partnership is dialogue, an active peacebuilding practice. Climate challenges and water scarcity can serve as an impetus for collaboration, especially in the implementation of climate adaptation projects. In Mali, the WPS partnership has established three dialogue programs to engage communities on water and security links, gather their perceptions of key risks and potential solutions, and present tools and advocacy opportunities to strengthen the voices of communities.[64] The programs resulted in 15 sessions (five per location) and were devoted to an introduction to conflict analysis, mapping of key water-related security risks in each location, in-depth analysis of key risks, and the presentation of prospective tools.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In Ethiopia, the WPS partnership's work is in the early stages of engaging with relevant stakeholders and it has conducted a four-day preliminary workshop with high-level decision-makers at the ministerial, regional, and basin levels. This resulted in a better understanding of the major challenges in the region's water resource management, serving to help the Omo-Gibe Basin development plan, identify potential pitfall traps, avoid repeated mistakes, and improve effective implementation.

Integrating dialogue into the planning and implementation stages of all adaptation projects is important for addressing community concerns. For example, adaptation projects could create economic or social winners and losers, increasing instability among the local population. Dialogue programs help to avert these missteps toward maladaptation and establish local partnerships that are more resilient to climate and conflict risks.

The WPS partnership provides a useful four-step model that can be applied to adaptation projects in Africa: understand, mobilize, learn, and dialogue. These steps can ensure that adaptation programs address the most serious climate-security risks and do so in a way that builds peace, rather than entrenching instability or exacerbating conflict risks.

"CLIMATE-PROOFING" SECURITY ACTION

The African security sector can make important contributions to climate adaptation action in a way that is "conflict-proof". Around the world, the military is increasingly on the frontline of responding to natural disasters. Traditional humanitarian institutions have raised valid concerns about the involvement of the military, especially in conflict or post-conflict societies where legacies of violence are pressing concerns for local communities. However, military forces, especially local security forces, are often the first and best equipped to take rapid action when disasters hit. They are also already primed for robust planning through training and scenarios exercises, which can inform anticipatory adaptation strategies.[65] Defining policies and best practices for security sector engagement in climate adaptation in Africa can help build on the opportunity for action.

The principles identified for a global framework in "The Responsibility to Prepare and Prevent: A Climate Security Governance Framework for the 21st Century"[66] translate well into an adaptation framework for Africa, which can guide the development of adaptation leadership and strategies. These principles include assessment and anticipation, elevation and translation, and coordination and alignment.

The first principle, assessment and anticipation, emphasizes the importance of establishing an oversight framework and body to anticipate risks. The African Union's Continental Early Warning System (CEWS), which currently focuses on conflict predictions alone, could become a natural home for more intersectional risk assessments.[67] An integrated risk assessment tool could analyze factors like natural disasters, drought, and climate-induced migration and predict the relationship between these factors and conflict risk. Following the example of the WPS early-warning tool, this information could be disseminated to regional and local actors, allowing them to anticipate and respond to oncoming risks.

The second principle, elevation and translation, focuses on the adoption of climate-security concerns and solutions by senior leadership. This high-level buy-in is critical because it can accelerate action across all levels of government and coordination between states. It can also enable conversations across the 4Ds (diplomacy, defense, development, and disaster response) for more integrated and effective climate-security action.

The third principle, coordination and alignment, seeks to align climate policy and action with security policy and action. As previously discussed, it is important to "conflict-proof" adaptation. Complementarily, it is important to "climate-proof" peace and security interventions. Climate practitioners should be responsive to conflict risks and security institutions must be prepared for climate risks.

Examples of Regional and Local Security Actors Undertaking Climate Action

The UN Office for West Africa and the Sahel (UNOWAS)

In 2020, the mandate of UNOWAS was updated to, "Take into consideration the adverse implications of climate change, energy poverty, ecological changes and natural disasters, among other factors, including by assisting the governments of the region

and the United Nations system in undertaking risk assessments and risk management strategies relating to these factors."[68] This mandate represents a significant positive step in the elevation of climate-security concerns and translation into action at senior levels.

Already, actions taken by UNOWAS include the establishment of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), research on emergent conflicts between pastoralists and farmers in the region,[69] and collaboration with the Economic Community of West African States (ECOWAS) on conflict-sensitive approaches to NAPs.[70] In addressing the implementation of adaptation plans, the UNOWAS–ECOWAS partnership has found that it is critical to draw on existing local knowledge, customs, and capacity in order to minimize the burden on local actors and find solutions that work in the given context.[71]

One of the largest recommendations for further work in the UNOWAS is to create mechanisms to respond to existing EWS and transfer the information they provide into existing local networks and governance systems. Existing tools like the Pastoral Early Warning System, which tracks drought, or an EWS developed by scientists to track locusts are available, yet the information they provide must be disseminated to the local communities that must adapt to changing climate impacts.[72]

Photo: UN Photo/Catianne Tijerina/Flickr

The African Union

The African Union has set a positive example for integrating climate-security concerns into their policies and frameworks, building a foundation for expanded action on these accelerating risks. The policy frameworks that address, in part, the security impacts of climate change include the African Union Master Roadmap of Practical Steps to Silence the Guns in Africa by Year 2020, the Continental Structural Conflict Prevention Framework (CSCPF), and the Africa Peace and Security Architecture (APSA) Roadmap 2016–2020.[73]

To examine one of these frameworks, the CSCPF creates a process for the development of country-specific vulnerability and resilience assessments, intended to understand the underlying structural dimensions that inform conflict. The document explicitly names environment and climate change as a potential structural cause of conflict and instability in the region and encourages assessments to shape effective structural vulnerability mitigation strategies. It is also tied to a continental EWS through the Africa Prospects tool.[74] This approach provides a theoretical foundation for addressing systemic risks, and follows the recommendation to link early-warning data with a strategic policy framework for response.

Given this foundation, moving from the development to the implementation of these policy frameworks is a clear next step for African Union leadership, which has the opportunity to elevate climate security to high levels across the continent. One of the African Union's largest strengths is its opportunity for cross-sectoral collaboration, which is already increasing on climate security. Leveraging partnerships to integrate climate-security policy frameworks into a diversity of portfolios of action including food security, humanitarian intervention, conflict prevention, and development is key to addressing the root causes of instability.[75]

Local Security Actors

In a series of interviews, IMCCS members based in Africa expressed the critical importance of local security forces in climate adaptation planning and disaster response. Even in locations where disaster management committees exist, they are often under-resourced and ill-equipped to respond to disasters in real-time. Therefore, local communities are most likely to turn to the military and/or the police to respond in times of crisis. When disaster strikes, deliberating on which kind of actors would be best to respond is a luxury. Those who are present and equipped to act become the default first responders, with few questions asked.

One former government official explained further that security forces are equipped with resources and personnel that would need to be externally contracted by a disaster response unit. While an under-resourced disaster response committee is working to contract medics for their mission, military medics are already on the ground responding to communities in need when disaster hits. Given the current distribution of resources, security forces play an essential role in responding to intensifying climate impacts and preventing loss of life.

A key role of security forces is strengthening the capacity of non-military actors to engage in long-term strategic planning in the face of climate and conflict risks. This would enhance the coordination between security forces and communities during disaster response initiatives, while also creating an environment in which climate-security adaptation measures are effective in the long term and managed by local stakeholders. In addition to making these approaches conflict-sensitive, interviews revealed that gender-sensitive approaches are also critical to prevent exacerbated risks for vulnerable communities.

Ultimately, regional and local security sectors in Africa have a vast opportunity to engage in climate adaptation and climate-security risk reduction. In many cases, they may be the only existing or best-equipped force to prepare for and respond to disasters. Creating strategies to improve this engagement for the benefit of local communities will guide future efforts to weather the increasing intensity of climate impacts.

RECOMMENDATIONS

The security landscape in Africa is evolving in response to rapidly shifting climate conditions. Integrating climate and security action is critical for adapting to the unprecedented challenges of a climate-changed world. As this chapter shows, climate adaptation projects cannot be designed and implemented in isolation of policies meant to address economic, social and political challenges faced by local populations, and vice versa. The climate-security adaptation framework presented in this chapter can support efforts to design more timely, effective, and resilient adaptation-based plans that are “conflict-proof” and “climate-proof”. Some points for policymakers to consider are:

1. Developing a conflict-sensitive climate adaptation strategy and a climate-sensitive security strategy requires a deep understanding of the climate-security nexus and of the ways in which this applies to the local context. Research on the climate-security risk nexus has identified several pathways by which climate change impacts can produce social, political and economic conflict. Many of these pathways have a direct application to Africa, and specific combinations of them can be identified in particular regions. Understanding these pathways and identifying vulnerable regions can facilitate the development of more specific data tools to predict and anticipate climate-security risks in Africa.
2. The design and deployment of effective EWS is an indispensable part of dealing with climate-security risk. Based on triangulated research methods involving local communities and climate-security practitioners, an effective EWS can be developed that informs the development of adaptation programs to address climate-security risks. EWS should rely on local actors and their knowledge in order to prevent maladaptation and to not enhance or exacerbate existing vulnerabilities of local and marginalized communities. Any action informed by EWS must be carefully evaluated to avoid unsustainable choices, unintended consequences for local communities, or escalations of humanitarian crises.
3. Regional institutions in Africa have begun to integrate climate-security risks into their policy frameworks, but urgency is required in translating those frameworks into action, especially by

building on the strengths of local security actors. UNOWAS and the African Union have both demonstrated strengths in the development of EWS and policy frameworks to understand climate-security risks. However, it is important for regional institutions to move from assessment into action to ensure adaptation for communities in practice. Local security actors play an important role in the application of adaptation strategies on the ground, as they are often the first and best equipped to respond to increasing climate risks.

4. Translating climate-security assessment into action requires participatory engagement through, for instance, scenarios exercises, training and dialogue, and co-creation with local communities. These tools can help to eliminate gaps in data dissemination and climate adaptation action, especially for vulnerable and/or disconnected communities.

5. Local communities should have a leadership role in responding to EWS. Local communities are the best choice for identifying conflict risks and potential solutions and analyzing the impact of adaptation interventions on conflict dynamics. Robust systems for information sharing exist at the local level, yet they are often misunderstood or underappreciated by regional or state institutions. However, when those local information-sharing systems are utilized, they can be very effective at mobilizing communities to action and doing so at a low cost. Therefore, another starting point for more security-proof adaptation policies is LAPAs, which can then help to shape broader NAPs.


Photo: MONUSCO/Force/Flickr

Migration and Climate Change

(based on the World Bank Groundswell Report Series)

In Africa, most climate-related migration currently takes place within countries (internal climate migration) or between neighboring states, rather than to distant high-income countries.[1] Migration can be influenced by many inter-related factors: social, political, religious, economic, environmental, or climatic. Population distributions in Africa historically have been influenced most by climate impacts on the water and agriculture sectors and will continue through impacts on ecosystems and increased climate risks (sea-level rise, floods, droughts, storm surges). These impacts influence the attractiveness and perception of the safety of a location by interacting with other aspects of the living environment and impacting livelihoods.

As highlighted in the "Conflict and Migration" chapter[2] in the 2021 State and Trends report, the loss of livelihoods due to climate change can trigger migration, though social, economic, demographic, and policy incentives encouraging or obstructing migration are likely to play a more prominent role. Generally, areas that are perceived to have more economic opportunities or that see positive deviations in water and productivity also see more in-migration.

Some attempts have been made recently to predict the impact of climate change on migration in Africa. For instance, the World Bank's first Groundswell report,[3] published in 2018, adopted a population gravity model to project mobility in Sub-Saharan Africa under different climate scenarios, covering countries in East Africa, West Africa, and the Lake Victoria Basin region. The study constitutes a robust model with crucial insights for the future, but still contains many uncertainties. In particular,


Photo: yoh4nn/iStock

> Climate change for us in Djibouti, as well as for African countries, means vulnerability. It is synonymous with poverty, migration and displacement. Djibouti is a country which sees several million migrants crossing toward the Middle East, North Africa, and most certainly toward the countries of Europe. In general, these migrants are not only migrants due to conflicts but also due to climate change."

Ilyas Moussa Dawaleh
Minister of Economy and Finance, Djibouti

the projections are based only on populations at risk, rather than the population who might decide to migrate. Furthermore, the modeling also falls short in accounting for the adaptive capacity of individuals or their degree of agency. Here we present the latest numbers given for North and West Africa and the Lake Victoria Basin countries, with overviews of specific countries per region.

Migration Projections under Different Scenarios for North Africa and Sub-Saharan Africa, with a Deep Dive Into Morocco

The second Groundswell report, published in 2021,[4] applies the population gravity model to three new regions: the Middle East and North Africa, East Asia and the Pacific, and Eastern Europe and Central Asia. The model projects mobility under different climate scenarios and estimates changes in population distribution by the year 2050, based on climate and development trends across three scenarios.

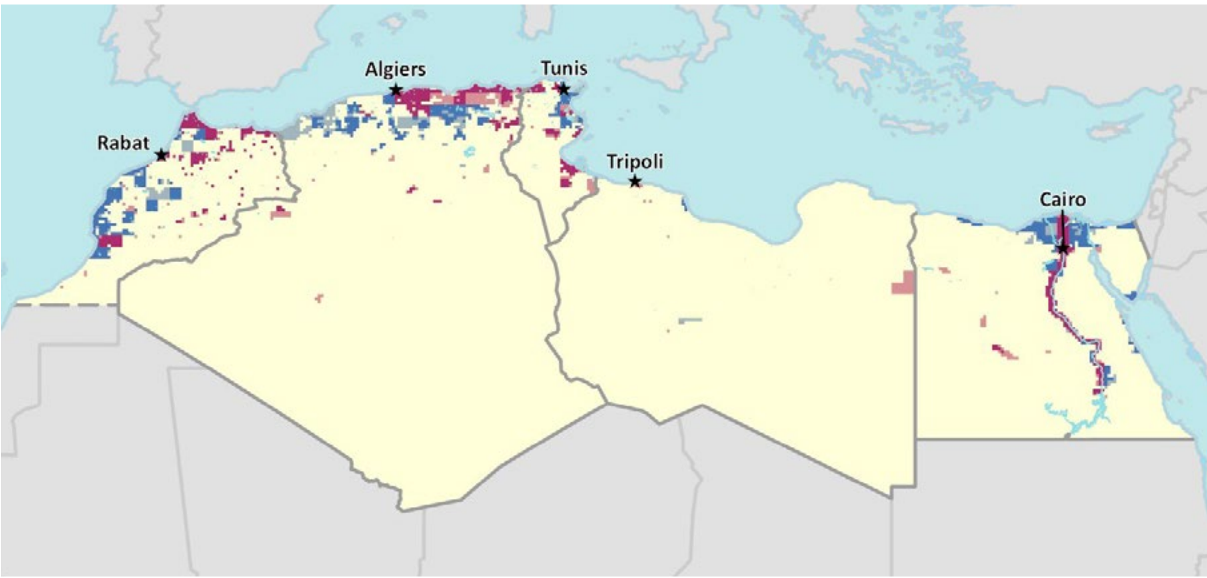
The scenarios are based on combinations of two Shared Socioeconomic Pathways—SSP2 (moderate development) and SSP4 (unequal development)—and two Representative Concentration Pathways—RCP 2.6 (low emissions) and RCP 8.5 (high emissions). The pessimistic RCP 8.5/SSP4 scenario (termed the "pessimistic reference scenario" in the report) projects high global greenhouse gas (GHG) emissions combined with an unequal development pathway; the RCP 8.5/SSP2 scenario (called the "more inclusive development scenario" in the report) projects equally high emissions with a more equal development pathway; and RCP 2.6/SSP4 projects a scenario (the "more climate-friendly scenario") with lower emissions and an unequal development pathway.

The model correlates spatial patterns with population change while inputting geographic, socioeconomic, and demographic characteristics of the landscape and existing population distribution. It accounts for climate impacts through four models with indices on water availability and crop productivity. Outputs were averaged to have a meaningful result. According to the model, under the pessimistic high emissions and unequal development scenario, the regions of North and Sub-Saharan Africa could witness 13 and 71 million internal climate migrants by 2050, respectively (Table 1). Under the lower emissions scenario, North and Sub-Saharan could record 4.5 and 28.3 million climate migrants, respectively.

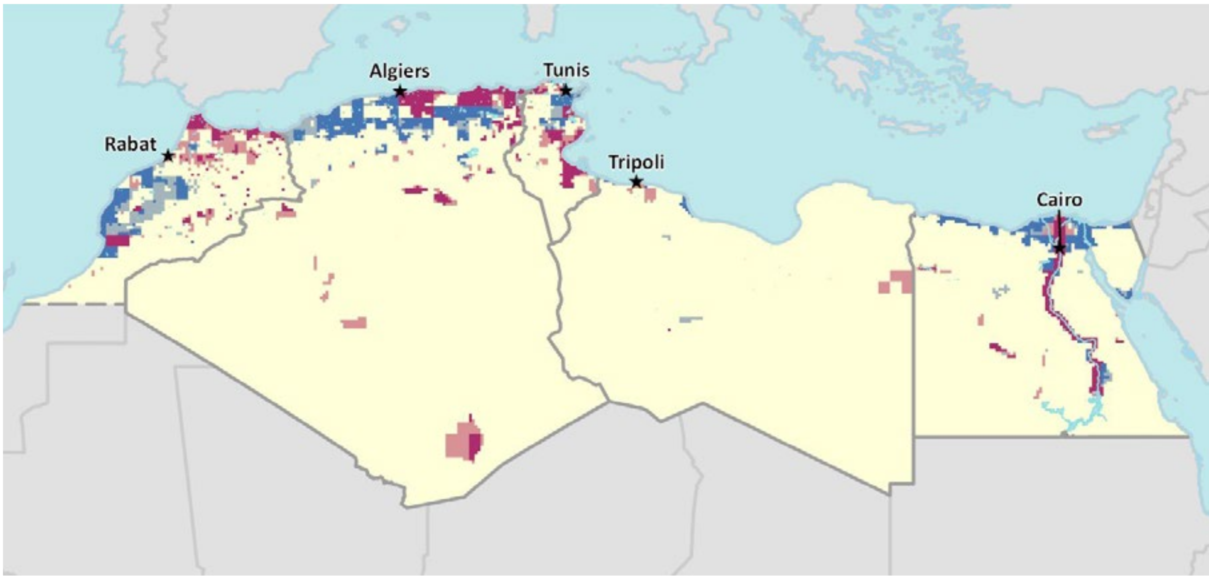
Given the projections across all development and climate scenarios for Sub-Saharan and North Africa, it becomes crucial to consider the influence of climate-induced migration on the present and future development of plans, policies, and strategies for the region. The Groundswell report's Migration and Climate-informed Solutions (MACS) framework could help governments mainstream climate migration considerations into multilayered planning through its core policies and action domains.

Figure 1. Areas Projected to Have High In-Migration and Out-Migration in North Africa, 2030 and 2050

a. 2030



b. 2050



In-Migration

- High certainty in high levels of climate in-migration
- Moderate certainty in high levels of climate in-migration

Out-Migration

- High certainty in high levels of climate out-migration
- Moderate certainty in high levels of climate out-migration

Note: High certainty reflects agreement across all three scenarios modeled, and moderate certainty reflects agreement across two scenarios.

Source: Reproduced from Figure 3 in Clement et al. (2021)[5]

For North Africa, major climate out-migration hotspots[6] due to sea-level rise and water scarcity might impact several coastal areas, such as the Nile Delta (eastern and western portions, including Alexandria); the northeast coast of Tunisia, including Kelibia; coastal areas in the northwest of Algeria, including Oran; and smaller areas of the west and the southwest coast of Morocco, including Agadir and Safi, by 2050. Inland out-migration would include the central Atlas foothills in Morocco due to the impact on rainfed croplands. Major in-migration hotspots[7] are projected to be in the Nile Valley and central Delta; the northwest and south coast of Tunisia, including the Gulf of Gabes; the eastern portion of the Algerian coast; and the northern coast of Morocco. Furthermore, densely populated urban centers like Cairo, Algiers, Tunis, Tripoli, the Casablanca–Rabat corridor, and Tangiers might also have an inflow of climate migrants (Figure 1).


Photo: UN Photo/Albert Gonzalez Farran/Flickr

Table 1. Projected Numbers and Shares of Internal Climate Migrants by 2050 for North Africa, Morocco, and West Africa

Region/country	Scenarios					
	Pessimistic reference (RCP8.5; SSP4)		More inclusive development (RCP8.5; SSP2)		More climate-friendly (RCP2.6; SSP4)	
North Africa						
Average number of internal climate migrants by 2050 (million)	**13.0**		**9.9**		**4.5**	
Minimum (left) and Maximum (right) (million)	6.6	19.3	5.8	13.9	2.9	6.1
Internal climate migrants as percent of population	**6.05**		**4.22**		**2.10**	
Minimum (left) and Maximum (right) (%)	3.08	9.02	2.50	5.94	1.36	2.84
Morocco						
Average number of internal climate migrants by 2050 (million)	**1.9**		**1.5**		**0.5**	
Minimum (left) and Maximum (right) (million)	1.1	2.7	0.9	2.1	0.3	0.7
Internal climate migrants as percent of population	**5.4**		**4.0**		**1.3**	
Minimum (left) and Maximum (right) (%)	3.7	7.7	2.3	5.6	0.8	1.9
Sub-Saharan Africa						
Average number of internal climate migrants by 2050 (million)	**71.1**		**53.4**		**28.3**	
Minimum (left) and Maximum (right) (million)	56.5	85.7	42.1	64.8	17.4	39.3
Internal climate migrants as percent of population	**3.49**		**3.01**		**1.39**	
Minimum (left) and Maximum (right) (%)	2.78	4.21	2.37	3.65	0.85	1.93

Source: Authors' synthesis of Groundswell modeling results[8]

Morocco

For Morocco, an upward trend in the number of internal climate migrants is projected across all three scenarios by 2050. A substantial difference can be seen between the pessimistic scenario with unequal development (an average of 1.9 million) and the "more climate-friendly development" scenario (an average of 0.5 million). Projections estimate that climate out-migration hotspots by 2050 will focus on the central foothills, including around Marrakech, on the west and southwest coast around Casablanca and Safi, and south of Agadir to Tiznit. Conversely, climate in-migration hotspots, partly fueled by migrants searching for job opportunities, may form in the southwest near Agadir, around Rabat, and the Tingitana Peninsula, including Tangiers.

Using the anthropogenic biome classes defined by Ellis et al. (2010),[9] the Groundswell Report II identified Morocco's three main livelihood zones: rainfed croplands with scattered irrigated croplands, pastoral and rangelands, and semi-natural and wildlands. Migration into or out of one of the zones implies changes in the livelihoods of those who migrate and might be partially driven by climate. The projected net change in the number of climate migrants by 2050 across Morocco would see small positive net climate migration on pastoral lands and rangelands, potentially exceeding 200,000 people in the two high-emissions scenarios. Rainfed croplands would see a small negative net climate migration by 2050, though the uncertainty range shows negative and positive values.

Migration Projections under Different Scenarios for the Lake Victoria Basin Countries (Tanzania and Uganda) and West Africa (Nigeria and Senegal)

Two subsequent Groundswell Africa reports applied an enhanced climate migration model to conduct regional studies for West Africa and the Lake Victoria Basin countries, along with four country

Photo: piccaya/iStock

studies, intending to better inform policy action and dialogue. The enhancements include shorter time steps, more climate impact parameters, adding non-climate factors such as age and gender, higher spatial resolution, and developing a fourth "optimistic" scenario (RCP2.6/SSP2). The reports held virtual multistakeholder consultations in February/March 2021 to further enhance the model.

While there is some level of uncertainty across the models in each study, it is clear that policies geared toward equitable development and low emissions can significantly reduce the number of climate migrants. Further, the uncertainty in scenario projections presents an opportunity for resilient development if concrete early action is taken.

Table 2. Projected Numbers and Shares of Internal Climate Migrants by 2050 for the Lake Victoria Basin countries, Uganda, and Tanzania

	Scenarios							
	Pessimistic reference (RCP8.5; SSP4)		More inclusive development (RCP8.5; SSP2)		More climate-friendly (RCP2.6; SSP4)		Optimistic development (RCP2.6; SSP2)	
Lake Victoria Basin								
Average number of internal climate migrants by 2050 (million)	**31.9**		**25.8**		**26.2**		**22.5**	
Minimum (left) and Maximum (right) (million)	25.3	38.5	21.0	30.6	18.9	33.6	16.6	28.4
Internal climate migrants as percent of population	**8.7**		**8.2**		**7.2**		**7.2**	
Minimum (left) and Maximum (right) (%)	6.9	10.5	6.7	9.8	5.2	9.2	5.3	9.1
Uganda								
Average number of internal climate migrants by 2050 (million)	**10.9**		**8.8**		**8.6**		**7.1**	
Minimum (left) and Maximum (right) (million)	9.7	12.0	8.1	9.5	7.7	9.6	6.4	7.8
Internal climate migrants as percent of population	**9.68**		**9.45**		**7.7**		**7.6**	
Minimum (left) and Maximum (right) (%)	8.6	10.7	8.7	10.2	6.9	8.5	6.9	8.3
Tanzania								
Average number of internal climate migrants by 2050 (million)	**13.4**		**11.2**		**11.4**		**9.8**	
Minimum (left) and Maximum (right) (million)	10.2	16.6	8.5	13.9	7.2	15.6	6.5	13.1
Internal climate migrants as percent of population	**11.25**		**10.94**		**9.60**		**9.57**	
Minimum (left) and Maximum (right) (%)	8.53	13.97	8.30	13.58	6.08	13.13	6.32	12.81

Source: Authors' synthesis of Groundswell modeling results[10]

Lake Victoria Basin: Tanzania and Uganda

The 2007 freedom of movement protocols established under the East African Community (EAC 2002) allows citizens of the five Lake Victoria Basin countries (Burundi, Kenya, Rwanda, Tanzania, and Uganda) to live and work throughout the region. Given the connectivity and free movement among these countries, the influence of climate-induced migration is crucially relevant to informing planning, policy, and actions in the region.

Across the Lake Victoria Basin region, climate migrants could represent half of all internal migration by 2030 under the pessimistic scenario.[11] Major climate in-migration hotspots are projected in the immediate areas surrounding the lake in Tanzania and eastern Uganda. Areas in Rwanda with high levels of climate in-migration are the central region close to Kigali and in the north near the Uganda and Tanzania borders. In Burundi, a narrow and long out-migration strip is found in the west, close to Lake Tanganyika. A band of climate out-migration, predominantly driven by declining water availability and crop productivity, is projected in southwest Kenya, including Kisumi. This lies alongside a band of climate in-migration, due to increasing water availability and crop productivity, covering Eldoret, and expanding into other areas of the Rift Valley.

Tanzania and Uganda together represent around three-quarters of the total numbers of climate migrants regionally, with between 6.5 and 16.7 million projected in Tanzania and between 6.4 and 12 million in Uganda by 2050 under a pessimistic scenario. The stark difference in climate migration projections with other countries is partly informed by the considerable projected population increases in both Tanzania and Uganda. Table 2 presents projected internal climate migrant numbers for the region and both countries.

United Republic of Tanzania

For the United Republic of Tanzania, temperatures can be expected to rise between 2.3°C (RCP2.6) and 5.2°C (RCP8.5) by the end of the century, which is set to have an impact on migration flows.[12] An upward trend in the number of internal climate migrants is projected across all four scenarios between 2025 and 2050. The average number of internal climate migrants under the pessimistic scenario by 2050 is projected at 13.4 million, representing 11.25 percent of the total projected population. This number is the lowest in the optimistic scenario, with a projected 9.8 million climate migrants, representing 9.57 percent of the total population. The more climate-friendly and inclusive development scenarios for the same period project an average of 11.4 million (9.6 percent) and 11.2 million (10.94 percent), respectively. .

The number of internal climate migrants is projected to outpace the share of other internal migrants by 2030 in three of the four scenarios. By 2050 under the pessimistic scenario, this number is 13.4 million climate migrants in contrast to 10.9 million other internal migrants. As derived from the current model, climate migrants reflect mobility driven by adverse impacts of climate in contrast to other internal migrants who move for economic opportunity, urbanization, population growth, income, and education.

Climate in-migration hotspots could emerge in the northern part of the country, particularly around Lake Victoria. High-certainty in-migration levels are seen for cities such as Magu, Mwanza, which is expected to emerge as a high-intensity hotspot as early as the 2030s, and Geita, which is expected to emerge as a high-intensity hotspot by the 2040s. Increasing water availability in this region may offer a possible explanation for its attractiveness to climate migrants, despite being partially offset by projected decreases in crop yield. Smaller in-migration hotspots are also found scattered in the west in Sumbawanga and Mpanda.

Out-migration hotspots are projected in the east and south, including such cities as Dar es Salaam, Arusha, Korogwe, Dodoma, and Morogoro. Arusha may

emerge as a high-intensity hotpot in the 2030s, and the same may be seen in Dar es Salaam in the 2040s. One hotspot is found in Kigoma, near the border with Burundi.

Migration projections by livelihood zone[13] from 2030 to 2050 present net positive climate migration for rainfed croplands consistently across the four scenarios, ranging from 190,000 (more inclusive development scenario) to 317,000 (more climate-friendly scenario) projected by 2030. Negative net migration is seen for irrigated croplands, dense settlements, and pastoral and rangelands. Rice-growing croplands and semi-natural and wildlands show mixed results across scenarios and timelines.

Uganda

Projections in the number of internal climate migrants in Uganda present an upward trend across all scenarios.[14] Under the pessimistic scenario, the country could see up to 12 million internal climate migrants by 2050. The lock-in for internal climate migration (the low end of the optimistic scenario) is 6.4 million by 2050. The more inclusive development and more climate-friendly scenarios show averages of 8.8 and 8.6 million internal climate migrants, respectively. The optimistic and more climate-friendly scenarios have the smallest proportions of climate migrants as a percentage of the total population, with mean percentages of 7.6 and 7.7, respectively. The same for the more inclusive development and pessimistic scenarios are 9.45 and 9.68, respectively.


Photo: guenterguni/iStock

Under the pessimistic scenario, internal climate migrants could overtake the share of other internal migrants by 2050. For both the more climate-friendly and more inclusive development scenarios, the scale of climate migrants is projected to be similar to that for other migrants.

The locality of Mbale, located in the southeast, and its surrounding areas, may emerge as a high-intensity in-migration hotspot by 2030. Mount Elgon, the capital Kampala, as well as the southwestern locality of Ntungamo, could all be high-intensity hotspots by 2050.

Three major out-migration hotspots are projected to emerge by 2050, mainly in the northwest and central-west areas around Lake Albert. The locality of Koboko could be a high-intensity hotspot by 2030, with rapid escalation expected between 2040 and 2050. Gulu and Lira could become out-migration hotspots by 2050.

Climate in- and out-migration hotspots in Uganda are predominantly driven by negative and positive changes in crop productivity and water availability. Drought-induced migration in the Karamoja area, for example, sees movement of agro-pastoralists with their livestock to areas with water and pastures within the region and to neighboring sub-regions of Teso and Acholi. This, in turn, fuels resource conflicts and violence with the host communities, further increasing vulnerability.[15]

Migration projections by livelihood zone show negative net climate migration for rainfed croplands and rice-growing areas, and positive net climate migration in dense settlements and semi-natural and wildlands, across all scenarios for all decades. Mixed results are seen for irrigated croplands and pastoral and rangelands.

West Africa, Nigeria, and Senegal

West Africa could see as many as 32 million internal climate migrants by 2050 under the pessimistic scenario.[16] Without any adaptation actions in place mitigating climate impacts on the region, people are expected to migrate from areas with lower water availability, declining crop yields and ecosystem productivity, and from areas affected by sea-level rise compounded by storm surges. Under the pessimistic scenario, Niger, Nigeria, and Senegal are projected to have the highest numbers of internal climate migrants by 2050: reaching a high of 19.1 million, 9.4 million, and 1 million, respectively, under the pessimistic scenario.

Considering that internal climate migration is not uniform across countries, as it depends on demographic patterns and economic trends, it is increasingly important to pursue tailored concrete climate and development action to yield a reduction of internal migration. Within a low-carbon and equal-development scenario the region would see a stark contraction in the projected average internal migration of 11.9 million people by 2050—going from 19.3 under the pessimistic scenario down to 7.4 million under the optimistic scenario.

Table 3. Projected Numbers and Shares of Internal Climate Migrants by 2050 for West Africa, Senegal, and Nigeria

	Scenarios							
	Pessimistic reference (RCP8.5; SSP4)		More inclusive development (RCP8.5; SSP2)		More climate-friendly (RCP2.6; SSP4)		Optimistic development (RCP2.6; SSP2)	
West Africa								
Average number of internal climate migrants by 2050 (million)	**19.3**		**14.8**		**11.0**		**7.4**	
Minimum (left) and Maximum (right) (million)	8.7	32.0	4.9	27.0	2.5	22.7	0.9	16.9
Internal climate migrants as percent of population	**2.44**		**2.18**		**1.39**		**1.09**	
Minimum (left) and Maximum (right) (%)	1.10	4.06	0.72	3.99	0.31	2.87	0.14	2.50
Senegal								
Average number of internal climate migrants by 2050	**602,646**		**382,214**		**133,769**		**91,574**	
Minimum (left) and Maximum (right)	189,283	1,016,008	153,886	610,540	70,279	197,259	60,069	123,078
Internal climate migrants as percent of population	**1.98**		**1.58**		**0.44**		**0.38**	
Minimum (left) and Maximum (right) (%)	0.62	3.33	0.63	2.52	0.23	0.65	0.25	0.51
Nigeria								
Average number of internal climate migrants by 2050 (million)	**8.3**		**5.1**		**3.9**		**1.1**	
Minimum (left) and Maximum (right) (million)	7.3	9.4	3.6	6.6	1.9	5.9	0.4	1.8
Internal climate migrants as percent of population	**1.93**		**1.38**		**0.91**		**0.30**	
Minimum (left) and Maximum (right) (%)	1.68	2.18	0.98	1.79	0.45	1.37	0.12	0.49

Source: Authors' synthesis of Groundswell modeling results[17]


Photo: Immanuel Afolabi/Flickr

Nigeria

By 2030, the total number of climate migrants is projected to represent 1.48 percent of the total projected population. Under the pessimistic scenario, Nigeria could see an average of 8.3 million climate migrants—one of the highest in West Africa. That number under the more inclusive development scenario is projected to be 5.1 million. Under both scenarios, an acceleration of the trend is seen in 2045. The more climate-friendly scenario could see an average of 3.9 million internal climate migrants by 2050. This scenario also exhibits the slowest increase in numbers from 2020 to 2050.

The number of other internal migrants exceeds that of climate migrants across all scenarios through 2050, largely owing to the large population growth projected for the country. Climate migrants as a share of total internal migrants, however, will increase steadily through 2050.

Hotspots of climate in-migration are projected in the far north, across the states of Kano, Katsina (these could emerge as high-intensity hotspots by 2030) and Jigawa, and the northwest states of Sokoto (emerging as a hotspot in the 2040s) and Kobi. These hotspots are located in rainfed cropland areas, and likely driven by projected increases in water availability and crop production along the border with Niger. These regions are also characterized by the highest poverty levels in the country.

Climate out-migration is projected with high certainty, particularly in the southeast and southwest regions, by 2050. Lagos and Rivers could emerge as high-intensity climate out-migration hotspots by 2030. Ogun and Akwa are projected to emerge as the same in the 2040s. Climate out-migration hotspots are likely due to sea-level rise and other coastal risks. They coincide with both low and high levels of poverty, thus cutting across the socioeconomic context.

Livelihoods in rainfed croplands show positive net climate migration numbers consistently across scenarios and decades. Negative net climate migration numbers are projected for dense settlements, with an estimation of –0.07 million (optimistic) versus –0.24 million (pessimistic) by 2030 and –0.23 million (optimistic) versus –1.28 million (pessimistic) by 2050. These are consistent with the projected decrease, albeit modest, in water availability in the coastal urban region. Livelihoods in pastoral land and rangelands show varying net migration numbers across scenarios.

Senegal

For Senegal, an upward trend in climate migration is seen across all scenarios. Between 2025 and 2050, under the optimistic scenario, the number of internal migrants could see a 2.7-fold increase, while a 4.6-fold increase could be seen under the pessimistic scenario. The mean number of climate migrants projected under the more inclusive development scenario is on average 382,000, representing 1.58 percent of the projected population, by 2050. Under the climate-friendly scenario, Senegal could see a mean number of over 134,000 (0.4 percent of the projected population) climate migrants by 2050.

Coastal zones in Senegal are predominantly areas of climate out-migration except for a small area of in-migration northeast of Dakar. Under the low-emission scenarios (optimistic and more climate-friendly) 41,000 and 77,000 coastal migrants are projected respectively, versus a projected 206,000 people under the pessimistic scenario (by 2050). High-intensity out-migration hotspots are projected along the Dakar–Diourbel–Touba corridor, which is prone to flooding. These hotspots could emerge in Dakar, an important economic center in the country, and Rufisque, as early as 2030 and in Thies by 2040. The primary climate drivers are sea-level rise compounded by storm surges along the coast and declining water availability in the west-central area. Kaolack, which is located in the low-lying Saloum Delta region, is projected to emerge as a high-intensity out-migration hotspot by 2030.

In-migration hotspots are projected near Ziguinchor on the Guinea-Bissau border, which could emerge as a high-intensity hotspot by 2030, and in the town of Matam on the Senegal River, which could emerge by 2040. In-migration hotspots are also projected in eastern Diourbel and western Kaffrine. A high-intensity hotspot is expected to emerge in the east of Tambacounda by 2050. Climate pull factors appear to be increasing water availability, net primary production and crop productivity in these areas. Notably, these areas are also characterized by high levels of poverty.

By livelihood zone, negative net migration numbers are consistently seen in dense settlements, which have an upward trend, and rainfed croplands across scenarios and decades. A downward trend appears under the more climate-friendly scenario, with −10,459 projected in 2030, −9,090 in 2040, and −2,273 in 2050. Positive net climate migration numbers are generally seen for irrigated croplands, pastoral and rangelands, rice-growing areas, and semi-natural and wildlands, across scenarios and decades.

RECOMMENDATIONS

The MACS framework stems from the Groundswell report and subsequent deeper dives of Groundswell Africa, which sought to better understand the implications of climate-induced migration and mainstream it into development policies, plans and programs.[18] The Groundswell report emphasized four lines of policy action to tackle climate-induced migration, which must be buttressed with a set of action domains to drive planning and action at scale. The core policy directions aim to assist governments in reducing forced migration due to climate change, while the action domains are meant to bolster the delivery of these core policy directions to ensure sustainable development and adaptation outcomes.

To mitigate climate migration, governments should consider the following four core policy directions:

Cut GHGs now to reduce climate pressure on people's livelihoods and the associated scale of climate migration

Lowering emissions through mitigation policies such as carbon pricing, urban and land use planning, and innovations in performance standards can reduce climate pressure on ecosystems and livelihoods, which in turn will lower the need to migrate from certain regions.

Pursue inclusive and climate-resilient development policies with targeted investments to manage the reality of climate migration

Policies need to be anticipatory and climate-resilient in nature, accounting for the connections migration has with future climate impacts and responding to the issue over the medium and long terms.

Embed climate migration in development planning for all phases of migration and across time scales

Successful adaptation measures would allow communities to stay in place through investments in climate-smart infrastructure, diversifying income-generating activities, and building a responsive financial protection system for vulnerable groups. Nevertheless, policies must focus on addressing the full migration cycle, adapt in place when possible, enable mobility to lower-risk areas if adaptation cannot respond to all the climate impacts, and provide an adequate ecosystem for people after migration.

Invest now to improve understanding of internal climate migration

Investment is needed to understand migration and its connection to climate through an enhancement of modeling resolution, and improvement of data gathering and monitoring in countries.

Climate-induced internal migration as a cross-cutting issue needs to be addressed through policy-informed action that is farsighted in its approach and implementation. Through its five action domains, the MACS framework can bolster the impact of core policies and help mitigate and reduce climate migration when possible:

1. Conduct spatio-temporal analytics to understand the emergence of climate migration hotspots.
2. Enable and embrace landscape and territorial approaches for farsighted planning to avert, minimize, and address climate-induced migration.
3. Address and harness climate-induced migration as an opportunity for jobs and economic transitions.
4. Nurture development–humanitarian–peace partnerships for end-to-end action at the national and local levels.
5. Bridge the gap in legal mandates and frameworks on climate-induced migration.

The MACS framework is designed to be flexible and adaptive. Its application is not restricted to any single local, country, or regional context and its operationalization is not predetermined.

Photo: Sadik Gulec/istockphoto

The Unfinished Research Agenda in Adaptation

Photo: Riccardo Mayer/Shutterstock

KEY MESSAGES

- Adaptation is a complex and multifaceted subject that is evolving rapidly as climate change impacts the world in ever more challenging ways. Hence there is a large research agenda to fill in present and future knowledge gaps on adaptation, spanning the disciplines of climate science, economics, psychology, and other social sciences.
- For adaptation to be effective, it requires knowledge of current and future climate-related risks. However, there is a dearth of climate risk data and models for actors seeking to invest in adaptation, particularly at a more granular level. One of the most important but difficult challenges is to gain a better understanding of adaptation to more extreme forms of climate change, such as those associated with 3–4°C of mean surface warming.
- The effectiveness of strategies for adapting to climate change depends on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution. Research needs to contribute to an understanding of all three.
- Collective action is at the heart of many decisions regarding the management of natural resources,

which are a key locus of adaptation. Greater insight can be gleaned on how collective action is central to adaptive capacity at various scales by case-specific research.

- At the local level, adaptation preferences across the African continent have been found to be rather heterogeneous and conditioned by a host of social factors. In addition, the adaptation strategies perceived to be most effective were those that addressed underlying drivers of vulnerability, rather than those that focused on climate change alone. Further research is required on adaptive behavior at the local level.

“

We need the signals that Glasgow meant something, that Paris is alive, that hope is alive, that 1.5 degrees is no longer hanging by a thread, that the evidence and the science, most importantly, the lives that have been lost, the livelihoods and the property that has been lost in Africa really does demonstrate the reality for over one billion people in jeopardy. So let's use this moment for a reset for Africa, and for the world, and for our future generations.”

Amina J. Mohammed
Deputy Secretary-General of the United Nations

INTRODUCTION

Climate change poses risks to land-based food security, water security, urban systems, terrestrial biodiversity, and more.[1] Some risks are particularly relevant for individual regions while others are global. Climate change is expected to reduce renewable surface water and groundwater resources in most dry subtropical regions, possibly intensifying competition for water among sectors. Water stress is already a major issue in many countries around the world.[2]

Climate change is expected to affect agricultural production and further undermine food security. For wheat, rice and maize in tropical and temperate regions, climate change without adaptation will negatively impact production for local temperature increases of 2°C or more above late 20th century levels, although individual locations may benefit. Temperature increases of about 4°C or more above late 20th century levels, combined with increasing food demand, are expected to pose large risks to food security globally, with reductions in maize and wheat yields reaching up to 50 percent for many countries across Sub-Saharan Africa.[3]

The risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. Countries in Sub-Saharan Africa are particularly vulnerable to climate change because multiple biophysical, political, and socioeconomic stresses interact to heighten the region's susceptibility and constrain its adaptive capacity. The risk of climate-related impact is geographically heterogeneous. Flood risk is most prevalent in southwest Africa and countries with large rivers in West Africa, fueled not only by increasingly extreme hydrometeorological activity, but also by deforestation and urban encroachment in flood plains.

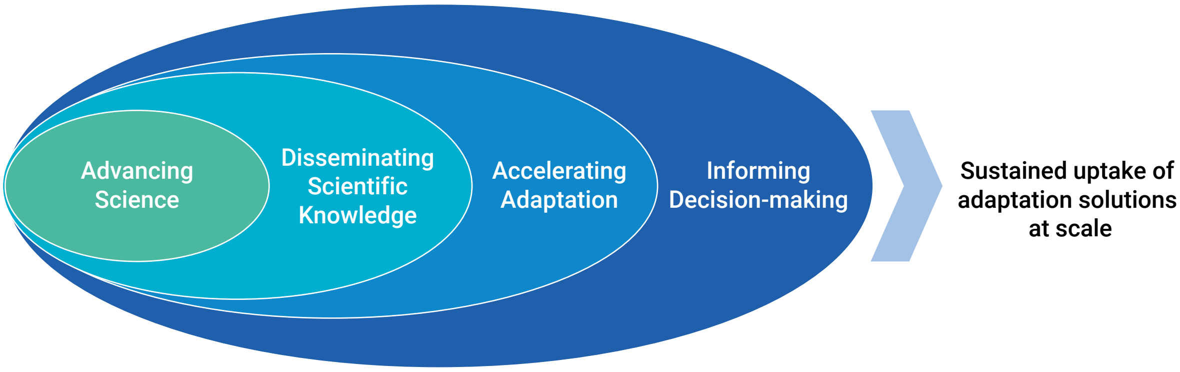
Sea-level rise is of particular concern in low-lying coastal areas, increasing flood frequency and risk of storm surge. This is of special concern given that half of the African settlements with 1–5 million inhabitants are located in low-elevation coastal zones, with some estimating that Africa's populations in low-elevation coastal zones will rise at more than double the world's average.[4] Extreme heat is particularly problematic because many cities in Africa have very little green space, leading to an increased heat island effect. Tropical cyclones, whereby one singular event can have a globally catastrophic impact, are also of concern. The livelihoods of 70 percent of Africans are dependent on rainfed agriculture, an activity that is characterized by small-scale, subsistence farms that are vulnerable to a variety of stresses, including those associated with climate change.[5]

Adaptation, defined by the Intergovernmental Panel on Climate Change (IPCC) as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities,"[6] is needed to manage current climate impacts and will be increasingly vital as the world continues to warm. Adaptation can take place at a number of scales, from local to global, addressing climate-related problems at that particular level, and making use of capacities available to that particular group of actors.

Since climate is inherently variable, human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes. Pastoralists in the West African Sahel, for example, have adapted to cope with rainfall decreases of 25–33 percent in the 20th century. Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits. However, adaptation progress is unevenly distributed with observed adaptation gaps. Also, many initiatives prioritize immediate and near-term climate risk reduction. To increase the efficiency and effectiveness of adaptation, integrated, multisectoral solutions that address social inequities, differentiate responses based on climate risk, and cut across systems are vital.

Research has a central role to play in achieving the transformational adaptation outlined above. However, it needs to go beyond assessing risks and identifying impacts and instead take a problem-focused and systems-oriented approach, pursuing user-centered solutions with a clear line of sight between research and its application. Figure 1 visualizes the theory of change of adaptation research for impact.

Figure 1. Theory of Change of Adaptation Research for Impact



ADVANCING SCIENCE AND DISSEMINATING SCIENTIFIC KNOWLEDGE

For adaptation to be effective, it requires knowledge of current and future climate-related risks. As an example, when planning for the coming season, a small-scale farmer might want to know when the rains are likely to start, and how long they are likely to last. Groundwater baseline data, 24–48-hour precipitation data, and forward-looking climate projections are key to determine what to plant and when to plant it in order to ensure optimal production. As another example, when planning a water storage and distribution system to ensure availability for a growing urban population, a government ministry will want to know where it should construct a dam and the associated infrastructure, and what their design should look like in order to ensure maximum efficiency and reduce the risk of losses or excessive maintenance and repair costs due to floods and drought.

Or consider the problem of coastal resilience, which needs to be understood before it can be solved. Erosion hotspots must be identified to inform the planning of actions to reduce erosion. Given the dynamic nature of coastal accretion and erosion processes, site-specific research and solutions are required. Hotspot identification requires monitoring and computational modeling of coastal morphology, sediment flows, and fluid mechanics as well as the impact of coastal developments in many locations. As another example, consider a country's National Adaptation Plans, which are supposed to direct investments toward strengthening the capacity of countries to cope with climate shocks. However, investments do not only need to help in coping with current and past shocks but also adapt to ongoing climate change trends. So, policymakers would need to know what to expect in the next 10, 20, or 30 years.

There is a dearth of climate risk data and models for actors seeking to invest in adaptation, particularly at a more granular level. Research also needs to provide insight into the conditions of vulnerability and exposure. The vulnerability to climate risk of individuals and of societies is determined, not only by the likely responses of the resources on which individuals depend, but by the availability of resources and, crucially, by the access of individuals and groups to these resources. This is well documented across a wide range of political and economic circumstances and development processes.

Vulnerability is thus a socially constructed phenomenon influenced by institutional and economic dynamics. As an example, on average, 60 percent of urban residents in Africa live in informal settlements.[7] In these settlements, existing vulnerabilities due to the lack of adequate income and assets, infrastructure, basic services, and voice in governance are further exacerbated by the degradation of ecosystems and habitats and climate change–related disasters and stresses.

Conducting vulnerability assessments and providing local climate projections can help formulate a clear climate rationale and identify where adaptation is needed the most. Informality characterizes a

Photo: Vlad Karavaev/iStock

significant portion of urban and rural economies across the African continent and must be understood if climate adaptation activities are to be effective. One of the most important but difficult challenges is to gain a better understanding of adaptation to more extreme forms of climate change, such as those associated with 3–4°C of mean surface warming. It is clear that those higher levels of warming could be extremely disruptive and adaptation strategies would have to change, perhaps fundamentally so. The empirical analysis is by design restricted to the relatively modest levels of climate variability observed in the recent past. Artificial intelligence is increasingly being used to expand the realm of future climate scenarios.

Researchers need to ensure that scientific knowledge is packaged in a comprehensible manner and disseminated to the broader public. Knowledge sharing among different stakeholders will help reduce transaction and information costs and involve the public and private sectors in identifying vulnerabilities as well as adaptation solutions. Data collection and analysis can also be empowering. Involvement of communities in data gathering and GIS mapping can help them to understand and articulate their needs and challenges better, and to negotiate more effectively with governments.

UNDERSTANDING ADAPTATION CONTEXTS

The diverse impacts of climate change and adaptation responses affect societies in numerous ways, including where and how food is produced and how water bodies are managed. The effectiveness of strategies for adapting to climate change depends on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution.[8] Research needs to contribute to an understanding of all three.

Adaptation processes involve the interdependence of agents through their relationship with each other, with the institutions in which they are situated, and with the resource base on which they depend. The nature of these relationships has been central to human ecology and geography, microeconomics, psychology, anthropology and the political sciences. Each discipline has theorized relations of trust, the nature of exchange relations and the cultural significance of and institutional constraints on the use of the natural environment. Economics has tended to focus on situations in which the agents can be expected to “know” or to have learned the consequences of different actions so that their observed choices reveal stable features of their underlying preferences. Economic theory is used to calculate how certain variations in the situation are predicted to affect behavior, but these calculations obviously do not reflect or usefully model the adaptive process by which subjects have themselves arrived at the decision rules they use.

Psychology has focused on "initial conditions" that determine the time path of a subject's behavior.[9] Research is required to find ways to measure and assess adaptive capacity, for example by conducting a further inquiry into the role, actual and potential, of adaptative elements in empirically oriented economic theory. Also, the political economy aspects of adaptation need to be considered in more detail, for example the role of vested interests such as homeowners in exposed areas, and the way different adaptation actors interact, for example in competition for water rights.

Incomplete markets shape the adaptation-related investments of firms including smallholder farmers. In rural areas of developing countries, financial market imperfections are pervasive, and there are broad regions in which almost every household manages farmland, effectively a firm. In these contexts, those facing constrained access to credit or insurance may choose to invest less, or differently, on their firm or farms than they would under perfect markets. Exposure to uninsured risks is another major constraint to technology adoption, including climate-smart technologies. Farms or firms that are exposed to risk invest more in unproductive assets to avoid the downside risk associated with exposure to flooding. This translates into lower income levels.

To respond to this, progress has been made with index-based insurance that could be well adapted to the conditions of smallholder farmers, with payouts triggered by a verifiable local rainfall index or a satellite-based small-area yield estimate. The use of index insurance has been shown to make a difference in inducing higher risk–higher yield investments in agriculture, but adoption has remained low. Research is required to identify ways of overcoming such practical barriers to adaptation. Insights from experimental psychology, which has traditionally focused on the process by which decision rules are replaced by others, may help to narrow the class of empirically interesting equilibria in certain economic models.

Many adaptation interventions, such as enhancing the resilience of infrastructure or providing common resources without clearly enforceable property rights like biodiversity, have traits of a public good and their benefits are expected to accrue over a longer time horizon.[10] Collective action is at the heart of many decisions regarding the management of natural resources. In agriculture, forestry, and other resource-dependent livelihoods, resources frequently exist under multiple property rights regimes. There are many different users, and there is limited information about the impacts of environmental change on sustainability.

Different social sciences have explored how societies choose to allocate scarce resources in the face of limited information and uncertain futures. Common to all theories of social interaction is the recognition that collective action requires networks and flows of information between individuals and groups to oil the wheels of decision-making. The nature of climate-related risk, the institutional context, the homogeneity of the decision-making group, and the distribution of the benefits of management and other factors are all important for collective action for adaptation. Greater insight can be gleaned on how collective action is central to adaptive capacity at various scales by case-specific research.

To generalize, one needs to learn from theoretical insights into institutions. In particular, there are the institutional prerequisites for the evolution and persistence of collective action and its relative importance compared to government intervention. To develop a conflict-sensitive climate adaptation strategy, for example, there is a need to better understand the climate security nexus and the ways in which this applies to the local context. Triangulated research methods involving local communities and climate security practitioners could result in an effective early-warning system that informs the development of adaptation solutions to address climate security risks.

Development economists are acutely aware of the importance of climate change for development.[11] They are concerned that unmitigated climate change will hit poor people particularly hard and may put development achievements at risk. But the climate risks that countries face are also determined to a considerable extent by the development decisions they take. The practical question that follows is:

How does climate-resilient development differ from conventional development? According to the IPCC, the risks associated with a given climate hazard are a function of the vulnerability and exposure of an economy to that hazard. Vulnerability and exposure can be reduced through appropriate adaptation. Of these three factors, economic development will generally lead to higher levels of adaptation, but vulnerability and exposure may either increase or decrease, depending on the development choices that are made.

The link between economic development and the level of adaptation is not obvious because development progress affects both the supply and demand for adaptation. On the supply side, the ability of economic agents to handle climate risks is a function of technical capacity, institutional factors and financial aspects (see discussion above). On the demand side, as income rises there is an increase in the demand for climate protection. The net effect of economic development, and a shift in location of economic activities from rural to urban, on vulnerability and exposure is ambiguous.[12] Further research is required to embed adaptation thinking into economic development plans. In macroeconomic terms, one way to model this is as the simultaneous accumulation of productive and adaptation capital.[13]

RESEARCH FOR INFORMING DECISION-MAKING ON ADAPTATION

Making adaptation decisions can be complex, requiring careful consideration of multiple factors and perspectives, and balancing different priorities over different timescales. Societies are said to only be at the start of a learning process that will continue for decades.[14] Decisions on adaptation are made by individuals, groups within society, organizations and governments on behalf of society. But all decisions privilege one set of interests over another and create winners and losers. Mainstreaming adaptation refers to the process whereby climate change concerns become an integral part of decision-making and influence the ways in which actors perceive the problem and consider climate change in their day-to-day activities.

At the macroeconomic level, successful adaptation policy would reduce tradeoffs across sectors and promote synergies; reduce under- and overreaction by departments, organizations, or ministries in response to climate change impacts; prevent inefficient investments of (scarce) resources; and promote coherence and consistency in implementing actions on the ground.

As mentioned before, long-term climate projections would facilitate policy design. But other challenges remain. We know a fair amount about the adaptation response of farmers, but much less about other sectors, such as the adaptation behavior of firms. We still know too little about the aggregate costs and benefits of adaptation and their distribution. Many adaptation interventions have traits of a public good and their benefits are expected to accrue over a longer time horizon. This renders their rate of return difficult to assess and quantify. In addition, adaptation lacks a commonly accepted metric for comparing and valuing its benefits, similar to the system of carbon credits received for investing in climate change mitigation.

Adaptation finance is meant to be provided over and above traditional development assistance. To quantify the incremental cost of adaptation, development projects would need to be designed under two scenarios: with and without climate change. While conceptually challenging, this is a promising line of inquiry. Of course, the two forms of funding are fungible, which means recipient countries will realign their spending decisions to achieve the adaptation–development mix they desire.

For decision-makers to be able to move from predict-to-act to risk-of-policy approaches, researchers need to assess the effectiveness of adaptation policies at the sector level, including the performance of adaptation measures under different climate scenarios, and then integrate these results in economy-wide models where they can also make linkages to the mitigation agenda. Such economy-wide models would also allow policymakers to assess impacts of adaptation strategies on poverty reduction and employment generation, which are important considerations from an equity point of view. The Comprehensive Africa Agriculture Development Program (CAADP) provides a good guide for the risk-of-policy approach.

At the local level, adaptation preferences have been found to be rather heterogeneous and conditioned by a host of social factors across the African continent. Case studies reveal that local preferences consistently supported the need for both autonomous and planned adaptation; a mix of hard and soft measures; and awareness of the importance of pursuing both collective and individual adaptation measures.

In addition, the adaptation strategies perceived to be most effective were those that addressed underlying drivers of vulnerability, rather than those that focused on climate change alone. Further research is required on adaptive behavior at the local level, for example the farm household, so that simulations run on that level can inform and predict the workings of the overall economy. Insights in adaptive behavior could also inform policy measures designed to build adaptive capacity of the more vulnerable.

Decision-making for scaling or replication of adaptation actions needs to be informed by learnings from adaptation actions on the ground. Several projects have already introduced adaptation solutions, for example a climate-smart adaptation technique or providing weather index–based insurance to farmers, but an intervention bias, the pilot or experimental nature of such initiatives, and a lack of methodologically sound impact studies, makes it difficult to draw lessons from these.

Impact evaluation, which includes identifying impact pathways of adaptation actions, would shed light on the limits to adaptation and reduce the risk of maladaptation pathways.

Of course, a sound evaluation would require a baseline and ideally a control group and thus needs to be conceived of ex ante. In addition to conventional impact evaluation, any new adaptation project or program, such as those under the Africa Adaptation Acceleration Program (AAAP), would have to be accompanied by research for the duration of its life cycle. Accompanying research is crucial for enhancing the impact of adaptation interventions. For example, data collection and analysis during project implementation can shed light on barriers to "soft" measures to address these.

To summarize, to achieve sustained uptake of adaptation solutions at scale, research efforts need to produce and ensure dissemination of comprehensive and disaggregated information on climate risks, to identify context-relevant adaptation solutions with high potential for uptake, and to develop decision-making tools that enable scaling. What is more, these various elements need to speak to each other.

Photo: BOULENGER Xavier/Shutterstock

Annex

- Country Profiles
- Endnotes

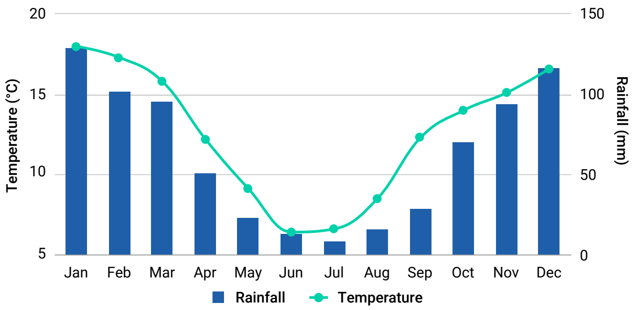
Photo: Joe Saade/UN Women/Flickr

Lesotho Climate Risk and Adaptation Overview

Adapted from the World Bank's Climate Risk Country Profiles Series, 2021

Climate Trends

Average Monthly Temperature (T) and Precipitation (Ppt), 1991–2020[1]



Country Context

Population **2.1 m (2020)**	Annual growth rate **0.8% (2020)**
GDP **US$1.8 bn (2020)**	Annual growth rate **–11.1% (2020)**
GDP per capita **US$861 (2020)**	GNI per capita **US$1,100 (2020)**

Literacy rate, adult female/male: 85% / 68% (2014).
Geography: Landlocked country surrounded by South Africa; land area: 30,355 km²; the country has four ecological zones: the lowlands (17%), foothills (15%), mountains (59%), and the Senqu River Valley (9%). Topography is mountainous with sharp terrains.
Broad climate: Temperate with alpine characteristics. Hot summers and relatively cold winters.

Climate Projections[2]

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (°C)	**+0.6 to +1.7** (+1.6°C)	**+1.5 to +3.0** (+2.1°C)	**+2.4 to +4.5** (+3.3°C)	**+3.4 to +6.2** (+4.4°C)
Annual Precipitation Anomaly (mm)	**–21.6 to +20.1** (–0.5 mm)	**–27.3 to +21.0** (–1.9 mm)	**–26.5 to +26.7** (–1.6 mm)	**–30.2 to +28.2** (–2.9 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

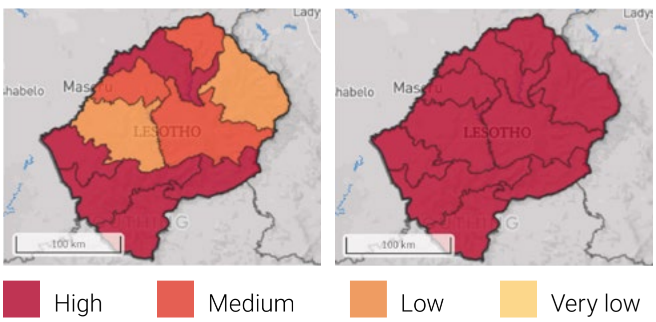
Climate Hazards

- More than 90% of disasters in Lesotho are related to climate variability and change, specifically drought, snowfall, hailstorms, strong winds, floods, early frost, and pest infestations.
- The country is particularly vulnerable as more than 70% of the population live in remote and ecologically fragile mountainous terrain.
- Lesotho has experienced increasingly frequent occurrences of drought in recent years. The country recently suffered from a severe drought from 2015 to 2017, due largely to El Niño events that affected Southern Africa. This significantly impacted food security and required international food assistance from international donors.
- Impacts of extreme rainfall events on public and private infrastructure have resulted in costly repairs, road closures, limited or no access to electricity, and complete failures of sewage and storm-water systems.
- Lesotho saw unprecedented rains, floods, and rock slides in December 2010 and January 2011, causing total losses and damages estimated at 3.2% of GDP.
- Increased temperatures and increased aridity will also heighten the country's risk of wildfires.
- Rural farmers are more sensitive to impacts of disasters due to having limited resources and low adaptive capacity.

Natural Hazards Occurrence, 1991–2022[3]

Hazard	Subtype	Events	Deaths	Affected
Drought		6	–	3,608,515
Flood	Riverine	2	26	5,000
Storm	Unstated	5	1	3,780
	Convective	2	–	4,500
Total		**15**	**27**	**3,621,795**

Risk of River Flood (left)[4], Risk of Wildfires (right)[5]



ENABLING ENVIRONMENT

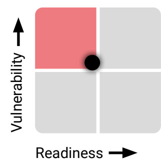
Leadership and Governance

- Ministry of Energy, Meteorology and Water Affairs (MEMWA): Responsible for the country's climate change strategies and serves as the national climate change focal point.
- The Lesotho Meteorological Service is responsible for the collection, processing, formatting, and management of data relating to weather and climate change for the Government, and supports reporting on climate change to the UNFCCC.
- Lesotho is also actively coordinating its climate change policies and strategies with stakeholders in the public and private sectors, including non-governmental organizations (NGOs), civil society, the donor community, and local communities.

ND-GAIN Index[6]

Country Index rank (score): 129 (41.4)
Vulnerability: 0.484
Ecosystem Services 18%, Food 21%,
Human Habitat 22%, Health 26%, Water 12%

Readiness: 0.311
Economic 36%
Governance 46%
Social 17%



Key Adaptation Policies

Key Policy Documents: Lesotho Vision 2020 (2018), Nationally Determined Contribution (2017), National Climate Change Strategy 2017–2027 (2017), National Resilience Strategic Framework and Theory of Change (2016).

Disaster Risk Management (DRM):

- Lesotho is in the process of developing and implementing a Disaster Risk Management Act and a corresponding Disaster Policy to strengthen institutional linkages between DRM and climate change adaptation.
- The Lesotho Meteorological Service plays a critical role in providing meteorological forecasts and extreme climate event information to the country's Disaster Management Agency (DMA) and other ministries in support of preparatory and response efforts to climate-related natural disasters.
- The DMA has undertaken systematic risk assessments specifically in regard to the country's water resources sector (including on flooding and drought potential) and water management systems.
- The DMA received technical support from the World Bank and the World Food Programme in order to build its early-warning systems in 2015. This was used to improve the country's preparedness and response capabilities.

ND-GAIN Evolution

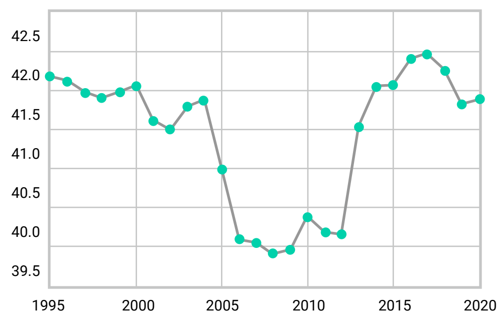



Photo: pg-images/iStock

SECTORAL ADAPTATION PLANNING

WATER

The sector contributed approximately 10% to Lesotho's GDP (in 2018).

Main Climate Change Impacts

- Longer dry spells interspersed with heavy rainfall events could intensify the potential for soil erosion.
- Increased temperatures are expected to decrease water availability and thus stream flows, increasing evapotranspiration and reducing runoff.
- An increase in the intensity of rainfall, coupled with a change in seasonality and duration, is likely to result in the increased occurrence of floods and droughts, which may also compromise irrigation potential.
- Future projected water supply constraints and temperature rise will impact food production and food security.

Milestones

- The Lesotho Highlands Water Project is a multistage infrastructure project that enables the transfer of water to Gauteng Province, South Africa.

Proposed Adaptation Strategies

- Develop policies to protect wetlands from persistent degradation and land-use mismanagement.
- Services and job creation can promote decentralization, which in turn could relieve pressure on water resources in urban centers.
- Implement integrated catchment conservation and management programs, expand rainwater-harvesting, water conservation techniques, water use, water reuse, and irrigation efficiency.
- Expand construction of dams to enhance water storage.
- Planning and adaptation strategies for water resources should also be included within development strategies for agriculture, infrastructure, and energy sectors.

AGRICULTURE

60–70% of the country's labor earnings are derived from agriculture, predominantly small scale, and characterized by rainfed cereal production with extensive animal grazing.

- **Important domestic crops:** maize, wheat, sorghum, potato, beans, peas, fruit trees, vegetables such as cabbage and tomato.
- **Major livestock:** sheep and goats (primarily for wool and mohair), cattle and pigs.

Main Climate Change Impacts

- Projected changes in precipitation and increases in temperature from September to May through mid-century are likely to positively impact yields for maize, sorghum, and wheat, and to negatively impact growth of beans and cucurbits (gourds).
- The projected decrease in precipitation from July to August through the end of the century will reduce soil moisture reserves and negatively impact the growth of winter crops.
- Decreased water availability is likely to reduce yields. The reduction in soil moisture may alter areas suitable for agriculture or the production of specific crops.
- Southern areas of the country are expected to be more adversely affected with regard to crop yields and productivity.
- Increased heat and water scarcity conditions are likely to increase evapotranspiration and contribute to crop failures and overall yield reductions.

Proposed Adaptation Strategies

- Develop linkages that connect smallholders to export and domestic markets.
- Switch to a more traditional farming system that combines the use of crop rotation, relay cropping, and intercropping practices with the application of manure and plant ash to conserve soil moisture and replenish soil fertility.
- Implement climate-smart agriculture practices.
- Improve water management and promote water-harvesting techniques.
- Improve monitoring and early-warning systems, and develop knowledge and decision-support systems.

NEEDS

Research

- Improve Lesotho Meteorological Service capabilities in projecting future climate trends and identifying the occurrence and magnitude of hazards.
- Widen participation of the public, scientific institutions, women, and local communities in planning and management, accounting for approaches and methods of gender equity.
- Strengthen environmental observation and monitoring capabilities for more effective environmental management.
- Expand capacity to use and apply analytical tools and models for enhancing effective and efficient decision-making.
- Increase the priority of research related to climate change and environmental sustainability efforts.
- Strengthen the technical capacity to integrate climate-smart agriculture, agricultural financing opportunities, and risk management for small-scale farmers.

Data and Information

- Increase sectoral data availability, particularly regarding land use and forestry and health sectors.
- Develop early-warning systems for dangerous hydrometeorological phenomena.
- Develop a geo-information-based approach in storage and management of data for accessibility and manipulation within the context of Lesotho's National Spatial Data Infrastructure.
- Establish a unit within the Bureau of Statistics that will facilitate data collection and archiving for environmental and climate change studies.
- Quantify the required international financial, technological, and capacity-building support for the implementation of vulnerability abatement measures up to and beyond 2030.
- Ensure that nationwide climate change and atmosphere monitoring systems are maintained and enhanced where necessary, including through monitoring networks at appropriate spatial density and frequency.

Institutional

- Intensify coordination across ministries, departments, and sectors on collection and exchange of specific data among stakeholders.
- Ensure that National Climate Change Strategy goals are developed within sectoral and regional plans and in line with financial opportunities with donors.
- Integrate climate change concerns into relevant policies and planning processes at state and national levels.

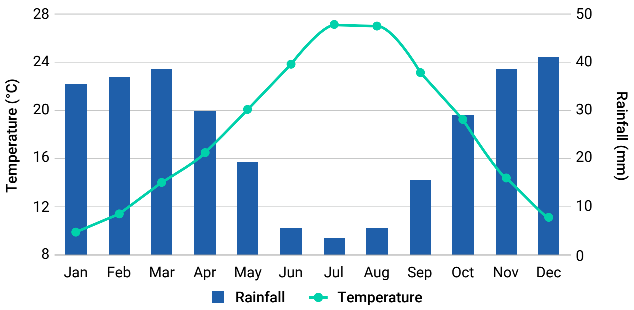
1 World Bank. 2022. "Lesotho – Current climate > Climatology" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/lesotho/climate-data-historical
2 World Bank. 2022. "Lesotho – Climate projections" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/lesotho/climate-data-projections
3 Authors' summary based on data from: Centre for Research on the Epidemiology of Disasters (CRED) EM-DAT database. Université catholique de Louvain, Brussels, Belgium. http://www.emdat.be (accessed June 2022).
4 ThinkHazard! 2020. "Lesotho: Water scarcity." https://thinkhazard.org/en/report/142-lesotho/DG
5 ThinkHazard! 2020. "Lesotho: Extreme heat." https://thinkhazard.org/en/report/142-lesotho/EH
6 Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index. https://gain.nd.edu/our-work/country-index/

Morocco Climate Risk and Adaptation Overview

Adapted from the World Bank's Climate Risk Country Profiles Series, 2021

Climate Trends

Average Monthly Temperature (T) and Precipitation (Ppt) 1991–2020[1]



Country Context

Population
36.9 m (2020)

Annual growth rate
1.2% (2020)

GDP
US$112.8 bn (2020)

Annual growth rate
–7.1% (2020)

GDP per capita
US$3,000 (2020)

GNI per capita
US$3,020 (2020)

Literacy rate adult female/male: 64.59% / 83.30% (2018).
Geography: Located in the northwest of Africa; bordered by the Atlantic Ocean and the Alboran Sea; topography includes the Rif Mountains in the north, the Atlas Mountains in the center, plateaus in the east, plains and coast in the west, and desert in the south.
Broad climate: Most of the country experiences a Mediterranean climate. Mild, wet winters and hot, dry summers.

Climate Projections[2]

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (°C)	**+0.6 to +2.3** (+1.4°C)	**+1.5 to +3.7** (+2.4°C)	**+2.6 to +5.3** (+3.7°C)	**+3.6 to +7.0** (+4.9°C)
Annual Precipitation Anomaly (mm)	**–8.9 to +7.0** (–1.4 mm)	**–10.5 to +7.0** (–1.8 mm)	**–12.4 to +4.7** (–3.2 mm)	**–13.9 to +5.3** (–4.0 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

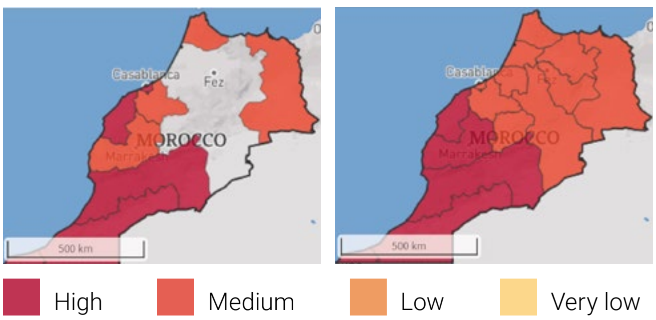
Climate Hazards

- Impacts from natural hazards are estimated to cost the country US$800 million annually.
- Extreme rainfall has resulted in soil erosion, land degradation, loss of ecosystems and ecosystem services, alien species invasion, salinization of groundwater and flood trails containing pesticides and fertilizer.
- Increasing incidence, severity and duration of drought in Morocco is the most significant concern for the country. This will exacerbate food insecurity through crop damage, loss of pasture and water sources, loss of animals, hunger, disease outbreaks, asset depletions, malnutrition and migration.
- Extreme weather events, such as storms and flash floods, are also expected to become increasingly more common.
- Changing rainfall patterns are expected to play a significant role in agricultural production and harvest seasons, with later onsets expected to impact crop productivity as well as livestock health.
- Rising sea levels pose a high risk especially to coastal urban zones as 60% of the population and the majority of the country's economic activities are along its coast.

Natural Hazards Occurrence, 1991–2022[3]

Hazard	Subtype	Events	Deaths	Affected
Drought		3	–	275,000
Flood	Unstated	4	65	3,650
	Riverine	11	921	116,400
	Flash	9	212	114,375
Storm	Unstated	1	14	–
	Tropical	1	1	–
	Convective	2	49	117,000
Landslide		2	16	10,000
Total		**33**	**1278**	**636,425**

Risk of Coastal Flooding (left)[4], Risk of Extreme Heat (right)[5]



ENABLING ENVIRONMENT

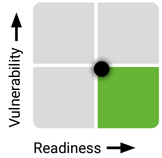
Leadership and Governance

- The National Committee for Climate Change and Biological Diversity (established in 2007) oversees all climate-related and biodiversity activities.
- This committee is chaired by the Ministry of Energy, Mines and Environment, which is also the national focal point for the UNFCCC.
- Morocco recognizes climate change as a multisectoral and cross-cutting issue. Critical sector attention is paid to water, agriculture, fisheries, shorelines, forestry, and health.
- Between 2020 and 2030, Morocco plans to invest at least US$35 billion in adaptation-related efforts for the country's most vulnerable sectors.

ND-GAIN Index[6]

Country Index rank (score): 66 (52.6)
Vulnerability: 0.380
Ecosystem Services 16%, Food 19%, Human Habitat 17%, Health 22%, Infrastructure 15%, Water 10%

Readiness: 0.432
Economic 39%
Governance 35%
Social 25%



Key Adaptation Policies

Key Policy Documents: Updated Nationally Determined Contribution (2021); Le Plan Maroc Vert, Bilan et Impacts, 2008–2018 (2020); The 2030 National Climate Plan (PCN) (French) (2019); Second Biennial Update Report (French) (2019); The 2030 National Sustainable Development Strategy (NSDD) (2017); Third National Communication (2016).

Disaster Risk Management (DRM):

- Morocco is committed to integrating systematic DRM processes to be implemented at national to local levels, including: risk management finance initiatives, insurance programs, and adaptation research assessments to support implementation and strengthen vulnerable sectors.
- Morocco is working to finalize its National Adaptation Plan. This process is guided by the National Climate Change Policy (2014) to respond to climate change and disaster risks and promote more proactive risk reduction and adaptation planning.

ND-GAIN Evolution

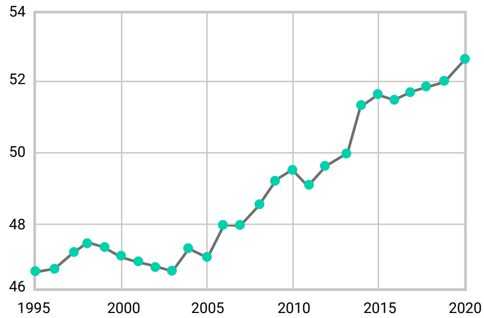


Photo: Rudolf Ernst/iStock

SECTORAL ADAPTATION PLANNING

WATER

Irrigation consumes an estimated 80–85% of available water.

Main Climate Change Impacts

- Rising temperatures and more erratic rainfall have reduced river flows and increased evaporation and siltation of storage dams, leading to a 20% reduction in overall water resources in the last 30 years.
- Rising temperatures are expected to reduce stream flows and overall water availability. Reservoirs of the Hassan Addahkhil and Idriss I, both critical water sources, are projected to decrease by 7–40% by the 2080s.
- Changing precipitation patterns and reduced water availability are expected to significantly alter some fertile regions, which may shift from semi-arid to arid or from sub-humid to semi-arid.
- Rainfall and evaporation changes also impact degrees of surface water infiltration and recharge rates for groundwater.
- Temperature increases have the potential to result in increased soil moisture deficits even under conditions of increasing rainfall.

Proposed Adaptation Strategies

- Morocco is in the process of constructing 60 large dams to mobilize 1.7 billion m^3 per year and support more efficient transfer from the northern basins to the south.
- The Government has committed to improve the country's water adaptation efforts through improving its wastewater treatment at a rate of 50% in 2016 to 60% by 2020, construct an average of three dams per year to reach 25 billion m^3 in stocking capacity in 2030, and invest in the desalinization of seawater to reach a capacity of 500 million m^3 per year.

Milestones

- A National Water Strategy has been implemented to improve water resource demand management and efficiency through irrigation programs.

AGRICULTURE

Accounts for about 15% of Morocco's GDP and 23% of its exports. Represented 69% of rural employment and 39% of jobs nationally (as of 2019). Some 87% of the country's total crop production is primarily rainfed, dominated by cereals. Morocco accounts for 53% of total Middle East and North Africa regional EU agribusiness exports.

- **Key agricultural exports:** citrus fruit, vegetables, almonds, table olives, olive oil, dairy products, blueberries, cherries and asparagus.

Main Climate Change Impacts

- Hotter, drier conditions are expected to increase crop water requirements by up to 12%, increasing demand for irrigation and further stressing limited water resources.
- Rising temperatures are expected to reduce yields of rainfed crops by 50–75% during dry years.
- Erratic precipitation and increased aridity and drought conditions will result in shortened growing seasons, reduced yields, and lowered productivity.
- Drought also promotes proliferation of the Hessian fly, increasing the risk of damage to wheat yields.

Proposed Adaptation Strategies

- Shift traditional rainfed systems in cereal production to conservation agriculture techniques (including no-tillage).
- Shift cereal production in fragile areas to more resilient crops such as olive trees or almonds.
- Promote climate change–resilient technologies.
- Establish monitoring and early-warning systems to improve drought decision-support systems and preparedness efforts.
- Expand emergency operational planning to develop networks and awareness across the most vulnerable areas.

Milestones

- Morocco has committed to switch from current to localized irrigation systems covering over 550,000 ha and to extend irrigation to over 260,000 ha of new agricultural areas.
- The sector will increase multi-risk insurance for cereals and legumes covering farming areas of 1 million ha.

NEEDS

Research

- Improve understanding of the impact and magnitude of climate change events and trends across the country.
- Widen participation of the public, scientific institutions, women, and local communities in planning and management, accounting for approaches and methods of gender equity.
- Strengthen environmental monitoring capabilities for more effective environmental management.
- Invest in weather stations and expand the country's national hydrometeorological monitoring system to advance networking for the measurement of climate parameters.
- Strengthen technical capacity to integrate climate-smart agriculture techniques, improved water resource efficiency, and climate change risk management across identified key sectors.
- Introduce academic curricula specializing in climate risk and climate change.

Data and Information

- Develop early-warning systems for hydrometeorological phenomena and climate risk management.
- Ensure maintenance and enhancement of nationwide climate change and atmosphere monitoring systems.

Institutional

- Integrate climate change concerns into relevant policies and planning processes at state and national levels.
- Implement cross-sectoral climate-smart solutions at national and subnational levels.
- Finalize land demarcation and the registry of forested areas to support adaptation planning.
- Build capacity for developing, financing, implementing, and monitoring climate change adaptation projects at institutional and local levels, inclusive of public–private partnerships.
- Strengthen adaptation of infrastructure against bad weather and future weather conditions.
- Develop and implement a monitoring and evaluation system to assess Morocco's vulnerability and adaptation progress.

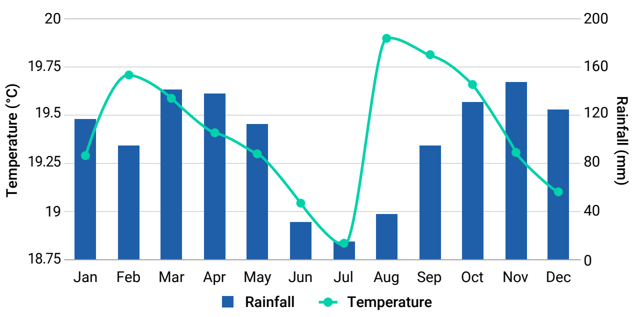
1 2021. Climate Risk Profile: Morocco. Washington, DC. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-09/15725-WB_Morocco%20Country%20Profile-WEB.pdf
2 Ibid.
3 Authors' summary based on data from: Centre for Research on the Epidemiology of Disasters (CRED) EM-DAT database. Université catholique de Louvain, Brussels, Belgium. http://www.emdat.be (accessed June 2022).
4 ThinkHazard! 2020. "Morocco: Coastal flood." https://thinkhazard.org/en/report/169-morocco/CF
5 ThinkHazard! 2020. "Morocco: Extreme heat." https://thinkhazard.org/en/report/169-morocco/EH
6 Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index. https://gain.nd.edu/our-work/country-index/

Rwanda Climate Risk and Adaptation Overview

Adapted from the World Bank's Climate Risk Country Profiles Series, 2021

Climate Trends

Average Monthly Temperature (T) and Precipitation (Ppt) 1991–2020[1]



Country Context

Population
12.9 m (2020)

Annual growth rate
2.5% (2020)

GDP
US$10.3 bn (2020)

Annual growth rate
–3.4% (2020)

GDP per capita
US$798 (2020)

GNI per capita
US$780

Literacy rate adult female/male: 69.39% / 77.56% (2018).
Geography: Landlocked country in central Africa. Total land area: 26,338 km².
Broad climate: The country has four primary climatic regions: the eastern plains, central plateau, highlands, and the region around Lake Kivu. Tropical climate.

Climate Projections[2]

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (ºC)	**+0.7 to +1.5** (+1.1ºC)	**+1.4 to +2.6** (+1.9ºC)	**+2.3 to +4.0** (+2.9ºC)	**+3.1 to +5.3** (+3.9ºC)
Annual Precipitation Anomaly (mm)	**–18.4 to +29.3** (3.3 mm)	**–23.3 to +39.3** (5.1 mm)	**–26.4 to +63.6** (9.5 mm)	**–24.5 to +91.5** (18.2 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

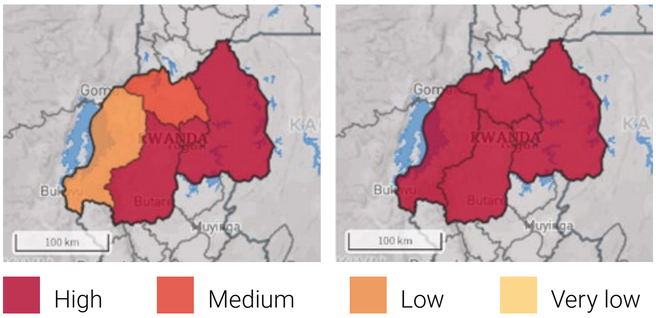
Climate Hazards

- Since the early 2000s, the frequency and severity of disasters, particularly floods, landslides, and droughts, have increased significantly.
- Droughts have already resulted in famine, population displacement, conflicts, and biodiversity loss. Seasonal droughts are expected to become longer, which will cause problems especially in the east and southeast of the country (Bugesera, Mayaga, and Umutara).
- Heavy rainfall events and at times flash flooding have become increasingly common, especially in the northern and western provinces, and can trigger landslides and mudslides. The risk and intensity of flooding through increased frequency and the intensity of heavy rainfall events are expected to increase due to climate change.
- Land degradation and soil erosion, exacerbated by recurrent floods, adversely impact agricultural production, disproportionately affecting the livelihoods of the rural poor.
- Recent population growth and land scarcity have pushed people to settle in flood-prone areas, worsening the effects of flood hazards.
- Approximately 40 percent of the population are exposed to landslides because they reside in highly vulnerable areas in the highlands of the western, southern and northern provinces.

Natural Hazards Occurrence, 1991–2022[3]

Hazard	Subtype	Events	Deaths	Affected
Drought		3		1,976,545
Flood	Unstated	11	183	18,690
	Riverine	9	122	56,968
	Flash	3	106	42,210
Storm	Convective	2	3	6,525
Landslide		5	113	32,000
Total		**33**	**527**	**2,132,938**

Risk of River Flood (left)[4]**, Risk of Wildfires (right)**[5]



ENABLING ENVIRONMENT

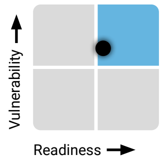
Leadership and Governance

- The Ministry of Environment is responsible for designing and monitoring national climate policies.
- The Rwanda Environment Management Authority (REMA) is responsible for climate policy implementation through its Department of Climate Change and international obligations.
- The Fund for Environment and Climate Change (FONERWA) aims to mobilize domestic and international financing for environmental and climate change projects.

ND-GAIN Index[6]

Country Index rank (score): 124 (42.0)
Vulnerability: 0.586
Ecosystem Services 19%, Food 20%, Human Habitat 20%, Health 25%, Water 15%

Readiness: 0.426
Economic 42%
Governance 42%
Social 15%



Key Adaptation Policies

Key Policy Documents: Updated Nationally Determined Contribution (2020); Third National Communication (2018); National Strategy for Transformation (NST 1) 2017–2024 (2017); Vision 2050 (2015); Green Growth and Climate Resilience Strategy (2011); Rwanda Biodiversity Policy (2011); National Adaptation Plan of Action (2006).

Disaster Risk Management (DRM):

- In 2010, the Ministry of Disaster Management and Refugee Affairs was established to manage natural disasters.
- The National Disaster Management Policy (2012) and the National Disaster Contingency Matrix (2016) serve as the country's legal and institutional framework for DRM.
- Efforts are focused on strengthening institutional capacity, coordinating DRM mechanisms across sectors, enhancing disaster preparedness, and ensuring alignment with local and national disaster management plans. Public-warning and disaster-related information systems are also being developed and promoted.
- Rwanda is committed to improving its disaster management and will conduct country-wide risk assessments and vulnerability mapping by 2030 to improve planning and related adaptation efforts.

ND-GAIN Evolution

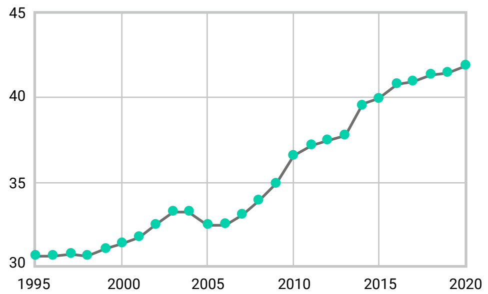


Photo: Vadim_Nefedov/iStock

SECTORAL ADAPTATION PLANNING

AGRICULTURE

Employs over 70% of the working population. About 51% of land area is agricultural, of which about 73% is used to grow crops and 27% is kept fallow or used for pastures and afforestation.

Main Climate Change Impacts

- Rising temperatures, increasing frequency and intensity of heavy rain events, and increased duration of dry spells threaten Rwandan agriculture.
- Rising temperatures threaten to compromise the quality and productivity of highly lucrative, temperature-sensitive crops such as tea and coffee (which account for more than 20% of export earnings).
- In contrast, temperature increases are likely to expand production through mid-century for maize, Irish potato, cassava, and sorghum.
- Warming temperatures are also likely to expand the range of crop pests, such as the coffee berry borer beetle, and livestock diseases, such as Rift Valley fever.
- 90% of crops are grown on hills and steep slopes. Heavy rainfall events may lead to landslides and further exacerbate soil erosion and degrade cultivated lands.
- Projections of longer dry spells are particularly concerning in the east and south.

Proposed Adaptation Strategies

- Mainstream agroecology techniques on farms to improve productivity, soil health, and water conservation.
- Promote recovery and reuse of both organic waste and wastewater to restore and maintain soil fertility, and promote the use of organic fertilizer and enriched compost.
- Expand soil conservation and land husbandry programs through installing land protection structures such as radical and/or progressive terraces.
- Increase investment in irrigation.
- Diversify local and export markets to meet growing demand and maximize agricultural trade.

FORESTRY

Nearly 30% of the country is covered by forests.

Main Climate Change Impacts

- Rwanda already experiences high rates of soil erosion that are depleting topsoil in forests and riparian corridors, with the Gishwati ecosystem being particularly vulnerable.
- Rising temperatures threaten plants and wildlife through increased physiological stress and disruption of pollination and predator–prey relationships.
- An estimated 107 mammal, 199 bird, 31 fish, 34 amphibian, and 79 plant species in the Albertine Rift region have high thermal sensitivity and/or are highly vulnerable to changes in habitat suitability induced by climate change. Most notably affected are the hippopotamus, African wild dog, western rift puddle frog, grey crowned crane, and mountain gorilla.
- More frequent droughts will likely increase deforestation, forest degradation, frequency and severity of forest fires, and reduce the capacity of water catchments.
- Increased precipitation may increase forest productivity. However, increased extreme weather events such as strong winds, violent storms, violent floods, and landslides will negatively affect forest resources. These threats to biodiversity are likely to decrease tourism.

Proposed Adaptation Strategies

- Improve spatial planning.
- Strengthen sustainable forest management.
- Establish seed banks for reforestation activities.
- Extend the network of protected areas on land and in the wetlands.

Milestones

- Rwanda's National Forest Policy (2001), which aims to make the forestry sector a key pillar of the country's economy, won the World Future Council's Future Policy Award as the world's most inspiring and innovative forest policy.
- Through the use of mixed-species approaches, Rwanda aims to achieve an overall 30% sustained forest cover of the total national land surface by 2030 from 28.8% in 2013. Additionally, by 2030, Rwanda will implement public–private partnerships to sustainably manage all forestry plantations.

NEEDS

Research

- Improve, support, and reinforce the teaching of meteorology, climate science, and hydrology in higher education and build staff capacity.
- Enhance capabilities for handling climate change data at national, regional, and local levels.
- Develop a system for monitoring, preventing, and effectively responding to the human diseases associated with climate change.
- Develop a Monitoring, Reporting and Verification (MRV) framework for tracking the progress of project implementation and Rwanda's pathway toward achieving its NDC, while meeting its international obligations under the Paris Agreement.
- Evaluate needs and develop a national strategy for technology transfer to support NDC adaptation measures.

Data and Information

- Improve technical capacity to analyze hydrometeorological data and project impacts across sectors.
- Complete an updated technology needs assessment.
- Establish institutional capacity for providing timely early-warning systems to farmers for improved decision-making.
- Increase the understanding of water resource threats and groundwater risks to improve long-term management and improve water-use efficiency in agriculture and urban management.
- Improve regulation and enforcement to protect forests, rainforests, and protected areas.
- Increase public awareness and participation in the climate change adaptation debate.

Institutional

- Establish a national environment and climate change research center.
- Expand Rwanda's technical and vocational educational and training to develop skills for effective climate change impact translation and improved adaptation planning across sectors.
- Establish land-use plans by type of use.
- Integrate climate change concerns into relevant policies and planning processes at state and national levels.
- Provide national-level adaptation reporting.
- Finalize regulations to fund and implement climate change impact studies.

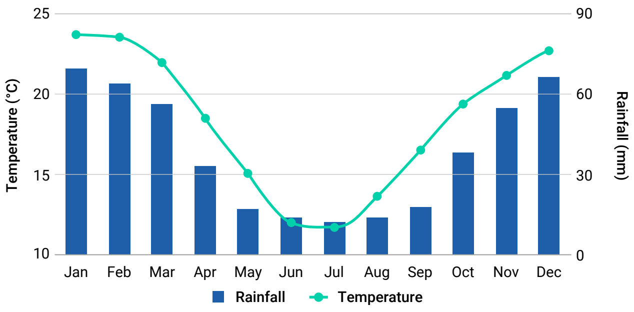
1 World Bank. 2022. "Rwanda – Current climate > Climatology" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-historical
2 World Bank. 2022. "Rwanda – Climate projections" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-projections
3 Authors' summary based on data from: Centre for Research on the Epidemiology of Disasters (CRED) EM-DAT database. Université catholique de Louvain, Brussels, Belgium. http://www.emdat.be (accessed June 2022).
4 ThinkHazard! 2020. "Rwanda: River flood." http://thinkhazard.org/en/report/205-rwanda/FL
5 ThinkHazard! 2020. "Rwanda: Wildfire." http://thinkhazard.org/en/report/205-rwanda/WF
6 Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index. https://gain.nd.edu/our-work/country-index/

South Africa Climate Risk and Adaptation Overview

Adapted from the World Bank's Climate Risk Country Profiles Series, 2021

Climate Trends

Average Monthly Temperature (T) and Precipitation (Ppt), 1991–2020[1]



Country Context

Population
59.3 m (2020)

Annual growth rate
1.3% (2020)

GDP
US$302 bn (2020)

Annual growth rate
–7.0% (2020)

GDP per capita
US$5,091 (2020)

GNI per capita
US$6,010 (2020)

Literacy rate adult female/male: 94.53% / 95.55% (2019).
Geography: Located at the southern tip of Africa, it has a coastline of 3,000 km, with the Indian Ocean on the eastern coast and the Atlantic Ocean on the western coast. Total land area: 1,219,602 km².
Broad climate: Cool and wet in the Drakensberg region; warm and subtropical in the northeast; Mediterranean in the southwest; warm dry desert environment in the central-west and northwest.

Climate Projections[2]

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (ºC)	**+0.5 to +1.7** (+1.2ºC)	**+1.4 to +2.9** (+2.0ºC)	**+2.4 to +4.4** (+3.2ºC)	**+3.3 to +6.0** (+4.2ºC)
Annual Precipitation Anomaly (mm)	**–16.2 to +14.0** (–1.6 mm)	**–21.4 to +11.9** (–3.7 mm)	**–22.2 to +13.2** (–4.3 mm)	**–26.1 to +12.4** (–5.9 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

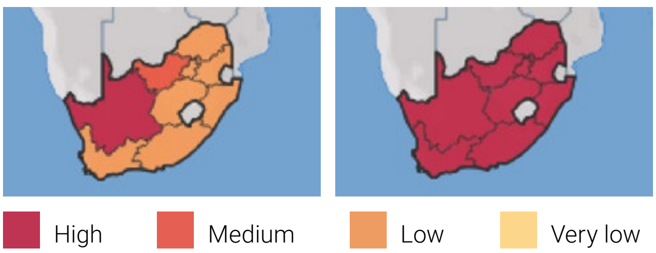
Climate Hazards

- The three most significant drivers of climate-related disasters in South Africa are drought, floods, and wildfires. Annually, these disasters incur approximately ZAR3 billion (US$163.3 million) a year in damages.
- Increasingly droughts and floods, along with rising temperatures and sea levels, pose challenges to municipalities. For example, recently the Western Cape struggled with one of the worst droughts in 100 years, severely limiting water supplies in urban areas.
- Climate change is expected to increase the risk and severity of water scarcity and drought, and future flood risk is also likely to increase across the entire country.
- As flood risks rise, so too will the incidence of waterborne diseases common in South Africa, such as cholera, dysentery, typhoid, and other rotavirus infections.
- The country is likely to become hotter and drier in the future, with continuing rainfall variability. This will likely result in increased soil erosion, deforestation, recurrent droughts, desertification, land degradation, and the loss of biodiversity including the country's unique wildlife populations.
- Coastal cities such as Cape Town, Durban, and Port Elizabeth are at risk from rising sea levels that could impact infrastructure and important economic sectors, such as tourism and fisheries.

Natural Hazards Occurrence, 1991–2022[3]

Hazard	Subtype	Events	Deaths	Affected
Drought		6	–	424,388,932
Flood	Unstated	13	646	176,330
	Riverine	17	252	406,645
	Flash	7	235	8,900
Storm	Tropical	2	4	4,550
	Unstated	5	42	150
	Convective	21	164	141,414
Wildfires	Unstated	1	9	5,500
	Forest	2	31	1,600
	Land	7	97	1,000
Total		**81**	**1480**	**425,135,021**

Risk of Urban Flooding (left)[4], Risk of Wildfires (right)[5]



ENABLING ENVIRONMENT

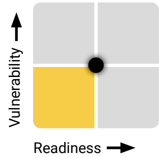
Leadership and Governance

- Climate change focal point: the Department of Environmental Affairs is responsible for developing and implementing the Climate Change Strategy, and ensuring the country is on track to meet its obligations outlined in its Nationally Determined Contribution (NDC) and development plans.
- Cross-sector efforts involve actions from national departments of: Energy; Mineral Resources; Basic and Higher Education; Health; Agriculture, Forestry and Fisheries; Cooperative Governance and Traditional Affairs, including the National Disaster and Risk Management Centre; Transport; Science and Technology; Statistics; National Treasury; Trade and Industry; Water Affairs; Human Settlements; International Relations and Cooperation; Public Enterprises; and the Presidency.

ND-GAIN Index[6]

Country Index rank (score): 96 (47.4)
Vulnerability: 0.415
Ecosystem Services 19%, Food 18%, Human Habitat 21%, Health 18%, Infrastructure 10%, Water 13%

Readiness: 0.364
Economic 35%
Governance 45%
Social 19%



Key Adaptation Policies

Key Policy Documents: Updated Nationally Determined Contribution (2021); Third National Communication to the UNFCCC (2018); National Climate Change Adaptation Strategy (2018); National Climate Change Response White Paper (2017); Second Biennial Update Report (2017).

Disaster Risk Management (DRM):

- DRM is led by the National Disaster Management Advisory Forum, a technical committee tasked with coordinating and managing disaster recovery and preparedness actions. Work is guided by the Disaster Management Act (2002) and Disaster Management Framework (2005).
- Working to integrate its disaster management strategy into sectoral policies and programs, and to shift thinking from a largely reactive system toward more proactive risk reduction and adaptation planning.

ND-GAIN Evolution

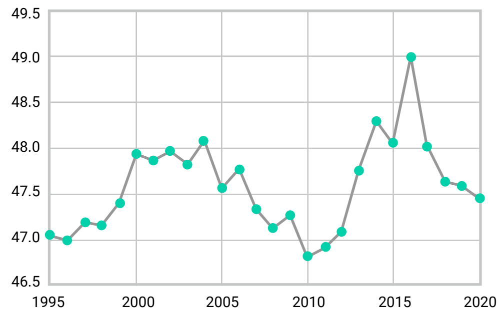


Photo: Rocky89/iStock

SECTORAL ADAPTATION PLANNING

WATER

South Africa is a highly water-stressed country: less than 9% of annual rainfall received filters into the region's rivers and only 5% goes on to recharge groundwater aquifers. There are 794 large dams in the country, with a combined storage capacity of about 31 billion m³.

Main Climate Change Impacts

- Heightened dry conditions and increased pressure on water resources are expected by mid-century. Severe drought conditions and water scarcity are likely by the end of the century.
- Southwestern areas are projected to experience the most severe drought conditions.
- Rising temperatures are expected to decrease water availability and thus stream flows. For example, stream flows for the Limpopo and Okavango catchments are projected to decrease by 35% and 20%, respectively.
- Altered water infiltration and groundwater recharge rates are expected due to rainfall and evaporative changes.
- More variable rainfall is also likely to increase disasters associated with droughts, floods, and waterborne diseases.

Proposed Adaptation Strategies

- Additional water resource capacity is needed to meet a growing demand for domestic needs.
- Water resource management strategies need to incorporate sourcing from catchment and river systems, storage, abstraction, and securing return flows from irrigation projects.
- Planning and adaptation strategies for water resources should be included within development strategies for agriculture, infrastructure, and energy sectors.

Milestones

- South Africa has developed a National Water Master Plan to support its broader climate change adaptation agenda.

AGRICULTURE

The sector employs over 860,000 people. It is dominated by maize, wheat, sugarcane, and sunflower seed. Some 14% of the country considered arable, with one fifth of this land having high agricultural potential.

Main Climate Change Impacts

- Climate change is expected to have adverse impacts on cereal crop production, high-value export agricultural production, and intensive animal husbandry practices.
- Trends are, however, likely to positively impact the productivity of key tropical crops such as sugarcane, though these gains could be offset by increased pest diversity and distribution.
- Climate change impacts are crucially linked to future projected water supply constraints.
- Reduced water availability will likely reduce yields and increase soil moisture deficits.
- Rising temperatures, particularly the number of "very hot days" (maximum temperature > 35°C), are likely to increase the presence of pests and risks of wildfires.
- Increased intensity and frequency of extreme events are likely to negatively affect "regulating services" such as soil water maintenance, base flows, and filtration.
- Increased heat stress is likely to alter growing seasons and adversely affect livestock, reducing milk production and reproduction, particularly for cattle.
- Climate change impacts for the agricultural sector are compounded by issues of land rights and inequality.

Proposed Adaptation Strategies

- Implement climate-smart agricultural practices.
- Improve water management, and monitoring and early-warning systems.
- Develop knowledge and decision-support systems.
- Develop new crop varieties and technologies to support farming systems.
- Implement soil and water conservation strategies.

NEEDS

Research

- Improve understanding of expected future climate change trends and events, as well as key vulnerabilities, development impact, and possible adaptation responses.
- Widen participation of the public, scientific institutions, women, and local communities in planning and management, accounting for approaches and methods of gender equity.
- Strengthen environmental monitoring capabilities for more effective environmental management.
- Invest in weather stations and expand the country's national hydrometeorological monitoring system to advance networking for the measurement of climate parameters.
- Strengthen technical capacity to integrate climate-smart agriculture and climate change risk management into the agricultural sector.

Data and Information

- Develop early-warning systems about dangerous hydrometeorological phenomena and climate risk management.
- Ensure maintenance and enhancement of nationwide climate change and atmosphere monitoring systems, including through monitoring networks at appropriate spatial density and frequency.

Institutional

- Integrate National Environmental Strategy goals within sectoral and regional plans.
- Implement cross-sectoral climate-smart solutions at national and subnational levels.
- Integrate climate change concerns into relevant policies and planning processes at state and national levels.

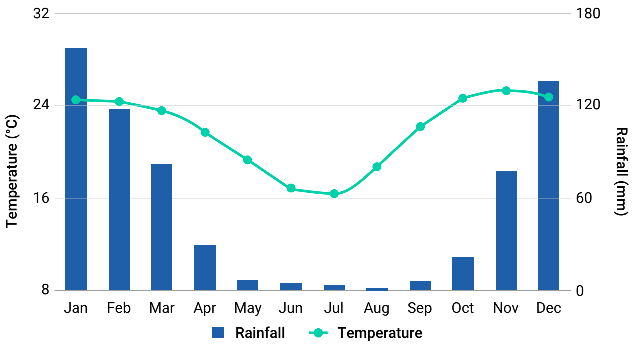
1 World Bank. 2022. "South Africa –Current climate > Climatology" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-historical
2 World Bank. 2022. "South Africa – Climate projections" in Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-projections
3 Authors' summary based on data from: Centre for Research on the Epidemiology of Disasters (CRED) EM-DAT database. Université catholique de Louvain, Brussels, Belgium: http://www.emdat.be (accessed June 2022).
4 ThinkHazard! 2020. "South Africa: Urban flood." http://thinkhazard.org/en/report/227-south-africa/UF
5 ThinkHazard! 2020. "South Africa: Wildfire." http://thinkhazard.org/en/report/227-south-africa/WF
6 Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index. https://gain.nd.edu/our-work/country-index/

Zimbabwe Climate Risk and Adaptation Overview

Adapted from the World Bank's Climate Risk Country Profiles Series, 2021

Climate Trends

Average Monthly Temperature (T) and Precipitation (Ppt), 1991–2020[1]



Country Context

Population
14.6 m (2019)

GDP
US$21.4 bn (2019)

Annual growth rate
–8.1% (2019)

GDP per capita
US$1,215 (2020)

GNI per capita
US$1,140 (2020)

Literacy rate adult female/male: 88.28% / 89.19% (2014).
Geography: Landlocked country in Southern Africa. Total land area: 390,757 km².
Broad climate: Northern area: subtropical climate with dry winters and hot summers; southern area: hot arid and steppe climate.

Climate Projections[2]

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (ºC)	**+1.1 to +1.5** (+1.2°C)	**+1.9 to +2.7** (+2.2°C)	**+3.2 to +4.0** (+3.4°C)	**+4.2 to +5.8** (+4.6°C)
Annual Precipitation Anomaly (mm)	**–12.5 to +1.0** (–3.3°C)	**–19.6 to +1.9** (–5.1°C)	**–27.8 to –1.3** (–7.4°C)	**–32.3 to –0.1** (–8.2°C)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

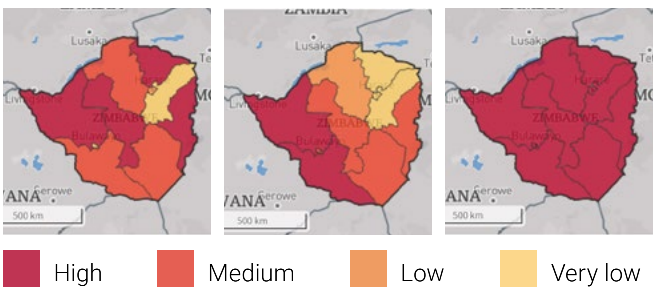
Climate Hazards

- The frequency and intensity of natural disasters, especially droughts, floods, and storms, have increased over the past decades, and are predicted to further increase as a consequence of climate change.
- The country's GDP growth has been severely impacted by a series of major droughts. For instance, the drought episode in 2007 affected 6 million individuals; and the drought in 2013 caused economic damage of up to US$500 million and affected over 4 million residents.
- Floods also generate large human and economic losses. As of 2017, riverine floods had led to monetary loss of over US$270 million.
- Wildfire has historically been one of the most dangerous natural hazards in the country, especially in the northern and southeastern areas. Wildfire is associated with more than 1 million hectares of loss in rangelands and forests per year.

Natural Hazards Occurrence, 1991–2022[3]

Hazard	Subtype	Events	Deaths	Affected
Drought		9	–	546,382,077
Flood	Unstated	2	13	30,000
	Riverine	9	271	260,275,897
	Flash	2	29	1,000
Storm	Tropical	6	890	375,400
	Convective	2	41	2,000
Total		**30**	**1244**	**807,066,374**

Risk of River Flooding (left)[4], Risk of Water Scarcity (center)[5], Risk of Wildfire (right)[6]



ENABLING ENVIRONMENT

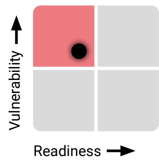
Leadership and Governance

- National Focal Point on Climate Change: Ministry of Environment, Water and Climate (MEW)–guides national compliance in all multilateral environmental agreements, including Intended Nationally Determined Contribution (INDC) efforts and the National Adaptation Plan (NAP) development process.
- The High Level National Steering Committee is responsible for providing policy direction in the implementation of the NDC in line with National Development Objectives.
- The Environmental Management Agency (EMA) is responsible for ensuring the sustainable management of natural resources and protection of the environment, the prevention of pollution and environmental degradation, and the preparation of Environmental Plans for environmental management and protection.

ND-GAIN Index[7]

Country Index rank (score): 174 (33.1)
Vulnerability: 0.554
Ecosystem Services 19%, Food 21%, Human Habitat 21%, Health 25%, Water 13%

Readiness: 0.216
Economic 40%
Governance 39%
Social 20%



Key Adaptation Policies

Key Policy Documents: National Adaptation Plan (2019); Third National Communication to the UNFCCC (2017); National Climate Policy (2016); Zimbabwe Agriculture Investment Plan (2013–2017); Nationally Determined Contribution (2016); National Climate Change Response Strategy (2015).

Disaster Risk Management (DRM):

- The Ministry of Local Government, Public Works and Urban Development has established a DRM Bill focused exclusively on the reactive aspect of DRM.
- Options for DRM include: Enhance early-warning systems and capacity of hydrometeorological services; invest in climate-resilient social infrastructure; promote climate-indexed insurance solutions and enabling market frameworks; scale up community-based DRM initiatives; conduct risk mapping of transboundary risks; coordinate DRM (prevention, mitigation, preparedness, response, and recovery) across technical staff at provincial/district, ward, and village levels; guarantee availability of cash reserves for rapid disbursement through fast-track mechanisms to support disaster response operations.

ND-GAIN Evolution

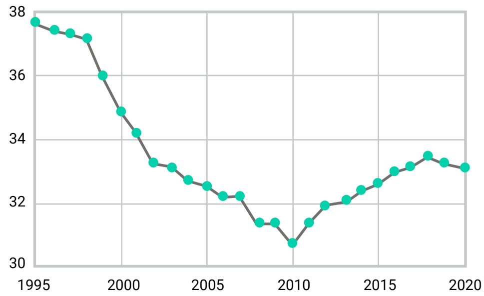



Photo: VV Shots/iStock

SECTORAL ADAPTATION PLANNING

WATER

There are seven river catchments in Zimbabwe: Gwayi, Manyame, Mazowe, Mzingwane, Runde, Sanyati, and Save. Total annual water generation amounts to over 23 bn m³: surface water resources: 90%; groundwater resources: 10%.

Main Climate Change Impacts

- Warming temperatures can contribute to increased water loss through evapotranspiration.
- Mean annual runoff is projected to decline in all seven basins under the majority of scenarios for the 2041–2050 period compared with the 1961–1990 baseline. Such changes in runoff could limit hydropower generation.
- Zimbabwe is highly susceptible to groundwater drought risk resulting from decreases in rainfall.
- Decreased water availability due to changes in annual precipitation could increase the cost for water treatment and wastewater management.
- Increasing temperatures may increase water demand for agriculture and energy generation.

Proposed Adaptation Strategies

- Promote and support water-harvesting.
- Develop, rehabilitate, and maintain surface and groundwater resources.
- Strengthen and intensify monitoring systems for hydrometeorological parameters.
- Promote efficient water-use practices in the economy across all sectors.
- Strengthen institutional capacity, research, and extension for integrated water resources management.
- Strengthen biodiversity conservation management and integrity of natural ecosystems to adapt to climate change.
- Conduct more frequent yield assessments of surface- and groundwater resources.
- Incorporate climate change into water infrastructure planning and design, and rehabilitate water infrastructure (e.g. existing reservoir storage systems).
- Employ water-demand management approaches and put in place appropriate water allocation and water pricing mechanisms.

Milestones

- A National Water Resources Master Plan for 2020–2040 (NWRMP) is being developed. It will serve as the blueprint for sustainable water resources development, utilization, and management in the country.

AGRICULTURE

Total agricultural land area: 42% of total land area. The sector accounts for 67% of total employment (2016); 80% of agricultural production is rainfed; total irrigated land area is 123,000 ha.

- **Main grain crops:** maize, sorghum, mhunga, rapoko, oilseeds.
- **Main industrial crops:** tobacco, cotton, edible dry beans, paprika.
- In terms of market value, tobacco, cotton, and maize are the most important crops.

Main Climate Change Impacts

- Changes to Zimbabwe's agroecological regions (AERs) indicate that the country is trending toward more arid and non-arable climatic conditions, which could potentially lead to food insecurity, an increase in unemployment, and a reduction in economic growth.
- Diminished rangeland productivity, as well as decreased livestock production, especially in the southwest and northwest areas of the country, are expected due to limited precipitation and extreme heat.
- Threats to rainfed agriculture due to increasing frequency and intensity of droughts and floods.
- Challenges for irrigated agriculture as water demand increases and water availability declines. Major cash crops, such as tobacco, cotton, tea, coffee, and horticultural crops are likely to be affected.

Proposed Adaptation Strategies

- Strengthen early-warning systems on cropping season quality, rangelands conditions, droughts, floods, disease/pest outbreaks, and wildlife movement to enhance farmer preparedness.
- Develop frameworks for promoting science-based crop production and post-harvest technologies and management practices.
- Strengthen capacity to identify and promote adoption of indigenous and improved livestock breeds that are tolerant to climate-related stresses.
- Incorporate resistance through biotechnology to reduce production costs and livestock mortality, and combat new and re-emerging zoonotic diseases.
- Strengthen national research and extension capacity for development and integrated management of agricultural water resources.

FORESTRY

Forest rents make up 4.1% of the country's total GDP (2016). The three major forest ecosystems in the country are the Baikiaea (25% of total forest cover), Miombo (30%), and Mopane (45%).

Main Climate Change Impacts

- Climate change will potentially influence the extent of forest ecosystems, composition of plantation species in forest ecosystems, species volume and density, and biodiversity characteristics.
- The forest cover of Baikiaea and Miombo ecosystems are both projected to decrease dramatically by 2050, to 18% and 10% of total forest cover, respectively. Mopane forests are expected to expand to 70% of total forest cover by 2050.
- Increased frequency and intensity of wildfires due to heat stress, droughts, and reduced rainfall.
- Increased drought due to sustained high temperatures and decreased precipitation.

Proposed Adaptation Strategies

- Develop and enforce policies that regulate change from one land use to another, and establish land-use plans at district, ward, village, and farm management levels that clearly recognize forestry as a land use.
- Build forest management capacity.
- Strengthen research, planning, and financial support to forestry and natural resources management.
- Promote and strengthen biodiversity conservation management and the integrity of natural ecosystems by using an ecosystem-based approach to adapt to climate change and strengthen the effectiveness of Trans-Frontier Conservation Areas.
- Promote appropriate climate-smart land-use options for the drier natural regions where cattle production and wildlife ranching are the most suitable land-use options.
- Promote non-timber forest products and sustainable agroforestry practices to enhance forest-based adaptation.
- Strengthen community governance systems for common-property forestry management.
- Promote risk management of pest, diseases, invasive species, and wildfire through the deployment of surveillance drones and early-warning systems.

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Climate Risks in Africa

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Adaptation Finance Flows in Africa

1 The focus of this analysis is on adaptation finance to address physical climate risks in Africa. It does not capture other important climate risks, such as transition risks associated with the shift towards lower-carbon economies.

2 CPI reports two-year averages (2019 and 2020) to smooth out annual fluctuations in data. The adaptation finance flows presented here are from a report produced by CPI in partnership with FSD Africa and the Children's Investment Fund Foundation: CPI. 2022. "The Landscape of Climate Finance in Africa." Climate Policy Initiative. https://www.climatepolicyinitiative.org/publication/.

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8. The high share of adaptation finance as a percentage of total climate finance in Africa, compared with other regions, may be attributable to a variety of factors, including, in particular, increasing prioritization by DFIs of adaptation finance in line with commitments to reach parity in adaptation and mitigation commitments.

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21 CIF. 2016. "Private Sector Investment in Climate Adaptation in Developing Countries: Landscape, Lessons Learned and Future Opportunities." Report prepared by Vivid Economics. Washington, DC: Climate Investment Funds. https://www.climateinvestmentfunds.org/sites/default/files/7544-wb_cif_ppcr_report-v5.pdf.

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Fiscal Policies for Adaptation: IMF Perspective

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4 Ibid. See Figure 3. While the costs for advanced economies are estimated at less than 0.1 and 0.3 percent per year, for instance, for low-income countries they are estimated at about 0.2 and 0.4 percent, and for emerging economies at more than 0.3 and 0.8 percent.

5 Ibid. See Annex Figure 2.1. The estimated cost of protecting existing private sector assets from storm and flood risks exceeds 0.4 percent of GDP in advanced economies and 0.6 percent in emerging economies and low-income countries, and approaches 1 percent of GDP in small developing states.

6 Bellon and Massetti. 2022.

7 Massetti and Bellon. 2022.

8 Ibid.

Financial Instruments in North Africa

1 For this chapter, seven countries are considered part of North Africa: Algeria, Egypt, Libya, Mauritania, Morocco, Sudan and Tunisia.

2 More details on how financing needs can be assessed are provided in: UNFCCC. 2022. "Technical Assessment of Climate Finance in the Arab States: Annex to the Arab States Climate Finance Access and Mobilization Strategy." Needs-based Climate Finance Project. Bonn: United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/UNFCCC_NBF_TA_AS_final.pdf.

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4 Algeria has not specified any cost estimates in its NDC, and Libya has not yet submitted an initial NDC.

5 In this chapter, climate finance flows to North Africa are calculated by the ESCWA team based on data from the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC)—in particular, for climate-related development finance, recipient perspective, for 2000 to 2020. See https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm. The numbers in this chapter may be slightly different from the numbers for recent climate finance flows in the Africa-wide finance chapter, which are based on the Climate Policy Initiative's latest Landscape of Climate Finance in Africa, published in August 2022. Climate Policy Initiative numbers collate more sources and are based on a related, but different methodology.

6 See https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm; note 5 provides more details on how this differs from finance data used elsewhere in this report.

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9 See https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm; note 5 provides more details on how this differs from finance data used elsewhere in this report.

10 ESCWA calculations based on OECD DAC data (recipient perspective). See https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm; note 5 provides more details on how this differs from finance data used elsewhere in this report. (

11 See https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm; note 5 provides more details on how this differs from finance data used elsewhere in this report.

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Resilient Recovery: Senegal and Côte d'Ivoire

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City Resilience

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Nature-based Solutions in Agroforestry

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