GLOBAL CENTER ON ADAPTATION

Adaptation Insights *01*

PORTS

Climate Risks to African Ports: A Trade Corridor Approach for Resilience and Adaptation

TU Delft

Authors & Acknowledgements

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GLOBAL CENTER ON ADAPTATION

ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Center on Adaptation (GCA) is an international organization, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

TU Delft

ABOUT DELFT UNIVERSITY OF TECHNOLOGY

Delft University of Technology is built on strong foundations. As creators of the world-famous Dutch waterworks and pioneers in biotech, TU Delft is a top international university combining science, engineering, and design. It delivers world class results in education, research, and innovation to address challenges in the areas of energy, climate, mobility, health, and digital society.

Partner Organizations:

AFRICAN DEVELOPMENT BANK GROUP

THE WORLD BANK

PPIAF Enabling Infrastructure Investment

European Bank for Reconstruction and Development

CSE Centre de Suivi Ecologique

ICSI International Coalition for Sustainable Infrastructure

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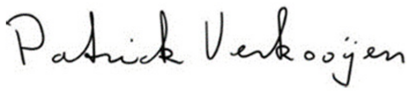
Foreword

It is with great pride that I introduce this inaugural report in our Adaptation Insights series. This series reflects the conviction that effective climate adaptation must proceed hand in hand with rigorous analysis and decisive action. Inspired by GCA's extensive portfolio of more than 100 adaptation projects across Africa and beyond, this first report distils hard-won lessons and lays out a compelling narrative for safeguarding the continent's vital maritime gateways.

Africa's ports are the economic lifeblood of the continent, handling more than 88 percent of its imports and 94 percent of its exports by volume. They underpin supply chains, fuel industry, and bolster food security. Yet these critical infrastructures are increasingly tested by a convergence of hazards—from sea-level rise and coastal flooding to cyclones, extreme heat, and intense precipitation. Today, climate-related disruptions already place nearly US $5.3 billion of Africa's trade at risk each year; without prompt and sustained adaptation efforts, direct damages could escalate to US $680 million annually by 2050—and would be far higher if we factor in projected growth in trade volumes. Such figures underscore the urgent need to view ports not only as static assets but as dynamic systems requiring continuous climate-proofing.

From Senegal's sandy coastline to the delta of the Niger, our work has demonstrated that proactive adaptation measures deliver returns far in excess of their upfront costs. At the Port of Banjul, for example, advanced hazard modelling and vulnerability assessments conducted under the Africa Adaptation Acceleration Program revealed that climate-related risks could soar from €5 million today to €45 million annually by 2100. By prioritizing targeted interventions—upgrading access roads, relocating ferry terminals to higher ground, and installing state-of-the-art early warning systems—stakeholders can achieve a threefold reduction in projected risks . Similarly, at the Port of Cotonou, our assessments showed that days with temperatures above 35 °C could reduce productivity by up to 10 percent, translating to annual losses of €2.2 million by the end of the century. Simple yet effective solutions—such as shaded workspaces, cooling facilities, adjusted shift schedules, and selective automation—offer the potential to halve these losses, yielding cumulative benefits of roughly €13 million through 2100 . These case studies illustrate the importance of embedding localized climate-risk data into every stage of port planning and operations. By integrating stress-testing into design standards for both new and existing infrastructure, port authorities can future-proof terminals against the growing intensity of coastal storms and sea-level rise. Nature-based solutions—mangrove restoration, dune reinforcement, and living shorelines—when combined with traditional grey infrastructure, not only buffer storm surges but also generate co-benefits for biodiversity and local livelihoods. Addressing extreme heat risks, meanwhile, safeguards worker health and productivity, ensuring that ports remain operational even under soaring temperatures.

This first report in the Adaptation Insights series—built on GCA's hands-on experience climate-proofing development investments across Africa through the Africa Adaptation Acceleration Program—proves that the science is clear and the solutions are proven. The moment has come for policymakers, financiers, port authorities, and private-sector leaders to translate these lessons into action. By channeling public, private, and multilateral capital—and embedding climate adaptation at every stage of planning, design, and operation—we will strengthen Africa's vital maritime corridors today and secure enduring prosperity for generations to come.



Professor Patrick V. Verkooijen
President & CEO
Global Center on Adaptation

> **"By investing in resilient port infrastructure today, we are laying the foundation for a future where African trade thrives, communities prosper, and our economies stand strong against any storm."**
>
> **Macky Sall**
> Chair of the Global Center on Adaptation
> Fourth President of the Republic of Senegal

Executive Summary

Africa's Trade Lifeline is at Risk Without Climate Adaptation
Ports handle 90% of Africa's trade, but climate disruptions already put $5.3 billion of trade at risk annually. Small, trade-dependent economies face the greatest vulnerabilities, threatening supply chains and food security.

Rising Climate Costs: A $680 Million Annual Threat by 2050
Port-related climate damages and revenue losses will triple to $530–680 million annually by 2050. Factoring in trade growth, risks could be 7x higher if infrastructure isn't built for future climate realities.

Extreme Heat Will Undermine Port Operations and Worker Wellbeing
By 2050, 43 ports will experience 30+ dangerously hot days per year, up from six today. 13 ports will exceed 100 extreme heat days annually, threatening worker safety and productivity.

Building Resilient Trade Through Redundancy
With transport costs 60% above the global average, Africa's reliance on a few major ports leaves trade routes vulnerable. Strengthening redundancy—alternative ports and resilient transport corridors—is key to keeping goods moving and securing the continent's supply chains.

Investments in Resilience can Reduce Risk by up to 70%
Targeted adaptation measures can reduce climate-related financial and operational risks by as much as 70%, protecting asset value and ensuring long-term performance .

Unlocking Private Sector Potential for Climate Resilience
Private finance is vital for Africa's climate adaptation, yet it accounts for only 14% of climate funding—less than 3% of which supports adaptation. The key challenge is bridging the gap between those financing climate measures and those reaping the benefits, worsened by mismatched timeframes.

CLIMATE THREATS TO AFRICAN PORTS: A GROWING BUSINESS AND INVESTMENT RISK

Seaports are the backbone of Africa's trade, handling over 88% of imports and 94% of exports. With maritime trade set to surge under the African Continental Free Trade Area (AfCFTA), port expansion and modernization are inevitable. However, climate change poses a severe threat to both existing and future port infrastructure, increasing the risk of financial losses, trade disruptions, and economic instability. If adaptation measures are not integrated into investment plans, the climate risk to African ports could be underestimated by a factor of seven.

At the same time, addressing these challenges presents a major investment opportunity. Resilient ports will be better positioned to handle growing trade volumes, improve operational efficiency, and support Africa's blue economy—generating jobs, securing supply chains, and enhancing food security. Unlocking climate finance for adaptation can catalyze private-sector investments and drive sustainable economic growth.

BILLIONS AT STAKE: THE RISING COST OF INACTION

Annual climate-related damages and revenue losses already cost African ports $230 million per year. By 2050, this figure could rise to $530–680 million. Port downtime currently puts $5.3 billion in trade at risk annually, particularly impacting trade-dependent economies like Mauritius, Madagascar, Comoros, Gambia, and Guinea-Bissau. Extreme heat is also emerging as a critical risk, with 43 African ports expected to experience at least 30 dangerously hot days per year by 2050, directly impacting worker safety and productivity. Supply chain vulnerabilities will intensify, with a one-month disruption at major ports like Durban or Port Louis threatening up to 4% of national GDP, creating ripple effects across regional trade networks. These risks extend to the blue economy, where fisheries, coastal tourism, and marine transport—key economic drivers—face increasing disruptions from extreme weather and rising sea levels.

A CALL FOR ACTION: BUILDING CLIMATE-RESILIENT PORTS AS INVESTMENT HUBS

Failing to address climate risks will lead to costly retrofits, trade losses, and declining investor confidence. But there is a clear business case for climate adaptation. A proactive approach—integrating resilience into new investments, maintenance strategies, and financial planning—can significantly reduce future costs and disruptions. Granular case studies from Cotonou and Banjul demonstrate that adaptation investments yield high benefits relative to costs.

Climate adaptation in ports is not just about avoiding losses—it is an investment opportunity to build modern, efficient, and sustainable trade hubs that attract international capital and enhance Africa's position in global markets.

A FRAMEWORK FOR THE PRIVATE SECTOR-LED RESILIENCE AGENDA

1. Make Climate Risk Data Actionable

- Embed climate hazard assessments into operational guidelines and investment decisions.
- Leverage global climate models but complement them with localized risk data.

2. Climate-Proof New and Existing Port Infrastructure

- Require climate stress testing for all new port investments to future-proof assets.
- Retrofit aging port infrastructure with adaptation measures during maintenance cycles.
- Strengthen design standards to ensure infrastructure can withstand future climate shocks.

3. Scale Nature-Based Solutions (NbS) for Coastal Protection

- Integrate NbS, such as mangrove restoration and wetland buffers, to reduce storm surge and flooding risks.
- Combine green and grey infrastructure for long-term resilience.
- Align port adaptation efforts with broader blue economy investments.

4. Tackle Extreme Heat Risks for Workers

- Implement cost-effective heat adaptation measures such as shaded work areas and adjusted shift schedules.
- Use data from pilot projects (e.g., Port of Cotonou) to refine best practices.
- Develop climate-smart workforce management strategies to maintain productivity.

5. Quantify and Manage the Economic Impact of Disruptions

- Conduct economic impact studies on port disruptions to strengthen the business case for adaptation finance.
- Promote cross-border cooperation to mitigate cascading economic losses.
- Highlight the links between port disruptions, food security, and supply chain risks.

6. Strengthen Port-Hinterland Resilience

- Invest in redundancy across key transport corridors to prevent supply chain bottlenecks.
- Enhance logistical flexibility for landlocked countries relying on single-port access.
- Improve multimodal transport systems to ensure supply chain continuity.

7. Embed Adaptation in Public-Private Partnerships (PPPs)

- Structure PPPs to incentivize private investment in climate resilience.
- Use best-practice models from other sectors to share adaptation costs and benefits.
- Offer financial incentives (e.g. concessional loans, blended finance) to attract private sector.

8. Address Residual Risks through Insurance & Contingency Planning

- Develop risk-sharing mechanisms such as climate insurance to safeguard financial stability.
- Strengthen contingency planning to ensure trade continuity during extreme climate events.
- Establish emergency response frameworks to minimize economic shocks.

Introduction

Ports are vital trade gateways that fuel the growth of African economies. Currently, 88% of the continent's imports and 94% of exports—by volume—rely on maritime transport, passing through one or more of Africa's ports (Verschuur, Koks, and Hall, 2022). As socio-economic growth accelerates and trade barriers diminish, the demand for maritime transport is expected to rise significantly in the coming decades. The African Continental Free Trade Area (AfCFTA), for example, is forecast to increase intra-African maritime freight by 62% (UNCTAD, 2023). Moreover, Sub-Saharan Africa's economy, projected to grow at an average rate of 2.9% annually between 2024 and 2050, will more than double in size over the next 25 years, with African companies becoming more integrated into global supply chains (Oxford Economics, 2024). These trends underscore the urgent need for expanded port capacity and improved efficiency, which remains behind global standards despite some progress (UNCTAD, 2023).

Ports are complex infrastructures vulnerable to various climate hazards, including floods (damaging unprotected areas like material handling zones), high winds (toppling equipment such as cranes), sea state changes (restricting accessibility), and extreme heat (damaging transport and electricity systems, potentially triggering wildfires and affecting working conditions).

Figure 1. Illustration of port infrastructure damage due to natural hazards

Climate change is expected to increase the severity of climate-related hazards, putting greater pressure on Africa's critical infrastructure. Ports are already experiencing the effects of extreme weather. In 2018, a gantry crane collapsed at Port Elizabeth due to high winds. Cyclone Idai caused extensive damage and disruption at Beira Port in 2019, while flooding of access roads led to widespread trade delays (Editorial team, Safety4Seas, 2019). More recently, the 2022 floods in KwaZulu-Natal damaged Durban's port infrastructure and disrupted traffic for days.

Figure 2. AI-generated image of a seaport facing various climate-related risks

There is significant potential to integrate climate adaptation strategies into new port developments, including greenfield projects, terminal expansions, or the modernization of existing infrastructure. Climate change threatens not only the physical integrity of ports but also the operational reliability of the supply chains that connect them to national and regional hinterlands.

However, the full scale of climate-related risks to African ports and the economies they serve remains unclear. This report provides key insights into the challenges African ports face in the face of climate change, drawing on the Global Center on Adaptation's (GCA) experience and past initiatives. The analysis serves as the foundation for several recommendations aimed at enhancing the resilience of Africa's port and hinterland transport systems to climate impacts.

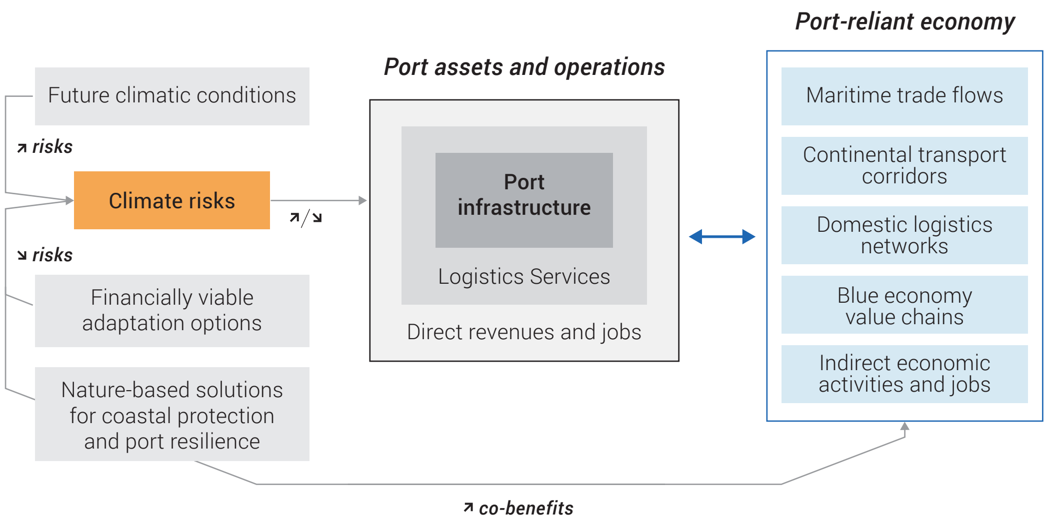
01

Climate Risks to African Ports: Economic Impacts and the Need for Adaptation

Climate Risks to African Ports: Economic Impacts and the Need for Adaptation

Climate-related disruptions to African ports present significant risks to national and regional economies, as illustrated in Figure 3. First, they can damage port infrastructure and surrounding transport networks such as access roads and railways, leading to high reconstruction costs. Second, they disrupt port and maritime operations, resulting in revenue losses for operators and delays for carriers. Third, port closures can have broader social consequences , affecting not only port workers but also those in the wider trade and commerce ecosystem reliant on port services. Finally, disruptions to trade flows can lead to expensive rerouting of shipments or, if rerouting isn't possible, temporary halts in trade. Such disruptions ripple through supply chains, eroding economic output and slowing growth, particularly for economies heavily reliant on imports and exports.

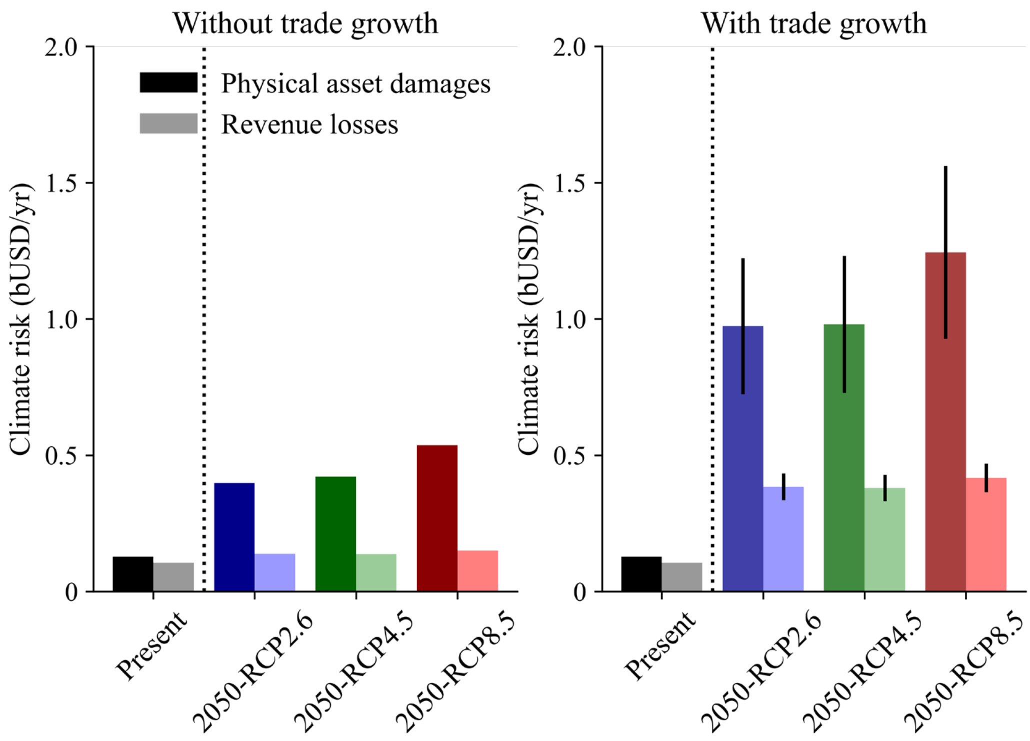
Figure 3. **Framework of impacts from climate risks to ports and dependent economic activities**



Currently, African ports face an estimated climate-related risk of $127 million per year in physical asset damage. Revenue losses from operational disruptions are similarly significant, reaching around $105 million annually. These operational revenue losses are comparable in scale to physical asset damage, underscoring the importance of addressing both infrastructure resilience and operational downtime. Simply adapting port infrastructure may not be enough to deal with the full scale of climate risk.

By 2050 (Figure 4), the risk to physical assets is projected to rise to between $398 million and $537 million annually, depending on climate scenarios. Revenue losses are also expected to increase, reaching $138 million to $150 million per year, primarily driven by increased downtime caused by extreme heat. Longer downtime is expected as climate hazards become more frequent, requiring more frequent restoration of port infrastructure. If infrastructure is designed based solely on historical climate risk data, these future risks could be underestimated by up to 2.5 times over a 35-year asset lifetime, and even more if the asset life extends beyond that.

Figure 4. Current and future climate risks to Africa's port sector, including physical damage and revenue losses due to downtime



Projections of rapid maritime trade growth across Africa is expected to intensify climate risks, as more port infrastructure and revenue become exposed. Under a trade scenario where maritime trade grows by 4.3% annually, economic impact of climate-related disruptions is expected to accelerate, outpacing the effect of climate change alone by 2050. Under this scenario, annual revenue losses could rise from $105 million to between $384 million and $537 million, while physical asset damage could increase from $127 million to between $973 million and $1.244 billion. The combined impact of trade growth and climate change could raise total climate risk by as much as sevenfold. However, the magnitude of these risks will depend largely on the degree to which adaptation is integrated into new port investments. The error bars in Figure 4 reflect the differences between scenarios with high adaptation and those without.

Over the next 30 years, risks are likely to rise substantially, driven not only by climate change but also by the anticipated growth in maritime trade flows through African port. Without targeted adaptation efforts, African ports will face increased climate-related losses. The African port sector must prioritize adaptation, both for existing and new infrastructure. Adaptation strategies will vary by port, depending on local risk profiles, natural processes, ecosystems, and the surrounding social environment. Nature-based solutions, such as restoring mangroves or wetlands around port areas could help protect against storm surges while boosting biodiversity and community resilience (see Box 1).

In Benin, for example, GCA's climate risk assessment for the Port of Cotonou found climate risks for the port facilities and operations could exceed €15–20 million annually by 2050, representing approximately 10% of its projected annual revenues. These costs are projected to increase in the longer-term from 2080 to 2100 to an estimated €40–68 million annually. Integrating appropriate adaptation interventions could help reduce these risks by 75% to €4–6 million annually up to 2050 and to €12–28 million annually between 2080 and 2100.

Box 1. GCA Supports Expansion of Port of Banjul with Climate-Resilient Strategies

The Global Center on Adaptation (GCA) is partnering with the African Development Bank under the Africa Adaptation Acceleration Program (AAAP) to support the expansion of The Gambia's Port of Banjul. GCA has conducted comprehensive climate hazard modeling and vulnerability assessments of the port's infrastructure, operations, and the adjacent Tanbi Wetland Complex. The findings reveal that extreme sea levels (42%), high temperatures (23%), and extreme precipitation (20%) are the primary climate risks facing the port.

The economic impact of climate change is substantial and projected to rise under both moderate and high greenhouse gas emission scenarios. The port's climate-related risks are expected to increase from €5 million annually today to €45 million by the end of the century. This escalation is driven by rising damages to assets and longer operational downtimes, resulting in significant revenue losses (Global Center on Adaptation, 2022).

To address these risks, a series of prioritized adaptation measures—spanning physical, social, and institutional solutions—have been proposed. These include upgrading the Bund access road to reduce vulnerability to sea-level rise and extreme temperatures, relocating the Banjul Ferry Terminal to a lower-risk area, and implementing a real-time multi-hazard early warning system. By quantifying future climate-related damages, GCA has provided a clear financial justification for these investment strategies.

The proposed adaptation measures are expected to deliver considerable economic benefits by reducing operational downtime and protecting port revenues. By the end of the century, these actions could reduce climate-related risks by a factor of three (see Figure 6). GCA's detailed climate risk assessment highlighted the potential financial costs of inaction—without adaptation, operational downtimes could reach 25 days per year by 2050, leading to cumulative revenue losses of over €45 million annually by 2100.

Economic modeling and appraisals have confirmed the viability of the adaptation strategies, paving the way for their integration into the Port Authority's advanced technical design and project implementation plan with the African Development Bank.

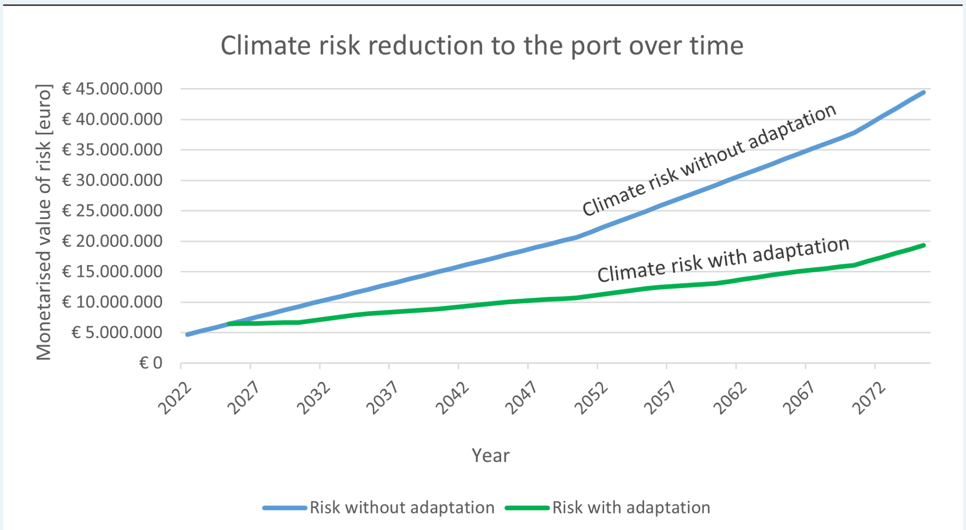
Figure 5. Site location of Port of Banjul

Table 1. Summary of the appraisal of shortlisted adaptation measures

Category	Type	Name of measure	Appraisal			
			Level of investment (Million Euro)	Low level risk reduction (Million Euro)	Low level risk reduction (Million Euro)	Cost efficiency
Physical	Structures	Upgrade of access road with climate resilient pavement	0.1 - 0.5	< 0.5	0.5	
	Structures	Additional buffer storage for extreme events	> 5	0.5	2	
	Structures	Additional parking for flexible operations	1 - 5	0.5	2	
	Structures	Prevent truck overloading with weigh bridges	0.5 - 1	< 0.5	1	
	Equipment	Heat resisant equipment	1 - 5	2	8	
	Systems	Heat resilient power supply	0.1 - 0.5	2	6	
	Structures	Weather protective staff facilities	0.1 - 0.5	1	5	
	Structures	High precipitation drainage system	0.1 - 0.5	< 0.5	2	
	Structures	Climate proof flood defence	1 - 5	2	6	
	Structures	Flood safe terminal area level	0.5 - 1	2	6	
	Nature based solutions	Mangrove restoration programme	1 - 5	1	4	
	Maintenance	Prioritise climate based maintenance	0.1 - 0.5	< 0.5	1	
	Monitoring	Install real-time monitoring equipment	1 - 5	0.5	3	
Social	People	Climate based staff scheduling	0.5 - 1	1	5	
	Information	Climate data collection and analysis	0.1 - 0.5	1	4	
	Education	Capacity building for climate awareness and skills	0.1 - 0.5	1	5	
Institutional	Governance	Climate stakeholder collaboration	< 0.1	< 0.5	1	
	Policy	Climate resilient zoning of assets and land-use planning	0.1 - 0.5	< 0.5	2	
	Policy	Shift to less rain-sensitive cargo type (containers instead of bulk/ general cargo)	> 5	< 0.5	2	
	Policy	Adjust standard operation procedures and extreme event safe working conditions	0.1 - 0.5	1	4	

Beneficial · Maybe beneficial · Probably not beneficial

Figure 6. Yearly monetized climate risk for the moderate climate scenario with and without adaptation measures



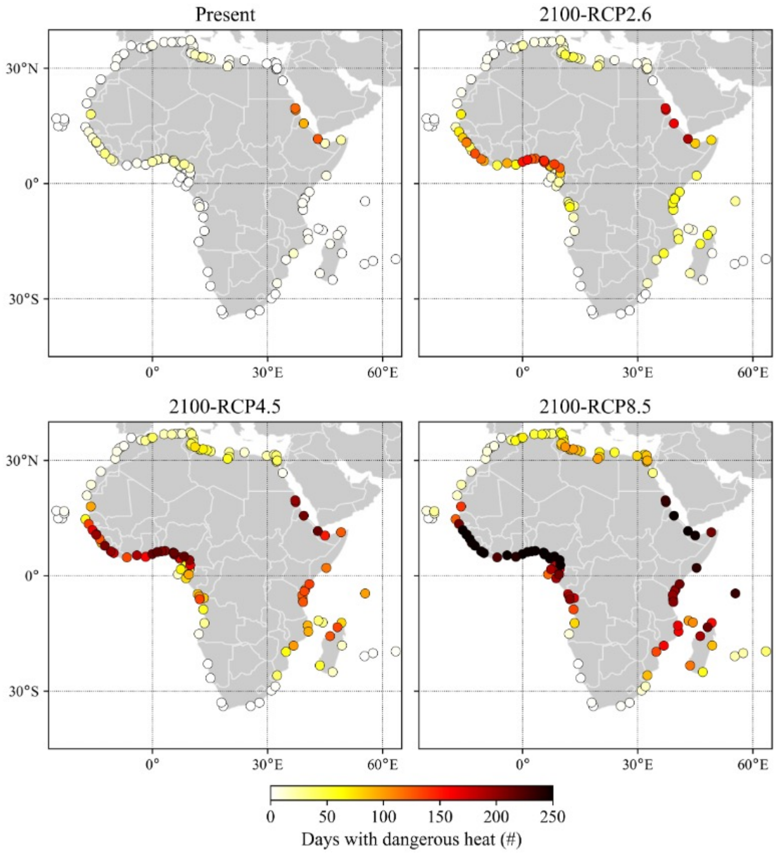
02

Extreme Heat and Worker Safety: A Growing Challenge for African Ports

Extreme Heat and Worker Safety: A Growing Challenge for African Ports

Ports located in dynamic coastal areas are vulnerable to a range of climate hazards, including storm surges, high winds, extreme waves, and heavy rainfall. However, the increasing threat of heatwaves—driven by global warming—is a growing concern. In tropical and subtropical regions, such as many African ports, heatwaves can create dangerous conditions for workers and crews (heat stress can lead to heat exhaustion, heatstroke, and other heat-related illnesses), while also accelerating wear and tear on infrastructure and equipment (such as the softening of pavement, which can subsequently damage yard equipment).

Figure 7. Projected Dangerous Heat Days (>40 degrees): Present vs Future[1]



1 Data obtained from Zeppetello, Raftery, and Battisti, 2022. "Probabilistic projections of increased heat stress driven by climate change." <https://www.nature.com/articles/s43247-022-00524-4#data-availability>

Currently, many ports around the equator face high numbers of dangerously hot days, with six out of 130 ports experiencing more than 30 such days annually, and three facing over 100 days annually. Key hotspots include Djibouti, Sierra Leone, Eritrea, Sudan, and Mauritania. Under moderate warming scenarios (RCP4.5), this trend will intensify, with 43 ports facing more than 30 dangerous heat days by 2050, and 81 ports experiencing the same by 2100. The number of ports exceeding 100 dangerously hot days will rise from three to 42 by 2100.

Extreme heat will soon become a pressing reality for ports located near the equator, with significant implications for operational efficiency. Although research on this specific matter remains limited due to its site-specific nature, existing regulations provide a basis for estimate: productivity could drop by up to 10% on days when temperatures exceed 35ºC.

At the Port of Cotonou, for instance, the economic impact of rising temperatures—particularly the increase in days exceeding 35ºC due to climate change—is expected to escalate significantly. In the near term, downtime-related costs are projected to reach €20,000 annually. However, by 2090, this figure could surge to over €2.2 million, with the expected growth in annual turnover exacerbating the financial impact. This trend highlights the urgent need for strategic adaptation to mitigate the long-term consequences of extreme heat on port operations.

For port operators, the challenge is twofold: mitigating workers' heat stress while also ensuring operational efficiency. Protective gear, essential for safety, can exacerbate overheating risks, and terminal equipment must be designed to withstand high temperatures. For example, Freetown port in Sierra Leone has invested in equipment that operates efficiently in hot conditions, and the Nectar Sierra Leone Bulk Terminal has implemented cooling breaks for workers during extreme heat (Adrienne Arsht-Rockefeller Foundation Resilience Center, n.d.).

Rising temperatures could have significant consequences for port infrastructure, particularly due to the sensitivity of materials used in construction. Increased heat exposure can lead to damage to road surfaces, rendering them unusable and causing delays in landside transport. For every 1°C rise above 35°C, road infrastructure damage is projected to increase by 2%. At the Port of Banjul, projections show that days exceeding 35°C could account for over half the year by the century's end under a high emissions scenario. More extreme temperatures above 47°C, previously unseen, are also expected. These conditions would strain electricity demand, risk equipment failure, and cause 10 days of annual downtime.
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Without adaptation, extreme heat could significantly impair productivity at African ports, worsening already low productivity levels in some areas. However, relatively cost-effective adaptation measures—such as adjusting shift schedules, increasing automation, and providing cooling solutions—can help mitigate these impacts.

Box 2. Addressing Heat Stress at the Port of Cotonou

GCA has supported the expansion of the Port of Cotonou in Benin, in partnership with the African Development Bank under the Africa Adaptation Acceleration Program (AAAP). A detailed climate risk assessment highlighted the significant socioeconomic impact of heat stress on port productivity. As temperatures rise, productivity is expected to decrease by 10% on days exceeding 35ºC (with relative humidity often above 80%). By 2090, under a high-emissions scenario (RCP8.5), the economic impact of this heat stress could escalate from €20,000 annually to more than €2.2 million, driven by an increase in dangerously hot days.

Measures which reduce the exposure to heat risk were proposed and discussed with the African Development Bank and Cotonou Port Authorities, including:

- Training and awareness campaigns on wellbeing during hot/humid periods
- Shorter shifts, especially during hottest times of the day
- Shift work (if possible) away from the hottest times of the day
- Provide additional facilities for shade, cooling, and drinking water
- Automation, i.e. reducing manual labor and exposure to extreme heat

A cost-benefit analysis showed that these measures would reduce heat-related productivity losses by half, saving an estimated €13 million in 2090. These strategies were found to be financially viable, yielding high returns on investment while improving workers' safety and well-being.

Figure 8. Projected Changes in Extreme Maximum Daily Temperatures (>35°C)

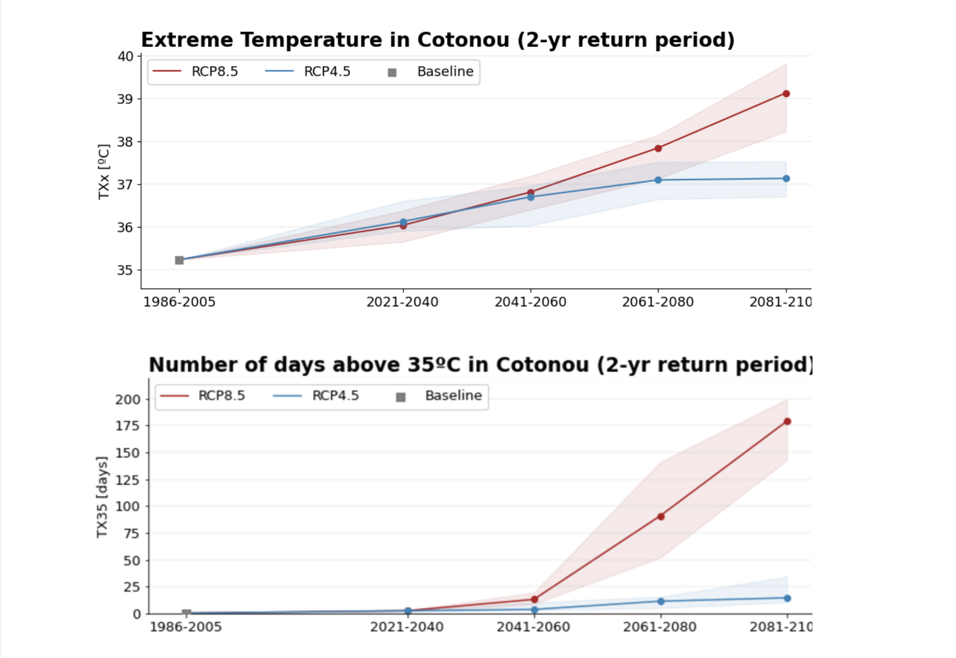
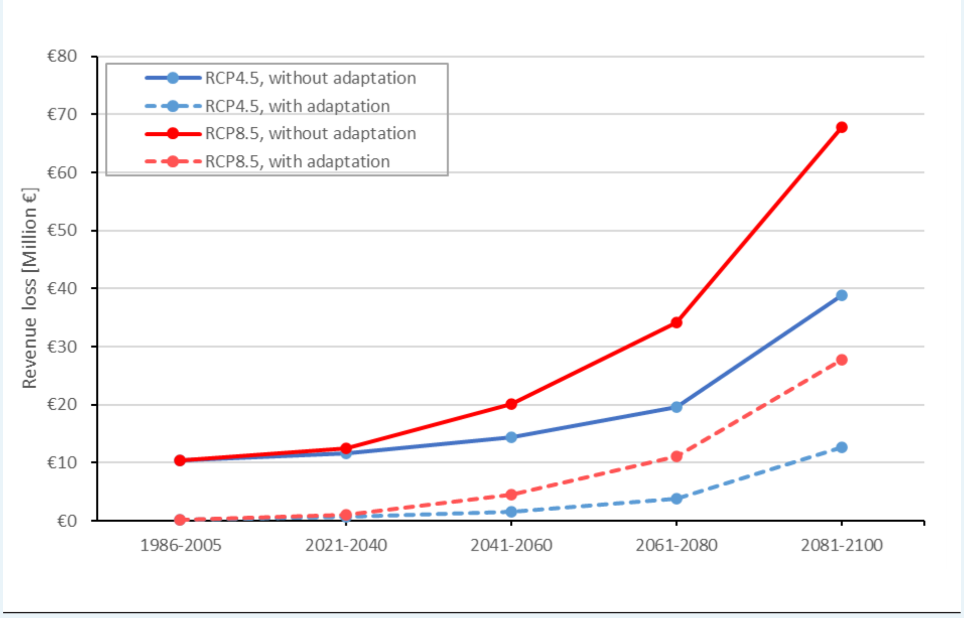


Figure 9. Projected Revenue Loss from Heat Stress with and without Adaptation, according to moderate and high climate scenarios



By adapting to rising temperatures, ports can both safeguard workers' health and improve operational efficiency. As global temperatures rise, these adaptation measures are not just cost-effective—they are essential to maintaining the long-term viability of port operations.

03

Strengthening Resilience: Addressing the Broader Economic Impact of Port Disruptions

Strengthening Resilience: Addressing the Broader Economic Impact of Port Disruptions

Port disruptions can have extensive effects, reaching beyond the port itself to encompass both domestic and regional contexts economies. This is especially critical for African nations, where many landlocked countries depend heavily on maritime transport. With a limited number of major ports and high trade openness—36 out of 48 African countries have a trade openness index above 50%, meaning over half of their economies rely on trade—the impact of port inefficiencies is profound. However, these broader economic consequences are difficult to quantify and are often overlooked in the assessment of adaptation measures.

Also, for countries heavily reliant on ports for imports and exports, such as Comoros and Benin, these disruptions pose a significant risk, exacerbated by climate change and shifting global trade dynamics.

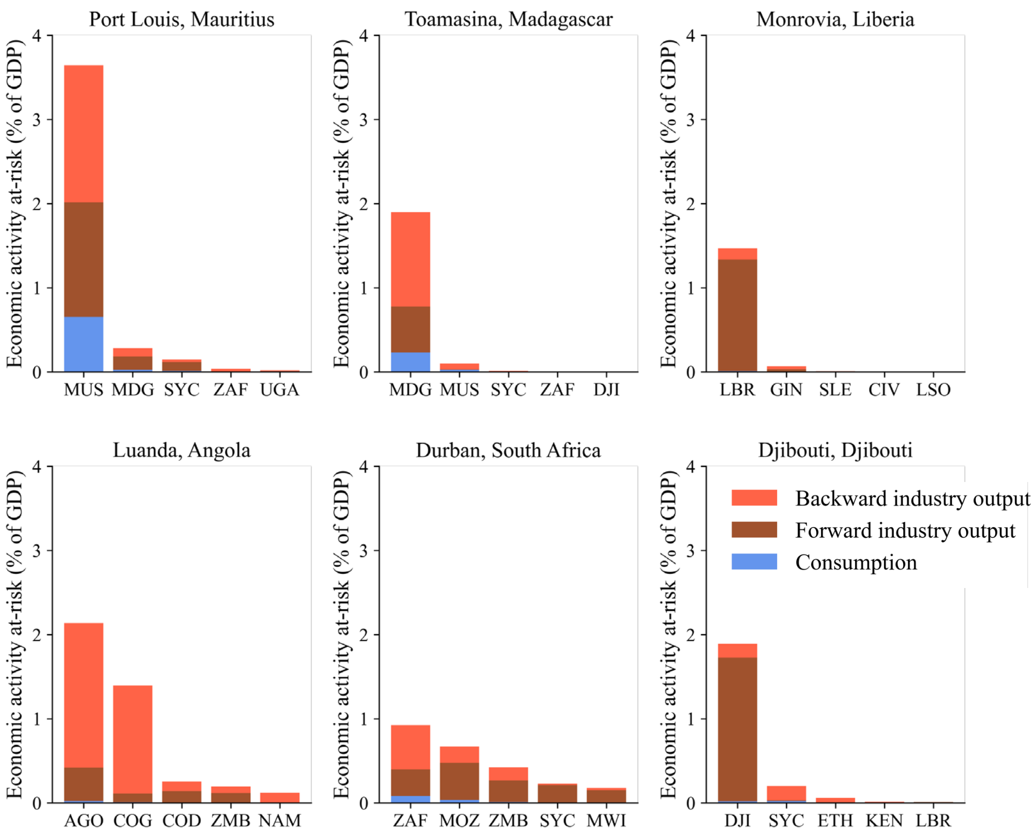
Take Comoros, for example. With agriculture accounting for 30% of GDP and 80% of exports, the country's economy is intrinsically tied to its port infrastructure. A disruption in port operations would directly affect agricultural exports, severely impacting livelihoods, economic output, and food security. Without reliable port connectivity to global markets, productivity across sectors could stagnate, as local businesses and farmers hesitate to invest or expand production.

Similarly, Benin faces dual challenges from climate-related droughts that reduce crop yields and disrupt export flows and domestic food production. While this creates a paradox of reduced exports and increased imports, the strain on port infrastructure becomes clear. Ports could experience congestion at bulk terminals, while container terminals sit underutilized—requiring targeted investments in bulk-handling capacity to balance these shifts.

The broader economic implications are stark. At present, port downtime across Africa puts $3.2 billion of exports and $2.1 billion of imports at risk annually (Verschuur, Koks and Hall 2022)[2]. These figures could rise dramatically due to climate change, with potential losses reaching up to $7 billion per year by 2050. Smaller, trade-dependent economies, such as Mauritius, Gambia, and Madagascar, are particularly vulnerable, as even minor disruptions to their ports can cause significant economic fallout.

As Africa integrates further into global trade networks, the broader macroeconomic effects of port disruptions will only intensify. Investing in resilient port infrastructure and transport networks is critical for protecting these nations against economic destabilization due to climate change and increasing port vulnerabilities.

Figure 10. **Economic activity at-risk because of a 30-day port closure**



For example, a 30-day closure at Port Louis in Mauritius could put nearly 4% of the nation's GDP at risk, due to both export halts and the disruption of imports. A similar pattern emerges in Madagascar's Port of Toamasina, with nearly 2% of GDP at risk. Ports like Monrovia and Djibouti mainly experience forward impacts, indicating a dependence on imports for production. Conversely, ports like Luanda in Angola primarily face backward impacts, with disruptions halting exports.

The wider economic impacts of port disruptions vary depending on the port's importance to domestic and regional economies. In countries like South Africa, the Port of Durban is crucial not only for South Africa but also for neighbouring economies like Mozambique and Zambia. These vulnerabilities will intensify as African economies continue to integrate into global supply chains, underscoring the need for investment in resilient infrastructure to protect against transportation disruptions.

2 We use the terminology "at-risk" if we refer to the trade or economic activity that is potentially affected by disruptions. This is different than this economic value being lost, as disruptions often lead to delays and not losses. Instead, we use it as a way to understand the macroeconomic criticality of ports.

04

Enhancing Port-Hinterland Redundancies for African Container Ports

Enhancing Port-Hinterland Redundancies for African Container Ports

Container ports are essential gateways for Africa's landlocked countries. Unlike other continents, Africa has a relatively small number of major container ports serving vast hinterlands. Many regions still face high transport costs due to limited infrastructure, long border delays, high transportation costs and inefficient routes. These challenges leave many areas heavily reliant on a few ports, making them highly vulnerable to disruptions—especially climate-related events. The ability to reroute goods to alternative ports during disruptions is critical to ensuring continued trade.

Improving redundancy in port-hinterland transport corridors is essential. Redundancy refers to the system's ability to redirect freight at minimal cost if the primary port is disrupted. Identifying and strengthening redundancies in both ports and transport networks is key for building resilience against climate-related disruptions.

In 2019, Sub-Saharan Africa handled about 18 million TEUs (twenty-foot equivalent units) through its ports. These ports are connected to transport corridors, facilitating the trade of goods across the continent. Key examples include:

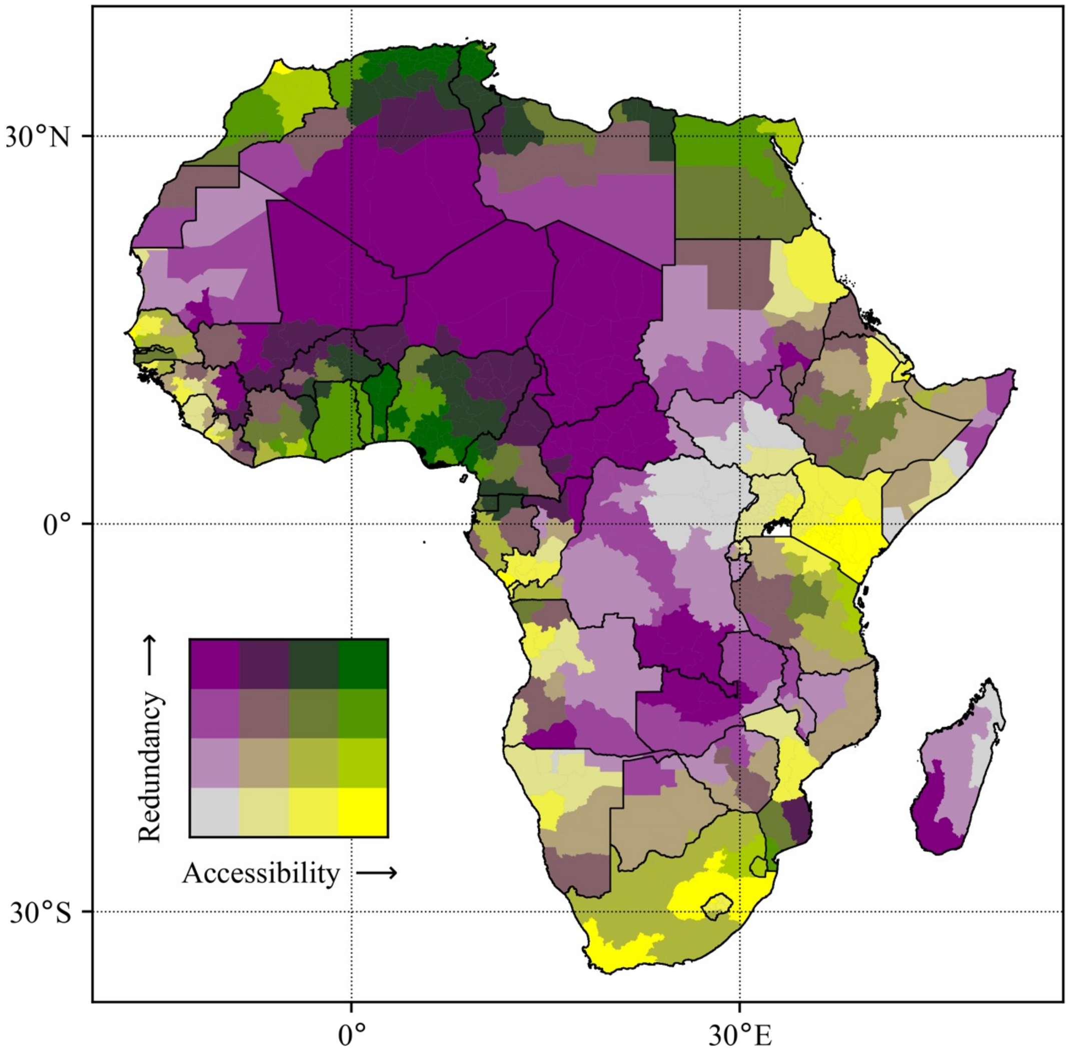
- The Addis-Djibouti corridor, linking Addis Ababa in Ethiopia to the port of Djibouti.
- The Mombasa-Nairobi-Addis Ababa Corridor, connecting Kenya and Ethiopia to the port of Mombasa.
- The Tema – Ouagadougou Corridor, linking Burkina Faso and Niger to the port of Tema.
- The Dakar – Bamako – Ouagadougou – Niamey Corridor, connecting the port of Dakar to landlocked countries in Western Africa.

3 In Africa, transport costs can account for up to 35% of total import costs, much higher than the 5-10% seen in regions like East Asia, North America, or Europe. (UNCTAD, Review of Maritime Transport, 2015)

Figure 11. The African port-transport corridors (African Development Bank 2019)

Regions can be classified based on two factors: accessibility (how easily they can reach major container ports) and redundancy (how effectively they can reroute trade in case of port disruptions). This classification provides a basis for targeted adaptation strategies, tailored to each region's needs.

Figure 12. Regional classification in terms of accessibility to major container ports and the redundancy to port disruptions at these container ports



The following joint adaptation strategies could be identified:

- ***Climate-proofing ports*** *(high accessibility – low redundancy)*: Regions with high access to major container ports but low redundancy are highly dependent on a single port. In case of disruptions, rerouting goods is either difficult or costly. For these regions, climate-proofing ports is crucial to ensure uninterrupted trade. These regions, typically close to the coast and major ports, need robust infrastructure to handle climate risks. (yellow color Figure 12).

- ***Climate-resilient logistics networks*** *(low accessibility – high redundancy)*: Regions with relatively high transport costs but served by multiple ports need resilient logistics networks. These regions, often located between different port areas, can benefit from flexible, climate-resilient corridors. Strengthening hinterland transport systems and diversifying routes can reduce disruptions, enabling smoother trade shifts between ports during crises.(purple color Figure 12).

- ***Disruption early warning systems*** *(high accessibility – high redundancy):* Regions with both high accessibility and high redundancy, such as parts of Egypt, Algeria, Tunisia, and Western Africa's coastal areas, can quickly shift trade to other ports in the event of a disruption. Here, early warning systems, real-time shipment tracking, and proactive planning are vital for maintaining trade flow and minimizing disruption impacts (green color Figure 12).

- ***Increasing coping capacity*** *(low accessibility – low redundancy)*: Regions with low accessibility and low redundancy face the greatest risk of major disruptions. These regions have limited access to alternative ports and may face severe economic consequences during port shutdowns. Strengthening local coping mechanisms, such as maintaining inventory buffers, is critical. Building firms' resilience to port disruptions is essential for these regions(grey color Figure 12).

The port-hinterland redundancy metric helps assess the potential economic impact of climate-induced port disruptions and highlights the importance of a resilient transport network. Strategic adaptation planning is necessary, focusing on strengthening redundancies and coping capacities. As Africa's economies face increasing climate risks, robust, diversified, and adaptable port-hinterland systems are essential to safeguard trade flows and economic stability.

05

Leveraging Public-Private Partnerships for Climate Resilient Port Adaptation

Leveraging Public-Private Partnerships for Climate Resilient Port Adaptation

The increasing need for climate adaptation of ports will require substantial investments in the coming decades, potentially amounting to billions of dollars. While these investments must be made locally, the benefits of port adaptation extend beyond the ports themselves, creating positive socio-economic impacts for all users, even those in neighboring countries.

The challenge lies in the misalignment of who should pay for these adaptations and who ultimately benefits from them. Furthermore, there is a mismatch in timeframes, as terminal operators often have contracts lasting around a decade, while the benefits of adaptation may not be realized until the full lifespan of the investment, typically 30 to 50 years.

Nevertheless, GCA's experience highlights that adaptation solutions can deliver strong short-term financial benefits by preventing revenue losses. For the Port of Cotonou, GCA's financial model shows that the adaptation measures could prevent up to €400 million in lost revenue over the first 30 years—essentially matching the project's total investment cost. At the Port of Banjul, proposed adaptation measures could reduce climate risk by 40-50%, with a Benefits-Cost Ratio suggesting that every euro invested would return €8 over 20 years, making the project financially viable.

The distribution of beneficiaries and those responsible for investment in port adaptation varies depending on the ownership structures of the ports. Private participation in Africa's port sector has been growing, with almost 12 billion USD in private investments made between 2013 and 2023—twice the amount of the preceding decade. In 2017, 60% of container throughput across Africa occurred in ports owned by private companies or international players. Private investment is even larger in the liquid and dry bulk port sectors, particularly as Africa's critical minerals are increasingly being exported for processing elsewhere.

Table 2 shows different port types in terms of private sector involvement and their ownership structures, influencing the way adaptation investments are made and benefits are distributed.

Table 2. **Port types in terms of private sector involvements and their ownership structures**

Type	Time contract (years)	Labor	Equipment	Buildings	Quay walls	Land	Breakwater, nautical service	Hinterland
Public port	-	Public	Public	Public	Public	Public	Public	Public
Tool port	5-15	Private	Public	Public	Public	Public	Public	Public
Landlord port	10-30	Private	Private	Private	Public	Public	Public	Public
PDMC[4]	10-30	Private	Private	Private	Public/ Private	Public/ Private	Public/ Private	Public/ Private
Private	-	Private	Private	Private	Private	Private	Private	Private

In fully public and fully private ports, all costs and benefits are accrued by the respective public or private entities.

In the case of tool ports, where stevedoring works are outsourced to private companies, the private entity may be responsible for adapting to climate extremes affecting workers, while the public entity handles adaptation to infrastructure.

In landlord ports, the public entity owns the port infrastructure, while private companies own the superstructure and equipment. Here, infrastructure damage affects both parties, but operational losses are typically the responsibility of the private company. As a result, while adapting infrastructure is the public entity's responsibility, the private company benefits from these investments. However, the private company may lack the incentives to make long-term adaptation investments, given that their concession contract usually lasts 10 to 30 years, while the benefits of adaptation may be felt over a longer period.

In the Port Development and Management Company (PDMC) model, where private companies hold more responsibility, port adaptation investments may be further hindered.

The misalignment of costs and benefits strengthens the case for public-private partnerships in adaptation. National governments, given the broader socio-economic advantages that ports provide, should also play a role in supporting port-level adaptation. Emerging examples of joint public-private collaborations in transport adaptation demonstrate how scarce resources can be shared effectively to fund critical adaptation investments., as highlighted in Box 4.

4 PDMC: Port Development and Management Company

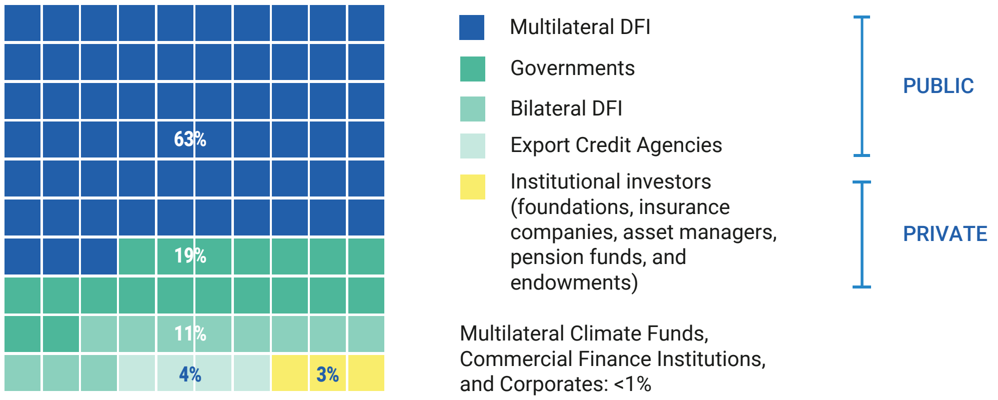
Box 3. Evolving trends in Climate Adaptation Finance in Africa

Adaptation finance in Africa delivers cross-sectoral benefits. In 2019-2020, of the total adaptation finance commitments, 41% (USD 4.7 billion) was directed towards cross-sectoral activities. These efforts spanned national policy, capacity building, disaster management, COVID-19 response, urban development, biodiversity protection, and social security initiatives. The agriculture, forestry, and land use (AFOLU) sector secured the second-highest average annual commitments, receiving 25% (USD 2.8 billion), followed by the water and wastewater sector, which accounted for 15% (USD 1.7 billion).

Notably, 2019-2020 marked the first period where multilateral Development Finance Institutions (DFIs) committed more funds to adaptation than to mitigation in Africa. Multilateral DFIs emerged as the dominant source of adaptation finance, contributing 53% (USD 6 billion) of the total. This was followed by government contributions at 23% (USD 2.6 billion), and bilateral DFIs at 16% (USD 1.8 billion), as illustrated in Figure 13.

However, the private sector's role in bridging Africa's adaptation finance gap remains crucial. Currently, the private sector accounts for just 14% of Africa's total climate finance—a stark contrast to the much higher contributions in regions like South Asia (37%) and East Asia and the Pacific (39%) (Meattle et al., 2022). Even more concerning, less than 3% of the private sector's funding is allocated specifically for adaptation efforts. While large investors provide the majority of adaptation finance, it is essential to enhance collaboration among multiple stakeholders. Improved tracking and transparency in private sector contributions, as well as more comprehensive data, are critical to boosting adaptation finance in Africa (Naran et al., 2022).

Figure 13. Adaptation Finance Flows in Africa, by Sources and Actors (Wignarajah, et al. 2023)



Box 4. Leveraging PPP frameworks to mitigate and manage climate risks to infrastructure

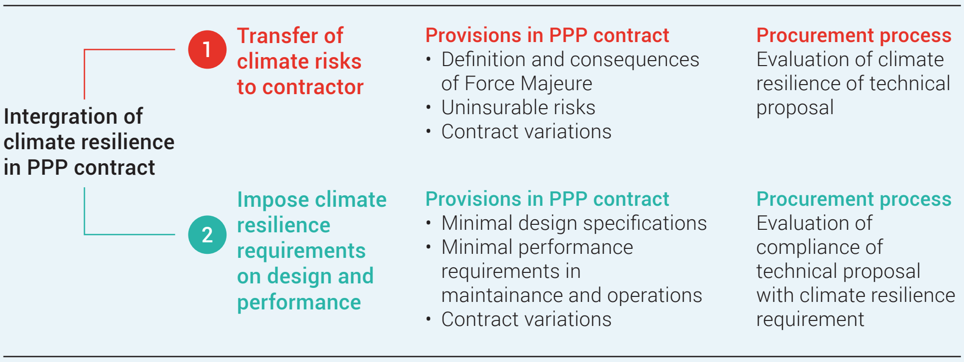
Public-Private Partnerships (PPPs) present a significant opportunity to integrate climate risk management into infrastructure development, boosting investments in climate adaptation and resilience. Given their long durations—typically spanning 20 to 30 years—PPPs necessitate a thorough analysis of the risks these investments may face over time. With long-term planning at the forefront, the design and implementation phases offer key opportunities to set climate resilience standards for both construction and operational stages. By carefully balancing and allocating risks between contractors and issuers, PPPs can be structured to ensure the long-term sustainability of infrastructure.

As part of its technical assistance to integrate climate adaptation into infrastructure projects and strengthen institutional capacity, the Global Center on Adaptation (GCA) has developed climate-informed PPP guidelines. These guidelines aim to manage and mitigate climate risks, protecting investments, infrastructure services, and potential revenue streams.

Key strategies include:

- Transferring Climate Risks to Contractors: Contractors assume responsibility for climate-related risks, incentivizing them to invest in adaptation. This works well in "User Pays" contracts, especially when climate risks are low or insurable.
- Imposing Resilience Requirements: Contracting authorities mandate specific climate resilience measures to ensure infrastructure is robust, particularly in government-pays contracts or areas with high climate uncertainty.
- Climate-Informed Performance Metrics: Service standards and KPIs are set to ensure infrastructure can withstand climate events, maintaining performance under changing conditions.
- Climate-Responsive Operations: Contracts include provisions for regular updates to resilience measures and emergency plans, adapting to evolving climate risks.

Figure 14. Conceptual Options for the integration of climate resilience in PPP contract

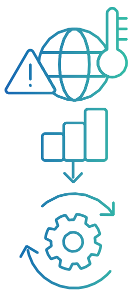


By embedding climate risk considerations into the design, implementation, and management of PPPs, governments and private sector partners can safeguard long-term infrastructure investments and public assets. This proactive approach not only reduces financial risks but also promotes sustainable development and aligns with global climate resilience goals. In doing so, it establishes a resilient foundation for future economic growth, ensuring that infrastructure remains adaptable and functional in the face of climate challenges.

A Framework for Enhancing the Resilience of Ports in Africa

The African port sector stands at a critical juncture. While climate risks remain manageable for now, both the escalating impacts of climate change and the rising demand for new port infrastructure are set to amplify these challenges. Port authorities, operators, businesses dependent on seamless port operations, and landlocked nations reliant on these hubs for economic stability will all feel the heat. Across Africa, promising examples of port adaptation are emerging, but the reality is that climate change adaptation is still not embedded in the core of port planning, operations, and maintenance. As this brief underscores, securing the future of African ports will require a unified effort—one that brings together port authorities, national governments, and the private sector.

Based on the analytics provided in this Brief, the following recommendations are being proposed:



1. Make Climate Risk Data Actionable

- Across much of Africa, ports are not adequately prepared for the growing challenges posed by climate change, lacking comprehensive data on both current and future climate hazards. To address this, integrating climate risk information into operational guidelines is critical. While global climate hazard data can provide a baseline, local climate data is essential to inform decisions with greater precision.
- This approach will empower port authorities and operators to better understand and mitigate climate risks, fostering resilience in day-to-day operations and long-term strategies

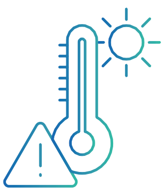
2. Climate-Proof New and Existing Port Infrastructure

- Port infrastructure across Africa is expected to expand rapidly over the next few decades, with projections suggesting a potential doubling of port areas by 2050. At the same time, the impacts of climate change are set to intensify the risks ports face, with potential escalation by two to three times, compounding future threats by up to seven times.

- Incorporating climate adaptation into the design of new infrastructure can reduce these risks by up to 40%, ensuring long-term viability and protecting expected revenue streams. Adapting early during the investment phase is far more cost-effective than retrofitting later. Additionally, port modernization initiatives provide an opportunity to embed climate resilience into existing infrastructure

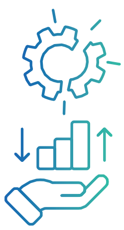
3. **Scale Nature-Based Solutions (NbS) for Coastal Protection**

   - Strategically integrate Nature-based Solutions to enhance climate adaptation and maximize socio-economic benefits for port resilience, contributing to the Blue Economy.
   - A hybrid approach combining green and traditional grey infrastructure offers long-term resilience, enhancing coastal protection, supporting marine biodiversity, and bolstering infrastructure durability. By adopting NbS, ports can address both environmental and economic challenges, contributing to the broader Blue Economy.



4. **Tackle Extreme Heat Risks for Workers Address Extreme Heat Risks and Worker Safety**

   - The increasing frequency of extreme heat events due to climate change presents a direct threat to the safety and productivity of port workers. By 2050, 43 out of 130 African ports could face over 30 days of dangerous heat annually, with projections indicating 81 ports will be affected by 2100. This issue is particularly pressing for ports near the equator.
   - To address these risks, ports must implement adaptive strategies such as shaded workspaces, adjusted shift schedules, and cooling systems. Lessons from pilot projects like the Port of Cotonou in Benin can inform best practices for maintaining worker safety and productivity in extreme conditions.



5. **Quantify and Manage the Economic Impact of Disruptions**

   - The broader economic consequences of port disruptions often remain underappreciated in adaptation efforts, despite their substantial effects on regional trade and supply chains. Quantifying these impacts is essential for justifying investments in port resilience.
   - The Port of Cotonou's recent expansion project in Benin highlighted how understanding the economic toll of disruptions can drive critical adaptation investments. Port disruptions ripple through supply chains, affecting trade, food security, and overall economic stability.

Comprehensive economic impact studies, alongside regional collaboration, will ensure that adaptation planning accounts for the full range of risks.

6. Strengthen Port-Hinterland Resilience

- Ports connect with regional transport networks to facilitate the flow of goods within port hinterlands. In these broader freight transport networks, the vulnerability of the system is determined by its weakest link. However, decision-making on climate adaptation takes place in isolation and rarely takes an integrated approach.
- Taking an integrated adaptation approach to the port-hinterland transport network can help identify where investments are most urgently needed and identify additional investments to improve the system's resilience.

7. Embed Adaptation in Public-Private Partnerships (PPPs)

- Even with robust adaptation measures in place, climate risks will continue to escalate. Therefore, it is essential to implement additional risk-sharing mechanisms, such as climate insurance, to protect financial stability. These mechanisms can help safeguard investments and ensure that ports remain operational during extreme weather events.
- Strengthening contingency planning is also critical to ensure trade continuity during extreme climate events. Ports should develop emergency response frameworks that minimize the economic impacts of disruptions, enabling them to recover quickly and maintain their role in global trade.

8. Address residual climate risks through insurance and contingency planning

- Even with robust adaptation measures in place, climate risks will continue to escalate. Therefore, it is essential to implement additional risk-sharing mechanisms, such as climate insurance, to protect financial stability. These mechanisms can help safeguard investments and ensure that ports remain operational during extreme weather events.
- Strengthening contingency planning is also critical to ensure trade continuity during extreme climate events. Ports should develop emergency response frameworks that minimize the economic impacts of disruptions, enabling them to recover quickly and maintain their role in global trade.

ANNEXES

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METHODOLOGY

The climate risk analysis captures the probability and expected losses that ports and countries face due to a variety of climate extremes, at present and in 2050. To determine the climate risks in the climate risk layer, we use the output of a global multi-hazard risk analysis of ports, as described in Verschuur et al. (2023). In this work, first, the location of different port terminals were mapped. Second, hazard data (e.g. cyclone, river flooding, pluvial flooding, coastal flooding, earthquakes) from various sources were processed and overlayed with the location of port infrastructure. Third, the vulnerabilities of port terminals to specific hazards were prescribed, resulting in the physical damages and expected downtime associated with damage to port infrastructure and operational interruptions. Altogether this results in estimates of the downtime risk and physical asset risk for each port individually (see above for definitions). A similar exercise is performed for the future (2050), in which changes in the frequency of occurrence of hazards quantified for different climate scenarios (RCP2.6, RCP4.5, RCP8.5).

Physical asset risk: the expected annual physical asset damages (EAPD, in USD per year) to physical infrastructure in the port area. Physical infrastructure refers to port terminals, warehouses, cranes, roads, railway lines, and transmission lines. The EAPD captures the reconstruction costs across the hazards considered (see below) and the range of hazard likelihoods (e.g. an event with an annual probability of occurrence of once every 1, 5, 10, 100 years, etc). The EAPD is be found by taking the integral across the different event probabilities:

$$EAPD = \sum_{1}^{h} \int_{0}^{1} QPD(p)dp$$

With *h* the hazard considered and *QPD* the inverse cumulative probability function of the physical asset damages (*PD*) per failure probability *p*. The integral is performed using the trapezoidal rule, which is commonly applied to estimate the risk integral using discrete event probabilities.

Downtime risk: the expected annual downtime (EAD, in number of days per year) to the port operations as a whole. The EAD encapsulates both the downtime associated with reconstruction of damaged physical infrastructure, as well as downtime associated with the exceedance of operational thresholds (which do not cause damage). The EAD captures the downtime across the possible hazards (see below) and the range of hazard likelihoods (e.g. an event with an annual probability of occurrence of once every 1, 5, 10, 100 years, etc). The downtime risk is derived in a similar fashion as the physical asset risk:

$$EAD = \sum_{1}^{h} \int_{0}^{1} QD(p)dp$$

With *QD* the inverse cumulative probability function of the port downtime (*D*).

Hazards: The natural hazards considered include:

- ***Fluvial flooding:*** flooding associated with the overflow of rivers onto the surrounding low-lying land. The presence of existing river flood defences are taken into consideration.

- ***Pluvial flooding:*** flooding associated with the extreme rainfall that inundates land irrespective of the presence of an overflowing water body.
- ***Coastal flooding:*** flooding associated with extreme sea levels that overflows the surrounding low-lying land. The presence of existing coastal flood defences are taken into consideration.
- ***Tropical cyclones:*** extreme wind speed associated with tropical cyclones, hurricanes or typhoons (depending on the basin) at the port level.
- ***Operational thresholds:*** the exceedance of a port's operational thresholds linked to extreme waves, overtopping, (non-cyclonic) wind, and temperature.

Trade at-risk and revenue losses: We combine the downtime risk estimates with the different spatial networks to quantify trade flows at risk of disruptions and industry supply and consumption (*supply-chain layer)* are affected by port disruptions. To do so, data from the Oxford Maritime Transport (OxMarTrans) model is utilized. This model predicts the allocation of maritime trade flows (based on bilateral trade data) on the maritime transport network, including the port and route taken, to determine the dependency between ports and trade flow. In other words, it captures how trade between origin and destination are most likely being shipped across the global maritime transport network, including the port used for exporting, transhipment (if required) and importing. The resulting network consist of >2.1 million unique port-country pair combinations across >25,000 unique country pairs and 11 economic sectors, which capture the what share of maritime trade between two countries going through specific ports and on specific routes. The base year considered is 2020. Here, we only extract data for African economies.

Combining this information with the downtime estimates allows us to derive the trade that is at-risk of being affected because of a disruption at a selected port, in value terms. This could be because the port was exporting/importing a country's imports/exports, or because of transhipments. This impacts can be analysed in aggregate terms (across all commodity sectors) or per commodity sector. It should be noted that in most cases trade is not directly lost, but merely delayed in case of smaller disruptions (<7 days). However, in case of larger disruptions (>30 days) and limited possibilities to reroute goods, trade bottlenecks could occur, potentially resulting in severe supply shortages.

Similarly, we can estimate the expected revenue losses due to downtime, by combining the downtime estimates with the quantity handled at each ports, and multiplying this with an average revenue per tonnes handled. The average revenue we use in this analysis is 17 USD per tonnes.

Economic activity-at risk: To estimate the economic activity at-risk, we use data from a multi-regional input-output table (EORA MRIO). A MRIO captures how industrial production and consumption is dependent on sector input from within the domestic economy and from other economies (the MRIO covers 170 economies globally). By coupling this to the country trade network, we can embed the maritime transport of flows within the tables, thereby capturing how these trade flows are used in the economy. This therefore does not only capture how a supply-chain is exposed to downtime because of trade flowing through a certain port (direct links), but also indirectly how you are exposed as a firm because you rely on firms upstream in your supply-chain that trade through a port prone to downtime (the firms you depend on, 1st order suppliers, or firms that the firms that you depend on depend on, 2nd order suppliers, etc). In other words, as a supply-chain, you may be indirectly exposed to port disruptions without your direct input or consumption goods flowing through an at-risk port (e.g. you are exposed to closure of a raw materials exporting port without you directly using raw materials in your production process).

To understand the supply-chain dependencies between global supply-chains and a port, the Hypothetical Extraction Method (HEM) is used. The HEM hypothetically removes the share of trade flows between countries that go through a certain port from the MRIO and re-evaluates the industrial production globally without these flows, without any adaptation in the economic system. The difference between the original production and the HEM production is the dependency of various supply-chains on a specific port. The base year considered in 2020, which is the latest available MRIO table available.

We combine the downtime risk with the results of the HEM to estimate at economic activity at-risk. Similar as with the trade at-risk estimate, the absolute numbers are indicative numbers only, and represents the relative exposure of specific supply-chains to a port disruption, which allows identifying at-risk supply chains across countries and sectors.

Future scenarios: We combine three future climate and trade scenarios for the African continent. In terms of climate, we three possible future greenhouse gas emissions scenarios (also called radiative forcing) used for modelling of the future climate change scenarios. In the platform we cover three RCP scenarios:
- ***RCP2.6:*** expected warming of 1.3 to 2.9 (mean of 2.0) degrees Celsius in 2090-2100 compared to 1880-1900.
- ***RCP4.5:*** expected warming of 2.1 to 3.0 (mean of 3.0) degrees Celsius in 2090-2100 compared to 1880-1900.
- ***RCP8.5:*** expected warming of 3.8 to 7.4 (mean of 5.0) degrees Celsius in 2090-2100 compared to 1880-1900.

Per hazard, we use different climate indicators to scale the future probability of hazards. For instance, future fluvial flooding is derived by looking at extreme discharge charges, coastal flooding based on sea-level rise projections, cyclone wind based on cyclone-intensity scaling factors, and pluvial flooding based on changes in precipitation extremes.

In terms of trade, we use country-specific trade scaling factors per scenario, derived by feeding future bilateral trade estimates from Walsh et al. (2019) into the OxMarTrans model.

Further readings: For more information, the following papers can be accessed:

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