NOTE 2

Embedding Climate Resilience into Urban and Transport Projects

The Africa Climate Resilience Investment Facility (AFRI-RES) Learning Note

1. Why is embedding climate resilience into urban and transport sectors' infrastructure, planning, and policies important?

Africa is the fastest urbanizing continent with more than 40 percent of the population living in urban areas, an amount that is expected to increase to 60 percent by 2050 (World Bank, 2020). Rapid, unplanned urbanization is a major risk factor, leading to an increased concentration of people, inadequate provision of basic services, and infrastructure in exposed areas. Urban areas are particularly vulnerable to flooding, landslides, and coastal impact hazards. Climate change will affect rainfall patterns and temperature, further exacerbating the intensity and frequency of floods. Tropical cyclones bring associated high winds, flooding, and landslides. Climate change is predicted to increase cyclones' intensity, which can harm cities. Urban informal settlements and slums are extremely vulnerable due to their typically improvised and unregulated infrastructure, dense population, and prevalent poverty (World Bank,

The Africa Climate Resilience Investment Facility (AFRI-RES) is a partnership between the Africa Union, African Development Bank, the United Nations Economic Commission for Africa (UNECA), and the World Bank Group, established with support from the Nordic Development Fund (NDF). The partnership seeks to assist governments, planners, and private developers in integrating climate resilience in project planning and design, thereby attracting funding from both development and climate finance sources.

This note summarizes lessons and practices deployed in embedding climate resilience into the design of projects that received catalytic funds from AFRI-RES. It draws from application of the Resilience Booster Tool to specific projects, as relevant, Compendium Volume on Climate Resilient Investment in Sub-Saharan Africa (World Bank (2023a) and Guidance, Standards, and Good Practice Notes developed under the program.

African Union · United Nations Economic Commission for Africa · WORLD BANK GROUP · NDF Nordic Development Fund

forthcoming, b[1]). Expected threats to urban areas also include heat waves, vector-borne diseases, decreasing water supply reliability, and sea-level rise, many of which are expected to intensify due to climate change. Many of the rapidly expanding urban areas are coastal and are expected to be particularly negatively affected by severe climatic events over the next 30 to 50 years (World Bank, 2023c).

The lack of appropriate solid waste management (SWM) and drainage or sewerage systems is another highly relevant aspect of African cities' vulnerability to climate. This can constitute an important element conducive to flooding, along with increased water-borne diseases. Indiscriminate dumping into water channels reduces the discharge capacity of the drains and increases flood risks. As such, waste collected often ends up in open drains, watercourses, and streams or in illegal dumpsites, which causes higher flooding impacts.

At the same time, the rapid rate of urbanization in the region presents a unique opportunity to embed resilience into planning and policies. Climate-smart urban planning has the potential to reduce the impacts of the natural hazards on cities in Sub-Saharan Africa, bolster environmental sustainability, and create robust urban environments that can withstand the worsening impacts of climate change. Integrated into climate-smart planning, hydrologic and hydraulic studies can aid planning and designing for a once-in-a-50-year river flood protection for major rivers including the canal systems and drainage systems in urban areas. Public service design standards may be upgraded to the once-in-a-50-year return period flooding and landslide events. Standards should focus on housing, government buildings, and critical infrastructure systems. This entails promoting sectoral and spatial coordination, promoting risk awareness raising, scaling up citizen engagement, garnering private sector engagement, and enhancing awareness around guidelines and policies for preparation of risk-informed master plans. At the metropolitan regional level, fostering urban water resiliency requires (a) coordination across urban services, such as water supply, sewerage, drainage, wastewater treatment, and solid waste management, and (b) land use planning, including ecological zoning, protected areas, and public spaces.

Sub-Saharan Africa's transportation sector is key to regional economic development. In particular, road accessibility is necessary for inclusion and socioeconomic opportunities. Safe and all-season road accessibility advances the human capital agenda. Roads support inclusion and socioeconomic opportunities by connecting all community members to social opportunities, education, health and financial services, labor markets, and economic opportunities. Rural farmers and regional value chains benefit from rural infrastructure development because road access is critical to access markets and distribution centers and to acquire agriculture inputs.

While a fraction of Sub-Saharan Africa countries has 70 percent or more of their roads in good condition, fewer than 50 percent of the road networks across other Sub-Saharan African countries are in good condition. When focusing on rural roads, this value drops to almost 25 percent, affecting the transport of goods out of these areas and the provision of goods into these areas during much of the year (World Bank, forthcoming, a[2]). Not having safe and weather-resistant roads undermines communities' prosperity and exacerbates poverty in African communities. Also, high transport and other transfer costs caused by rural roads in poor condition are a severe constraint on the competitiveness of agricultural exports. Poor rural roads translate into high per unit transfer costs and limited access to markets, which limit farmers' ability to capture commodity price increases and their capacity to negotiate terms with traders.

1 The note was prepared in collaboration with Industrial Economics Inc. under the AFRI-RES program.

2 The note was prepared in collaboration with Industrial Economics Inc. under the AFRI-RES program.

Securing sound road maintenance practices allows countries in Africa to minimize and adapt to the impacts of climate change. World Bank analysis (Hallegatte, Rentschler, and Rozenberg 2019) shows that road maintenance is the first and most economical line of defense against climate change. Precipitation caused by climate change is expected to lead to rehabilitation costs 10 times above historical conditions, and stresses imposed by flooding will lead to a 17-fold increase. From Ethiopia in the east to Senegal and neighboring countries in the west, the middle of the continent is projected to have up to a 30 percent increase in intense precipitation events, with significant ramifications for paved and unpaved roads (World Bank, forthcoming, a).

Climate change will affect other transportation modes. The southern part of the continent, for example, is projected to experience increases of 2°C to 4°C. These temperature increases will affect rail, air, and highway systems through reductions in lifespan or operational delays (World Bank, forthcoming, a). Potential rail deformations will force providers to reduce service in times of intense heat. Similarly, air service will be delayed as providers face reduced capacity for lift during takeoff.

Sub-Saharan Africa's transport systems and the institutions that govern them have limited adaptive capacity. There is a need to improve the capacities of scientific institutions, central and local governments, (including transport offices), stakeholders, and civil society to help them prepare for climate change's effects on transport networks. Concurrently, tools should be developed to support adaptation and mitigation (including advanced early warning systems), cross-sectoral cooperation, and sharing of experiences and policies.

2. Integration of climate resilience into the urban and transport sectors in Sub-Saharan Africa

Key considerations for embedding climate resilience into urban contexts

Traditional gray structural approaches to reduce and manage urban flooding, such as drainage systems, run-off canals, and flood control barriers, are relevant but an end of the line solution. They are more effective as part of an integrated approach that addresses the climate vulnerability of ecosystems and natural terrain in which urban areas are ensconced. For example, loss of wetlands and inadequate management of solid waste and wastewater reduce the natural ability to reduce flood risks and contribute to increased levels of surface and groundwater, all of which negatively affect communities downstream. If unmanaged, increased surface water can damage infrastructure and development of the built-up area and can further exacerbate flood risks. Households in unplanned settlements are particularly vulnerable to the impacts of urban flooding and landslides. Acknowledging this interconnection between cities and their environment, and embodying perspectives from the Next Generation Africa Climate Business Plan (World Bank, 2020), an integrated approach is needed for managing risks across the natural and built environments (figure 1). Such an approach responds to the connectivity between land, water, and waste in cities, and targets the complementarity and integration of gray infrastructure and nature-based solutions, including green infrastructure, that can be replicated across countries and beyond (see figure 2 for examples of nature-based solutions applied to climate resilience). This integrated systemic approach

Figure 1. Integrated Approach to Urban Flood Risk Management Addressing Basin-Level Climate Vulnerabilities.

Source: World Bank 2020

can be applied to coastal and riverine cities, where water is a prominent part of the landscape and the risk of coastal flooding, coastal storm surges, and erosion is high (World Bank 2023b).

To secure water security and flood regulation downstream, city governments must partner with subnational and national authorities to ensure that upstream watersheds are well managed. The protection offered by ecosystems and nature-based solutions to increase resilience of cities to climate shocks and stresses needs to be integrated into climate-smart city plans. However, ensuring a stable and cheap water supply for the growing urban population and managing for the increasing frequency of floods may require additional cooperation with catchments beyond city jurisdictions—in addition to proximate catchments.

Proposed measures in urban sector projects to increase resilience

Structural measures to mitigate flood impacts.

Investments contribute to improved flood safety, focusing on areas at the highest risk of flooding in the river basin, frequently along the main river channels. Periodic dredging of river basins downstream for removal of sediments and waste restores their cross-section flow and hydraulic discharge capacity. To reduce the regular sediment load on the channels, sand traps can be built on the main channel and downstream sections of tributaries. Flood detention basins can be built to store peak floodwaters. In downstream sections, vehicular and railway bridges can be reconstructed to reduce hydraulic impediments where structural abutments in the channels and low bridge height may present obstacles to discharge. Sea outlets can be reengineered and reconfigured to reduce hydraulic interference at the point of discharge to the sea. Additional measures to climate-proof structural flood mitigation measures and achieve higher flood safety levels may include the development of additional flood detention basins and micro-water retention areas, or wadis, which follow nature-based solutions in parks, parking lots, sidewalks, playing fields, and so on.

Nonstructural measures to improve flood warning and preparedness.

This includes scaling up and modernizing flood forecasting, warning, and emergency response systems. Key agencies involved in the hydrometeorological, flood early warning, and response value chains need support

to enhance community awareness and preparedness. These actions aim at (a) laying the foundation for integrated modernization of hydromet and early warning services and (b) strengthening operational collaboration between national-level disaster response and meteorological agencies and local governments to provide effective flood early warning and response. A paradigm shift is needed to evolve from hazard-based early warning to impact-based early warning, improve last mile communication and community outreach, and support contingency planning and community awareness campaigns in a gender-sensitive manner. The outcome provides long-term climate resilience for all urban communities exposed to increasingly frequent and severe flooding.

Solid waste management improvements.

These efforts reduce the amount of solid waste flowing into primary discharge channels. Because this component leads to the reduction of solid waste that ends up in the ocean, it reduces marine litter. Actions include (a) community-based SWM interventions in targeted low-income communities, including outreach programs to sensitize and improve public behavior on SWM; improvements of litter management; waste transfer station construction; capping of old dumpsites: and final solid waste disposal capacity improvements. Reducing solid waste in the drainage channel and SWM improvements can bring climate adaptation and mitigation benefits from lowered methane emissions

Figure 2. Nature-Based Solutions for Climate Resilience.

Source: Van Zanten et al. 2023

Note: This group of intervention types is not a comprehensive list of all nature-based solutions for resilience types but instead focuses on interventions for adaptation and disaster risk reduction applications. The rivers and floodplains family includes riparian buffers; oxbows, side channels, and diversion channels; floodplains and swales; stream biofilters and leaky and woody barriers; and removal of invasive species that affect flooding. The urban green family includes green buildings and roofs; urban parks and open green space; green corridors; urban farming; bioretention areas; and sustainable urban drainage systems. The coastal wetlands family includes mangroves. Submerged aquatic vegetation includes seagrasses and kelp. Designs can include all three types in an integrated approach to urban flood risk management.

from unmanaged dump sites. Community-based SWM interventions can double as potential public work programs in adaptive safety net systems. Community campaigns can provide incentives to communities based on independently verified outcomes, such as improved waste collection and reduction of solid waste disposed into the drainage system. Physical barriers or fences, waste collection bins, and signages along the channel can prevent people from deliberately dumping waste into the channels.

Participatory community upgrading to increase longer-term resilience.

Participatory community upgrading can reduce vulnerability and strengthen climate resilience to flooding while improving living conditions in priority communities, including participatory upgrading of tertiary infrastructure and services prioritized by targeted low-income communities. This may include (a) construction or rehabilitation of drains, local roads,

Action Areas for Integrating Climate Resilience (Flooding) into Urban Sector Projects		
Intervention Area	**Purpose**	**Examples**
Structural Measures to Mitigate Flood Impacts		
Basin-level interventions	Restore hydraulic discharge capacity of river basin	Dredge river basins
	Reduce river and channel sediment load	Build sand traps
	Store/retain peak floodwaters	Build flood detention basins, micro-water retention areas ("wadis"), and other nature-based solutions in green spaces
	Reduce hydraulic interference at the point of discharge to the sea (coastal)	Reengineer sea outlets
Urban infrastructure interventions	Improve drainage system	Build/extend drainage infrastructure
Nonstructural measures to improve flood warning and preparedness	Scale up and modernize flood forecasting, warning, and emergency response systems	
	Enhwance community awareness and preparedness	Community outreach and education programs
	Reduce number of dwellings built in vulnerable areas to flooding	Develop flood risk and zoning maps
	Strengthen operational collaboration between the national-level disaster response and meteorological agencies and local governments	

Action Areas for Integrating Climate Resilience (Flooding) into Urban Sector Projects		
Intervention Area	**Purpose**	**Examples**
SWM Improvements	Improve waste sorting and management	Build waste transfer stations, implement separation of waste disposal programs
	Improve waste disposal	Improve final solid waste disposal capacity, cap dumpsites
	Create community-based SWM interventions to reduce litter accumulation	Create community outreach programs for sensitization, public works programs

Figure 3. Proposed Integrated Approach for Flood and Erosion Risk Management in Coastal Beira, Mozambique

Source: Royal Haskoning DHV, n.dz; in: Van Zanten et al 2023.

Note: For stretch 1, protecting the Port of Beira on the western side of the city, interventions consider an early warning system with other measures. Along stretches 2, 3, and 4, combinations of seawalls and dune restoration are proposed and evaluated. Stretch 1 = coastal stretch; stretch 2 = beachhead; stretch 3 = groins; stretch 4=coastal stretch

pedestrian paths, community sanitation facilities, streetlighting, open spaces, local markets, and terminals and (b) construction of primary/secondary infrastructure to make tertiary upgrading viable, such as interceptor sewers and storm water overflows, small wastewater treatment facilities, and micro-water retention/detention ponds and public open space. See table 1 for a summary of actions under each area of intervention.

Coastal Cities and Resilience

A large percentage of Africa's urban population live in coastal cities. In 2006, about 40.4 million Nigerians (19 percent of the national population) lived along the coastal zone, and about 7.8 million Senegalese (52 percent of the national population) lived in the Dakar coastal area, of which 60 percent were urban. The coastal zone is home to a key part of Africa's economies. About 90 percent of Senegalese industries are in the Dakar coastal zone. In Ghana, Benin, Togo, Sierra Leone, and Nigeria, the backbone of national economies is in coastal zones, frequently as part of urban areas (World Bank 2021b). In addition to the overall vulnerabilities to flooding and extreme heat that cities can present, coastal cities have vulnerabilities to coastal climate impacts. For example, the coastal nations of West and Central Africa have low-lying lagoonal coasts that are susceptible to erosion. They are threatened by sea-level rise and storm surges, in addition to marine and coastal pollution issues that exacerbate coastal and riverine flooding. Mozambique and Madagascar coastal cities in southeastern Africa are frequently exposed to tropical hurricane impacts (World Bank 2023b). For coastal urban resilience, nature-based solutions and green infrastructure can reduce the impact of storm surges, decrease climate vulnerability, and increase resilience. Nature-based solutions include ecosystem-based approaches such as restoration, protection, and management of mangroves, coral reefs, and other coastal ecosystems. See figure 3.

Key Considerations for Integrating Resilience into the Transport Sector

Key action areas to enhance increasing resilience of projects in the transport sector include the following:

Incorporate resilience throughout the design, construction, and maintenance stages of selected roads, taking a fit-for-purpose approach. Efforts can include activities to develop and conduct diagnostics of existing information, stakeholders, systems, and processes used to conduct vulnerability assessments of road networks; reviews of design, construction, and maintenance standards with a resiliency focus; and vulnerability assessments at the network and subproject levels as needed. To implement activities, assessments should look into specific climatic regional threats, such as wildfires or coastal and river floods, to support all-season access, especially for smallholder farmers.

Assess the need for institutional strengthening to develop clear guidance on embedding climate change considerations. Support development of climate change resiliency strategy and action plans for the road sectors and practical guidelines for project engineers and social and environmental specialists that are adequate to the rural road context. Contribute to effective implementation of climate resilience aspects by updating manuals and providing technical strengthening in climate resilience, including manuals and protocols for emergency preparedness and response based on the vulnerabilities specific for each country or region and its rural roads sector. Take a people-centered approach through inclusive consultations to embed green, climate-resilient considerations to foster inclusive approaches. These will complement engineering adaptation options to climate vulnerability. Where needed, projects should look to facilitate cross-institutional climate resilience work. Promote planning cooperation and share sources of data and knowledge on climate resiliency from the interministerial to local levels, including local practices. See table 2 for summaries of potential actions under each intervention area.

Action Areas for Integrating Climate Resilience (Flooding) into Transport Sector Projects

Intervention Area	Purpose	Examples
Design, construction, and maintenance of road networks	Identify key links for the good operation of the road network and that could constitute bottlenecks due to climate vulnerability	Conduct road network vulnerability assessment
	Ensure integration of climate resilience into transport infrastructure	Review design, construction, and maintenance standards with resiliency focus
	Ensure integrating resiliency to specific local climate threats (flooding, extreme heat, fire hazards) into transport networks to support all-season access	Conduct local network and subproject vulnerability assessments
	Address rural road network resiliency	Develop practical guidelines for project engineers and social and environmental specialists that are adequate to the rural road context

Action Areas for Integrating Climate Resilience (Flooding) into Transport Sector Projects		
Intervention Area	**Purpose**	**Examples**
Institutional and community capacity building	Develop clear guidance on embedding climate change considerations into the transport sector	Assess the need for institutional strengthening
	Ensure effective implementation of climate resilience into the road networks	Develop climate change resiliency strategy and action plans for the road sectors
		Update manuals and protocols for emergency preparedness and response based on vulnerabilities of each country or region
	Build long-term, integrated climate resilience across stakeholders and institutions	Promote planning cooperation and shared sources of data and knowledge on climate resiliency from the interministerial to the local level, including local practices
	Complement engineering adaptation options to climate vulnerability with community and other specialist views on resilience needs	Conduct inclusive consultations to embed green, climate-resilient considerations

Case Studies from the AFRI-RES–Supported Urban and Transport Sector Projects on Integrating Resilience into Designs

This section describes projects[3] supported by the AFRI-RES fund. Some used the Resilience Booster Tool to aid project design. The Resilience Booster is an interactive, step-by-step tool for development practitioners to embed climate resilience through a set of resilience attributes into project designs. It helps teams to think through, specify, and design project activities that build resilience by integrating resilience attributes. We report the results of the application of the Resilience Booster at the end of the project description if available[4].

Greater Accra Resilient and Integrated Development Project

The Greater Accra Region (GAR) in Ghana faces coastal impact challenges: a historical rate of coastal erosion is eroding 1.5 meters per year in some of Accra's coastal communities. A significant number of houses along the coast have been washed away, and the trend continues in select areas. The region faces increased flood risks. Floods affect poor urban households more than the rest of the GAR population. The urban poor tend to reside in low-lying or uninhabitable areas, and often these informal settlements (38.4 percent of the GAR population) are associated with overcrowding, substandard housing, and poor access to basic services. Their situation contributes to increased flood impacts: for example, inadequate solid waste collection and disposal services and inadequate drainage management contribute to drain blockage and flooding.

1 Greater Accra Climate Resilient and Integrated Development Project, Senegal Stormwater Management and Climate Change Adaptation Project II, Cameroon Douala Urban Mobility Project, Tanzania Development Corridors Transport Project, Tanzania Roads to Inclusion and Socioeconomic Opportunities (RISE) Project

2 See also Rigaud, Arora, and Singh (2023).

The aim of the Greater Accra Resilient and Integrated Development Project (US$ 200.00 million) is to improve the flood risk management and SWM in GAR and access to basic infrastructure and services in targeted communities. The project intervenes at the basin level to improve drainage, flood mitigation, and SWM. It also engages beneficiaries, local government jurisdictions, sectoral ministries, and other stakeholders at all levels to facilitate **participatory upgrading of critical services and infrastructure.**

Basin-level interventions ensure that upstream, middle, and downstream areas are planned and managed in a water-sensitive way to improve drainage and reduce flooding impacts. By applying **nature-based solutions and green/gray infrastructure** to mitigate the risk of flash floods, (a) upstream areas can absorb excess rainwater through **retention ponds,** (b) midstream areas can preserve open spaces for absorbing stormwater through **resilient drains and green spaces,** and (c) downstream areas can drain stormwater quickly by **widening channels and outlets to the sea**. The SWM interventions include a **multifaceted litter management strategy** to reduce waste entering waterways.

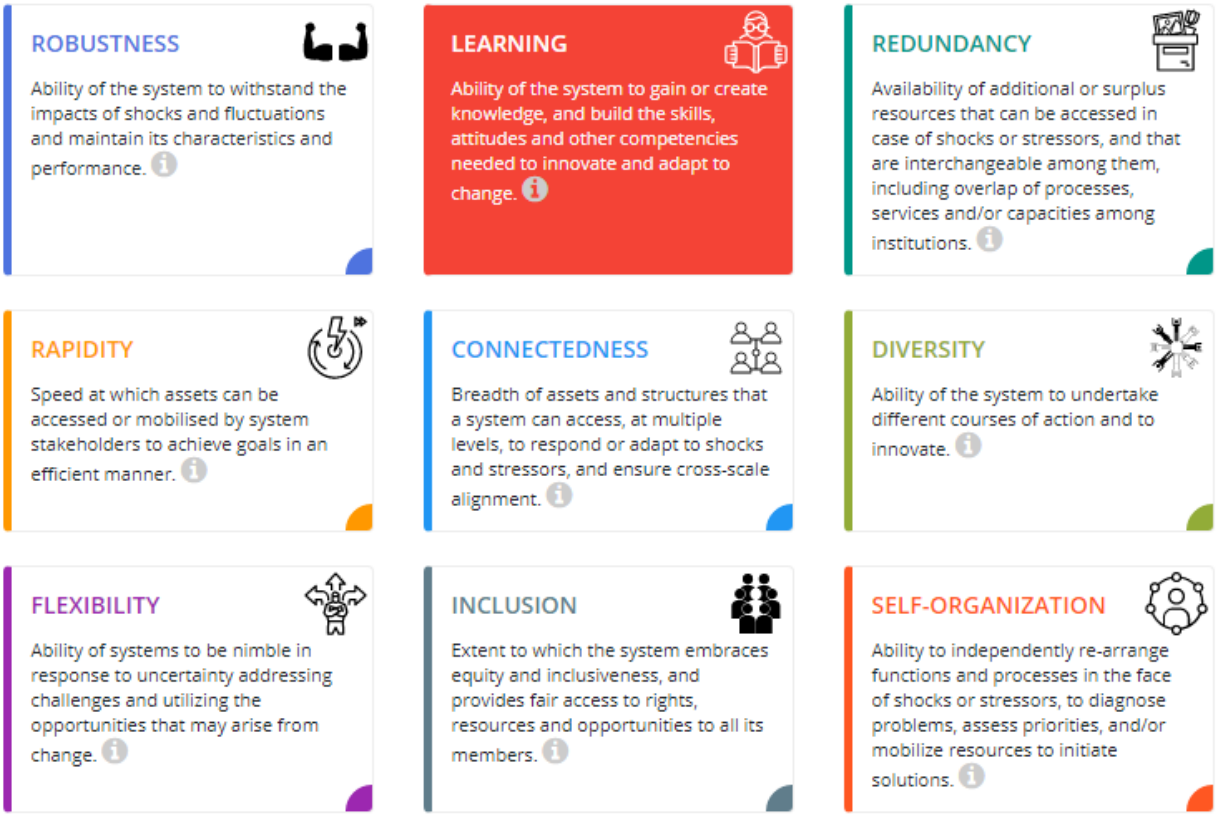
The project adopts an integrated approach toward addressing growing socioeconomic challenges related with uncontrolled growth and flooding in the GAR by bringing all key stakeholders together, including local government jurisdictions, and across sectoral ministries. In addition, the project design acknowledges there is no single solution, and flexibility across a long-term horizon supports experimentation, learning, and effective **solutions to bring effective change in citizens' mindsets** (for example, not settling in flood plains or keeping streams free of waste), government entities, private sectors, and nonprofit organizations. Finally, the project design heavily centers on **community engagement** early on and throughout **planning and prioritization of investments** to ensure effective outcomes and improve operations and management (O&M) after project implementation.

Senegal Stormwater Management and Climate Change Adaptation Project 2

Coastal floods affect Dakar urban and peri-urban areas, which will likely be aggravated with climate change. The population living in the low elevation coastal zone areas (32 percent of the total projected for 2030) in Senegal are highly vulnerable to the impacts of sea-level rise, storm surge, and erosion. After Nigeria, Senegal ranks second in Sub-Saharan Africa on the number of people exposed to coastal flooding. Sea-level changes and land degradation are leading to coastal erosion, which poses a major threat to Senegal's population and economy. Sea level could rise by up to 1 meter by the end of the century because of climate change. The observed erosion rate of the shoreline varies between 1 to 2 meters per year for sandy beaches. Erosion is affecting the coastal zone in the Dakar peri-urban area the most. In the Dakar Metropolitan Area, more than US$2 billion, or 5 percent, of physical assets are potentially exposed to high natural hazards.

The Senegal Stormwater Management and Climate Change Adaptation Project 2 (US$ 172.40 million) addresses these coastal erosion and flooding climate impacts through integrated urban planning and management actions. The project focuses on developing plans to better protect populations and infrastructure from increased flood risk and coastal erosion. It will **finance structural urban planning studies and contingency plans** across five water basins and **capacity building for the municipal planning authorities on flood management**. For each water basin, a **flood risk management plan** will be produced. Further, climate-resilient principles will be followed in the urban planning and land management plans because informal settlements are often in low-lying, flood-prone, and environmentally sensitive areas. The planning process will identify the most sensitive areas to implement **zoning regulations** to prevent construction in areas exposed to the worsening effects of climate change.

Figure 4. Resilience Booster Tool Attributes.



Source: World Bank AFRI-RES webpage, https://resiliencetool.worldbank.org/#/home.

Locally, the project will use studies to promote resilient and green city practices, all of which have strong adaptation and mitigation co-benefits. To enhance adaptation co-benefits, the studies on **flood risk management, rainfall harvesting and wetland management,** strategic planning of protected buffer zone areas, and information systems and **early warning systems** will support the security of urban coastal populations by reducing flood risks worsening with climate change.

The project will implement pumping and drainage infrastructure construction and management, informed by flood modeling that accounts for climate projections and the worsening effects of climate change. It will focus on the watersheds in the Dakar Metropolitan Area, which recent floods have affected heavily. All **infrastructure investments will be designed to climate-resilient standards**: planned, designed, built, and operated to anticipate, prepare for, and adapt to changing climate conditions, such as predicted evolutions in extreme rainfall events. Project **geographic targeting will focus on areas that are highly exposed to climate change** and sensitive to natural hazards such as flooding and erosion. **Green spaces** along the drainage network will be designed to improve conditions during heatwaves. Investments in **retention basins and pumping activities** will allow for increased resilience during flood events linked to the worsening effect of climate change. Technical studies will inform the **design of new drainage networks** in other peri-urban areas of Dakar and Saint-Louis. Further, the project has additional adaptation co-benefits because it will help improve water sanitation and **prevent clogging of networks with sewage systems**.

Applying the Resilience Booster tool, a focus on **robustness** as a resilience attribute is linked to structural investments such as **drainage elements,**

rainwater collection basins, and floodwater canals or outlets to the sea, which contribute to increasing the **absorptive** capacity. **Urban policy reforms** and elaboration of **urban risk plans** will increase the **adaptive capacity** of the system and affected communities through **capacity building of key flood management actors** (see figure 4).

Tanzania Roads to Inclusion and Socioeconomic Opportunities (RISE) Project

Many of the agriculturally rich areas in Tanzania are physically inaccessible year-round, often due to missing or unreliable road links. This negatively affects the extraction of full agriculture potentials. In many remote areas, the absence of reliable and adequate transport services and deficient transport infrastructure contributes to postharvest losses (estimated at up to 35 percent in some regions). Because most of the rural poor rely on agriculture, improving their road access can bring economic and social gains. Despite the importance of roads for rural communities, Tanzania is significantly underserved. Approximately 13 percent of regional and 42 percent of district roads are in poor condition. Estimates suggest that in the rainy season, between 20,000 and 30,000 kilometers out of 56,000 kilometers of the classified tertiary (district) road network are not passable by normal motorized vehicles. Also, the comparatively low road density allows for little network redundancy: there are no alternatives when sections are flooded. The national road density is approximately 9.8 kilometers per 100 square kilometers. Comparable figures from neighboring Uganda are 70 kilometers per 100 square kilometers and 28 kilometers per 100 square kilometers for Kenya.

The Tanzania Roads to Inclusion and Socioeconomic Opportunities (RISE) Project (US$ 300.00 million) addresses climate change issues in the rural road network, which is a critical lifeline for the rural poor who rely heavily on climate-sensitive agricultural livelihoods. The road sector is susceptible to damage from precipitation and related weather events. The unpaved road network is more vulnerable, especially in rural areas, not only because earth roads are inherently more vulnerable but also because maintenance practices are less institutionalized and resources are often scarcer. Precipitation events cause flooding and landslides that damage the road network and disrupt connectivity. For example, the floods of 2011 destroyed six bridges and several roads in Morogoro Region, and in 2014, heavy rains displaced over 10,000 people and damaged infrastructure in the same area. Tanzania's physical road vulnerability to climate impacts is coupled with limited resources and maintenance practices and institutional capacity, resulting in climatic impacts that harm efforts to reduce poverty and share prosperity.

Climate resiliency is embedded in all the components of the RISE project. It will continue to incorporate climate resilience aspects in **planning, design, community engagement, stakeholder coordination, implementation and maintenance of works, and capacity building** for emergency preparedness and response management.

Tanzania Transport Integration Project

The Tanzania Transport Integration Project (US$ 550.00 million) deploys climate resilience measures appropriate to road climate vulnerability and addresses airport climate vulnerability. The goals are to manage climate risks and enhance the resilience of infrastructure, services, and communities served.

This project will finance the upgrading and rehabilitation works of about 510 kilometers of roads, identifying key links for the good operation of the road network and that constitute bottlenecks due to climate vulnerability. The **roads** will be **rehabilitated and upgraded to integrate climate resilience measures** to enhance resilience and adaptation of these roads and the road network. The roads will receive routine and periodic **maintenance**, observing climate resilience requirements. Climate change adaptation measures entail **realigning the road network to reduce exposure** to natural hazards.

Structural measures include raising road formation levels based on maximum flood levels, adjusting embankment slopes, enhancing drainage, improving road permeability, using subsurface drains, introducing debris deflectors, conducting scour checks, preventing erosion, using roads for water management, monitoring conditions and establishing early warning systems, and improving pavement and bridge design.

The project will also finance the rehabilitation and upgrading of three priority regional airports that are exposed and vulnerable to climate change impacts. The interventions include **addressing asset damage caused by climatic events** and enhancing climate resilience of airports, such as **strengthening the climate resilience of runways, taxiway and apron, terminal building, and safety and security facilities. Airport capacity will be enhanced** to address projected medium- and long-term demand using **climate-resilient, international standards of safety.**

The project will strengthen monitoring and maintenance activities based on climate resilience objectives, such as establishing **extreme weather early warning systems**, introducing regular **inspection scour checks on runways**, and deploying timely **maintenance to prevent erosion**. It will also invest in **community-based social infrastructure** that considers climate resilience through selecting **locations that have low exposure** to natural hazards, and **incorporating design measures that enhance climate resilience**, such as deploying appropriate drainage, roofing, and cooling or shade provisions along segregated walkways at all populated areas along the road. Other project activities focus on e**nhancing institutional capacity**, including that of **climate risk management**. Climate considerations and risk management will be integrated in transport sector **policies** and strategies, road asset **management systems**, and **training**. Tools and provisions for **private sector participation in transport financing** will **integrate climate resilience** considerations.

Cameroon Douala Urban Mobility Project

Located at the estuary of the Wouri River, Douala, Cameroon, is highly vulnerable to extreme hydrometeorological events. The hydrographic network is dense and dendritic, with 23 catchment basins. Due to Douala's uneven terrain, stormwater is evacuated through streams that form in topologic depressions. In some areas, inadequate drainage systems lead to stagnating waters. According to climate projections, rainfall levels and intensity are expected to increase in the Littoral region, where Douala is located, in the coming decades. Heavy rainstorms are increasing in intensity and frequency, and rainstorms bringing high precipitations (205 millimeters per hour) are likely to occur every two years. Between 2015 and 2020, the city experienced annual high-impact flood events. Continued uncontrolled urban development in flood-prone areas and soil sealing will further increase the exposure of the city's population and economic development to greater climate risks. Rising sea levels induced by global warming will exacerbate flooding risks along Cameroon's coasts, including in Douala.

To mitigate these flood risks, the Cameroon Douala Urban Mobility Project (US$ 420.00 million) will design actions to increase the climate adaptation capacity of the urban transport infrastructure. Two technical feasibility studies will inform the proposed project, including a **flood modeling study** for Douala which was developed using hydrological and hydraulic modeling software. Flood simulations produced water speed and depth maps, which were then used to create **flood danger maps** for the city and its catchment basins. Based on these danger maps, **critical vulnerability points** were identified along the **bus rapid transit (BRT)** corridors.

Addressing these vulnerability hotspots will help to ensure that infrastructure design and transport operations are adapted to climate risks. A second study is assessing **flood risks associated with the project's activities** to inform climate adaptation plans

and measures. It will propose priority investments and measures to strengthen the climate resilience of the urban transport infrastructure and operations. This study will assess the **exposure of the BRT infrastructure** and selected feeder roads **to extreme hydrometeorological events** and inform the technical designers how to adapt to these events and **design drainage systems, bioswales, sewer and water supplies, stormwater retention vegetation, and traffic diversion routes**; and make sure crossing structures are correctly sized based on flood risks. It will identify and prioritize technical solutions to mitigate flood risks for the mass transit system and its feeder roads. These **technical solutions will combine structural and ecosystems-based approaches.**

The project will help to prepare climate-resilient O&M protocols for the BRT system and emergency response and contingency plans for BRT and other transportation services in case of extreme hydrometeorological events. To ensure long-term resilience, the study will **strengthen the capacity of municipal and national institutions to ensure climate-related hazards** are systematically considered in urban transport planning and management. It will review **transport infrastructure construction codes and standards** to assess how **climate-related risks can be better integrated**. An **expanded roadmap** will help stakeholders assess urban vulnerability to climate change and design an **adaptation strategy for urban networks. Local stakeholders will be trained** in urban mobility and climate change issues to better incorporate **climate resilience considerations in urban transport planning** and management.

The project's robustness and absorptive capacity of the system is increased through the Resilience Booster tool, introducing **climate-resilient structural adaptations** to the feeder roads and BRT infrastructure. The project's **adaptability** quotient is increased through planning the **transport network** system with **climate hazard mapping**. Preparing **climate-resilient O&M protocols** for the BRT system and **training local stakeholders** in urban mobility and climate change issues enhance **long-term resilience**, constituting a **transformational** change.

References

Hallegatte, Stéphane, Jun Rentschler, and Julie Rozenberg. 2019. Lifelines: The Resilient Infrastructure Opportunity. Washington, DC: World Bank. doi:10.1596/978-1-4648-1430-3.

Rigaud K., Arora A. and Singh A.G. 2023. From Concept to Action: Boosting Resilience in Africa. Lessons Learned from the Resilience Booster Tool: An AFRI-RES Product. Washington, DC: World Bank.

Van Zanten, B., G. Gutierrez Guizeita, L. Brander, B. Gonzalez Reguero, R. Griffin, K. Kapur McLeod, A. Alves, A. Midgley, L. D. Herrera, and B. Jongman. 2023. Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers. Washington, DC: World Bank. https://worldbankgroup.sharepoint.com/sites/DNRINT/Shared%20Documents/P176825-60fac3f5-db6c-4169-ada5-590d5948cb5b.pdf.

World Bank. 2019. Ghana: Greater Accra Resilient and Integrated Development Project (English)." Project Appraisal Document, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/675901559440929710/Ghana-Greater-Accra-Resilient-and-Integrated-Development-Project.

World Bank. 2020a. "Rwanda Second Urban Development Project." Project Assessment Document, World Bank, Washington, DC. https://projects.worldbank.org/en/projects-operations/project-detail/P165017.

World Bank. 2020b. "The Next Generation Africa Climate Business Plan: Ramping Up Development-Centered Climate Action." © World Bank, Washington, DC. http://hdl.handle.net/10986/34098

World Bank. 2021a. "Cameroon: Douala Urban Mobility Project (English)." Project Appraisal Document, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/398221654274052110/Cameroon-Douala-Urban-Mobility-Project.

World Bank. 2021b. "Senegal: Second Stormwater Management and Climate Change Adaptation Project (English)." Project Appraisal Document, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/210521622032644700/Senegal-Second-Stormwater-Management-and-Climate-Change-Adaptation-Project.

World Bank. 2021c. "Tanzania: Roads to Inclusion and Socioeconomic Opportunities (RISE) Project (English)." Project Appraisal Document, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/245301622426454522/Tanzania-Roads-to-Inclusion-and-Socioeconomic-Opportunities-RISE-Project.

World Bank. 2022. "Tanzania: Transport Integration Project (English)." Project Appraisal Document, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/959601653593525756/Tanzania-Transport-Integration-Project.

World Bank. 2023a. Climate Resilient Investment in Sub-Saharan Africa Compendium Volume: A Focus on Infrastructure Project Design in Key Sectors. Washington, DC: World Bank.

World Bank. 2023b. Enhancing the Climate Resilience of Transport Infrastructure Projects in Sub-Saharan Africa. Washington D.C. The note was prepared in collaboration with Industrial Economics Inc. under the AFRI-RES program

World Bank. 2023c. Enhancing the Climate Resilience of Urban Infrastructure Projects in Sub-Saharan Africa. Washington D.C. The note was prepared in collaboration with Industrial Economics Inc. under the AFRI-RES program.

Attribution: Please cite the work as follows:

Alcaraz, Marco and Rigaud, Kanta Kumari (2023) Embedding Climate Resilience into Energy Sector Projects

AFRI-RES Learning Note. World Bank. Washington D.C.

e-mail: pubrights@worldbank.org
www.worldbank.org