

## PROJECT EXEMPLAR

# Climate-Resilient Modernization of the Port of Cotonou: Addressing Heat Stress, Drought-Driven Cargo Shifts, and Coastal Flooding



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## KEY PROJECT INFORMATION



### Country / Region

Republic of Benin, West Africa



### Sector

Maritime / Ports



### Investment Value

\$109 million



### Implementation Period

2022-2025



### Key Partners

African Development Bank (AfDB),  
Port Autonome de Cotonou (PAC)



### Beneficiaries

100 million people



# THE ADAPTATION STORY

## Context and adaptation challenge

Benin's Port of Cotonou (Port Autonome de Cotonou - PAC) is the country's primary maritime gateway and a cornerstone of national economic performance, with port-related revenues estimated at 45% of GDP. It also serves as a vital trade corridor for landlocked neighbors including Niger, Burkina Faso, and Mali, handling more than 12 million tonnes of cargo in 2021.

Located on the low-lying Gulf of Guinea coastline, PAC faces escalating climate risks that threaten infrastructure reliability and operational continuity. **Climate projections indicate worsening hazards, particularly extreme heat, drought, and rising sea levels. Increasing temperatures are expected to significantly raise the number of dangerously hot days, reducing labor productivity and increasing health and safety risks, especially for manual operations.** More frequent droughts may alter regional trade flows, reducing agricultural exports while increasing food imports, placing pressure on bulk handling and storage. Meanwhile, sea level rise heightens flooding risks for low-elevation assets, particularly in the fishery port.

Without targeted adaptation, these pressures could drive mounting disruptions and financial losses, undermining Benin's trade connectivity and regional economic resilience.



Port of Cotonou

# What was GCA's role?

GCA, through the African Acceleration Adaptation Program (AAP) co-developed with the African Development Bank (AfDB), provided targeted technical assistance to integrate climate resilience into the major modernization and expansion program under its 2021-2026 Port Master Plan. **GCA delivered a high-granularity climate risk assessment and vulnerability stress test to quantify heat stress, drought, and extreme sea-level impacts on port assets and operations, translating these risks into projected damages and revenue losses.** Building on this analysis, GCA developed an investment rationale identifying economically viable adaptation measures and demonstrating their long-term financial and socio-economic benefits. This evidence base directly supported AfDB's successful request for concessional adaptation finance, helping mobilize additional resources to climate-proof the port and safeguard trade connectivity, jobs, and livelihoods, including \$18 million in climate finance from the Canada-African Development Bank Climate Facility to fund additional resilience components, strengthening the port's long-term operational and economic resilience.

**Close coordination between GCA and AfDB sector teams ensured that several recommendations were directly integrated into the project design.**

# Results and impact

Results confirm a clear intensification of key risks, particularly extreme heat and humidity, drought, and extreme sea levels. Screening these hazards across major asset classes, including breakwaters, navigation channels, quays, terminals, logistics areas, and fisheries infrastructure, identified three priority vulnerability pathways: heat stress impacts on labor productivity and operational downtime; drought-driven cargo shifts affecting terminal demand and storage/logistics performance; and coastal flooding associated with extreme sea levels, especially in low-elevation areas such as the fishery port. In response, **the assessment recommends a package of physical, social, and institutional measures to strengthen operational continuity and protect livelihoods.**

Together, these measures materially reduce climate-driven disruption and revenue losses, strengthen business continuity, and safeguard port-dependent livelihoods. **By integrating adaptation into infrastructure design and operations, the project protects thousands of jobs, stabilizes fisheries and logistics services, and enhances Benin's trade connectivity, delivering lasting economic and social resilience under escalating climate risks.**



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| INDICATOR                          | RESULT / TARGET                                                                                                                                                                                                                                                                                                |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Direct and indirect losses         | Without adaptation: increasing losses from heat stress and flooding, contributing to total climate impacts of €15-20 million/year by 2050 and €40-68 million/year by 2090.                                                                                                                                     |
| Benefits of adaptation investments | Adaptation investments of approximately €30 million are projected to prevent up to €400 million in cumulative revenue losses over the first 30 years, with annual avoided losses rising to €26-40 million by 2100, materially reducing operational disruption and strengthening long-term economic resilience. |

## Climate hazards, impacts, and prioritised adaptation measures:

### KEY CLIMATE HAZARDS

### IMPACTS ON INFRASTRUCTURE, SERVICES AND USERS

### PRIORITIZED ADAPTATION MEASURES



#### Flooding

**Infrastructure:** Damage to low-elevation assets (especially the fishery port), terminals, access roads, and utilities; increased maintenance needs and asset degradation.

**Services:** Port downtime, disrupted cargo handling and vessel operations, delays in logistics chains, and reduced reliability of port services during extreme sea-level events.

**Communities:** Impacts on fisheries livelihoods, income losses for port-dependent workers, and heightened exposure of nearby coastal communities to flooding.

Climate-resilient design standards for new and upgraded infrastructure; raised platform/site elevations and crest heights; detailed topographic surveys to refine flood thresholds; flood-proofing of the fishery port; elevation and drainage improvements in low-lying areas.



#### Extreme heat & humidity

**Infrastructure:** Accelerated wear of paved surfaces and equipment; increased cooling and maintenance requirements.

**Services:** Reduced labour productivity, higher health and safety risks, increased operational downtime, and lower handling efficiency during extreme heat.

**Communities:** Worker health impacts, increased heat stress, and reduced income stability for port labourers and informal workers.

Worker training and heat-risk awareness; shift scheduling away from peak heat hours; shorter shifts where required; provision of shade, cooling, and drinking water facilities; increased automation to reduce manual exposure.



#### Drought

**Infrastructure:** Pressure on storage, dry bulk terminals, and logistics facilities due to changing cargo volumes and composition.

**Services:** Shifts in trade flows (declining agricultural exports, rising food imports), congestion risks, and reduced operational predictability.

**Communities:** Indirect impacts on farming and trading livelihoods upstream, with knock-on effects for port employment and local food security.

Flexible terminal and logistics planning; contingency arrangements for overflow bulk handling; temporary storage and capacity solutions during periods of elevated import demand.

# KEY LESSONS

## LESSON

1

**Pairing physical adaptation measures with social and institutional measures strengthens long-term port resilience beyond infrastructure design alone.**

## WHAT WE HAVE LEARNT

Infrastructure upgrades alone are not sufficient to safeguard port performance under accelerating climate change. At the Port of Cotonou, engineering measures such as elevating platforms, improving drainage, and flood-proofing low-lying areas were essential to reduce exposure to extreme sea levels, but these investments needed to be complemented by operational and institutional actions to fully address risk. The climate vulnerability stress test showed that extreme heat and humidity are major drivers of productivity losses and downtime, highlighting the importance of worker heat-safety protocols, shift scheduling, and improved occupational health measures alongside physical works. Strengthening risk governance and integrating climate considerations into operational planning further enhanced continuity of services under compounding hazards. Together, this combined approach reduced disruption risks, protected livelihoods and strengthened long-term economic resilience. The experience demonstrates that effective adaptation requires an integrated package of physical, social, and institutional measures rather than a narrow focus on infrastructure design alone.

## REPLICABILITY

Replication requires a formal integrated resilience framework linking engineering design, occupational health and safety, and port operations, supported by dedicated financing, clear institutional accountability, and procurement requirements that embed climate-resilient standards and operational preparedness into project design, implementation, and long-term asset management across the full infrastructure lifecycle.



## Framing climate adaptation as a source of competitive advantage can strengthen the investment case for resilient port infrastructure.

### WHAT WE HAVE LEARNT

Climate resilience and adaptation can be framed not only as risk management but also as a strategic source of competitive advantage. The Port of Cotonou competes with 13 other West African ports for transit traffic serving landlocked countries such as Niger, Burkina Faso, and Mali, a hinterland market of nearly 100 million consumers. In this context, climate-related disruptions such as delays, operational downtime, or coastal destabilisation generate not only direct financial losses but also risk diverting cargo to competing ports. While the Port of Cotonou's original Master Plan acknowledged climate risks, it lacked the detailed evidence required to guide investment decisions. A robust, data-driven climate risk assessment provided the analytical foundation to prioritise adaptation measures and gave lenders greater confidence to finance resilience investments. By identifying both infrastructure and operational vulnerabilities, the climate risk assessment helped target cost-effective measures that protect service reliability. Strengthening climate resilience therefore also helps safeguard the port's long-term competitiveness as a regional gateway.

### REPLICABILITY

Where infrastructure serves as a gateway to a contested hinterland, climate disruptions can shift traffic to rival facilities. In these circumstances, investing in resilience helps maintain reliability and protect market position. The same principle can apply beyond ports to other climate-exposed infrastructure operating in competitive environments, such as airports, logistics corridors, border crossings, or energy export terminals, where users have viable alternatives and resilience can therefore become a market differentiator rather than simply an additional cost.



Containers by the port in Cotonou, Benin. Photo credit: Melissa Cooperman/IFPRI

# Actionable insights for MDBs

| THEME                           | INSIGHTS                                                                                                                                                                                                                                                                                                                   |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Operational resilience</b>   | Structure financing to cover both CAPEX and climate-related OPEX (e.g., heat management, maintenance, operational contingency). Concessional windows and blended finance can be used to fund the incremental cost of adaptation where avoided revenue losses and protected jobs demonstrably outweigh upfront investment.  |
| <b>Investment justification</b> | Request quantified avoided-loss analyses to strengthen the economic case for adaptation components. Evidence from PAC shows that relatively modest resilience investments can prevent large future revenue losses and improve project bankability.                                                                         |
| <b>Implementation</b>           | Embed climate-resilient design standards, O&M requirements, and operational preparedness measures into financing agreements, procurement documents, and supervision frameworks. Tie disbursements to delivery of resilience actions and require monitoring of downtime, safety, and climate-related financial performance. |



Cotonou, Benin. Photo credit: Saliousoft



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