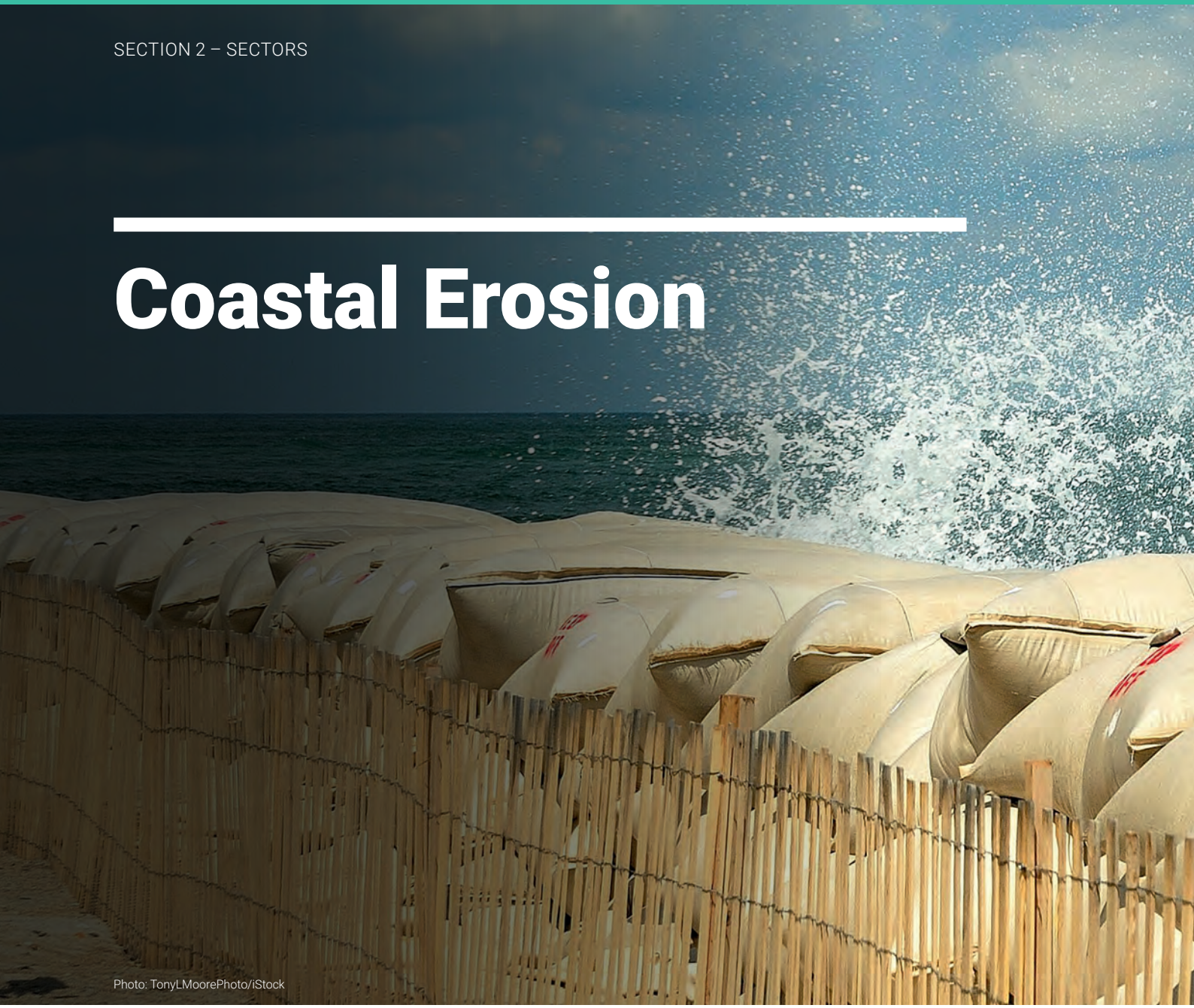
# Coastal Erosion



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## 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."**

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## 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.

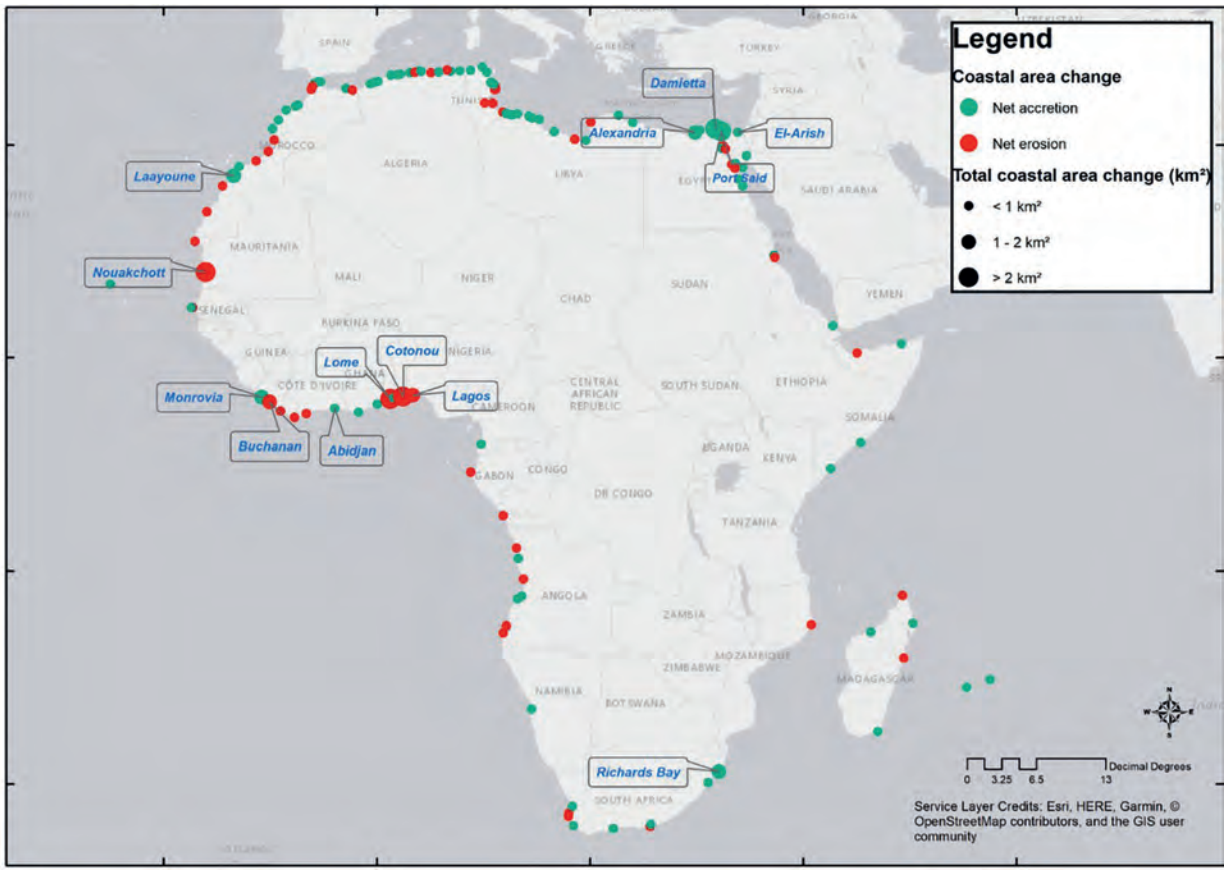
## The Impacts of Ports

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**

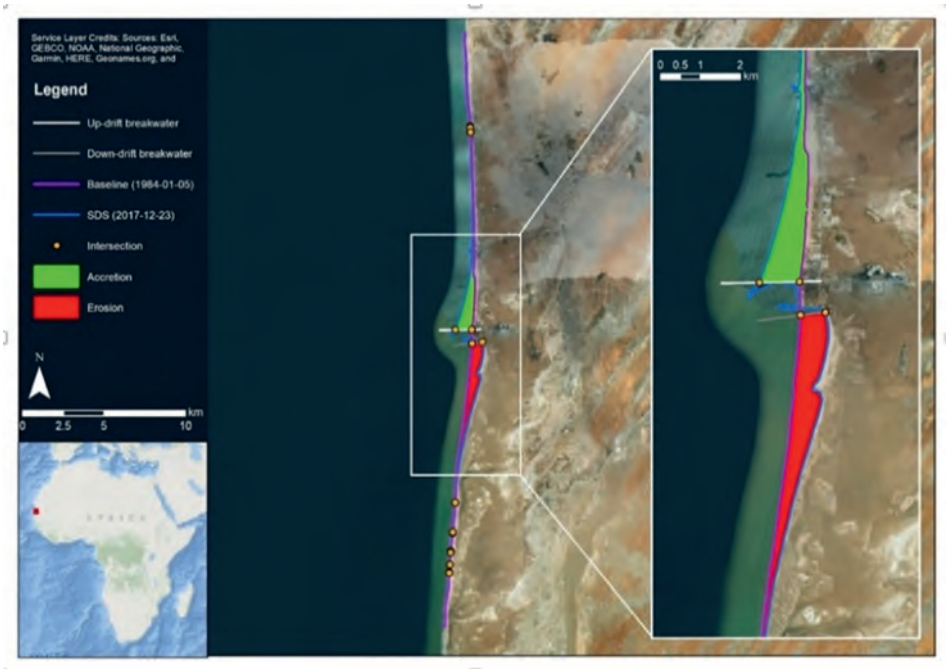



Source: de Boer et al. (2019)[5]

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

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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,

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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

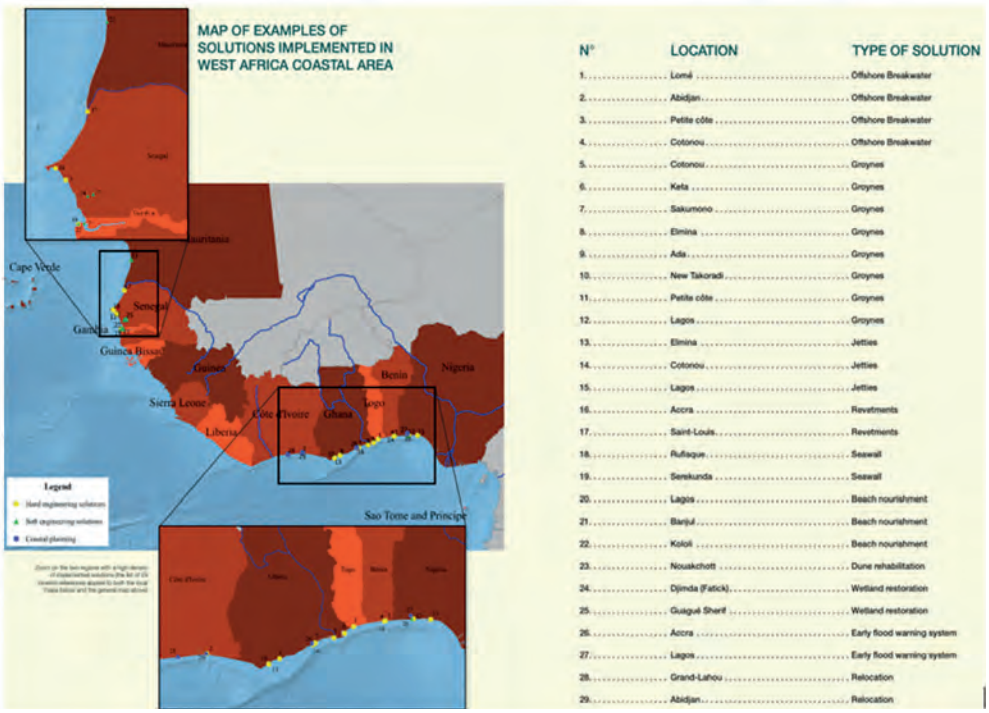
pressure and declining globally due to natural and anthropogenic pressures. Mangroves represent a solid example of NBS to mitigate climate and disaster risks, and detailed vulnerability assessments are necessary to develop mangrove-based coastal management strategies.

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**




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

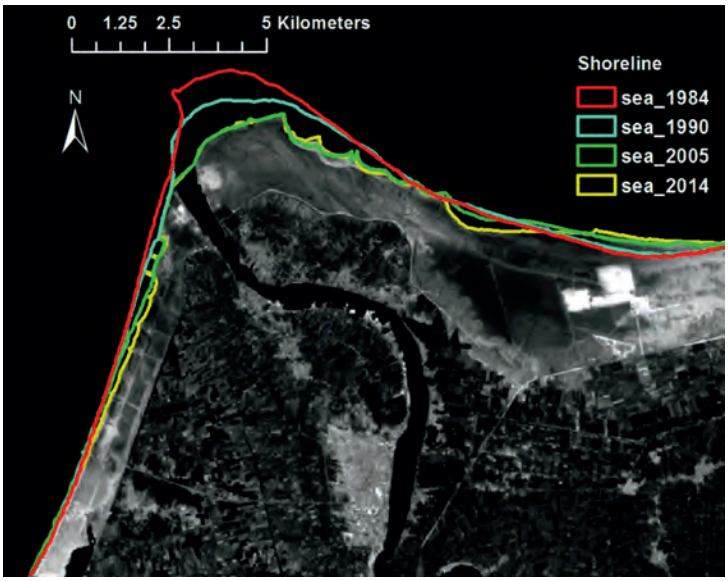
Coastal erosion rates in some North African countries, mainly Morocco and Egypt, exceed the global average by up to 10 times.[54] Inadequate management of coastal assets, exacerbated by unsustainable development along the coasts and climate change, has increased erosion of the region's shores. The region 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

Photo: Africanway/iStock

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]

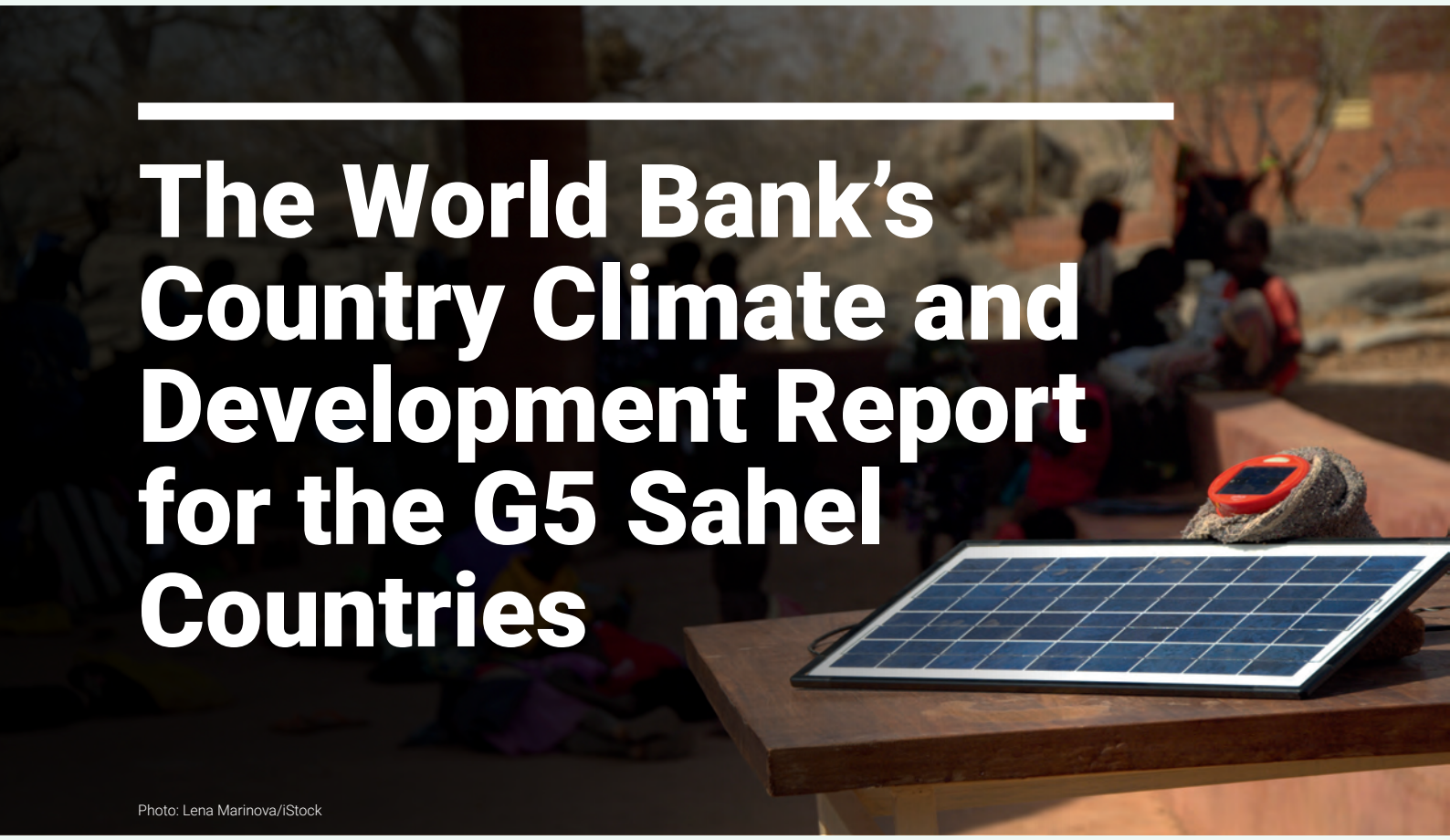
These NBS are not only cost-effective options that can help address coastal erosion and other forms of coastal degradation, but they can also be used to boost the health of coastal and marine ecosystems and their performance. If suitably planned, NBS can enhance the provisioning to coastal communities, 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.

Photo: mtcurado/iStock

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.

Photo: Senderistas/Shutterstock

**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.

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.

**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.