PROJECT EXEMPLAR

Strengthening Coastal Road Resilience in a SIDS: Climate-Informed Design and Maintenance in São Tomé and Príncipe

GLOBAL CENTER ON ADAPTATION

KEY PROJECT INFORMATION

Country / Region
São Tomé and Príncipe / Central Africa

Sector
Transport (road infrastructure)

Investment Value
US$ 42 million (investment value influenced by GCA)

Implementation Period
2023-2026

Key Partners
Global Center on Adaptation (GCA); World Bank Group

Beneficiaries
Approximately 220,000 inhabitants (60% of the national population)

THE ADAPTATION STORY

Context and adaptation challenge

São Tomé and Príncipe (STP) is a lower-middle-income small island state with limited infrastructure redundancy, constrained resources, and strong reliance on climate-sensitive sectors such as agriculture, tourism, and fishing. Climate change is increasing exposure to riverine and coastal flooding, extreme rainfall, landslides, coastal erosion, and rising temperatures, accelerating infrastructure deterioration and increasing the frequency of service interruptions. With an extremely limited road network, effectively a single primary route, any disruption can quickly isolate communities from essential services, placing increasing pressure on critical transport infrastructure nationwide.

Socio-economic vulnerability is closely linked to road reliability. As the backbone of national connectivity, **the coastal corridor serves about 60% of the population** and is vital for access to food, fuel, healthcare, and economic activity. Disruptions therefore trigger cascading social impacts, as seen when a recent bridge collapse cut off communities and prevented children from reaching school.

Adaptive capacity in the road sector remains constrained. **Institutional and financial limitations heighten exposure to climate shocks, while restricted access to materials, equipment, and skilled labor slows repairs and resilient recovery when infrastructure is damaged**. Large repair contracts often require external companies to bring machinery and materials from the mainland, delaying reconstruction and leaving STP unable to quickly rebuild critical roads and bridges once these actors depart.

What was GCA's role?

In 2024, as part of the African Acceleration Adaptation Program (AAAP), co-developed with the African Development Bank (AfDB), GCA supported São Tomé and Príncipe to climate-proof its key transport corridor through targeted technical assistance, stakeholder engagement, and investment planning. GCA worked closely with the World Bank Group (WBG) to **strengthen the case for climate-resilient design and infrastructure investment decisions**. Collectively, these activities have informed the WBG financing dialogues and positioned São Tomé and Príncipe to access additional climate adaptation resources.

GCA supported the WBG's access to finance efforts by conducting climate hazard and vulnerability assessments and developing the financing rationale for adaptation and resilience options for key road sections, including the Guadalupe-Neves-Santa Catarina corridor and the Lagarto Bay section within São Tomé City. In addition, GCA developed technical guidelines and design specifications for the corridor. This input was developed to directly inform the Project Appraisal Document, strengthening the integration of climate adaptation and resilience considerations into project design and investment decisions.

Coastal road, São Tomé and Príncipe (credit: GCA)

Results and impact

Through GCA's climate risk analysis, exposure and hotspots were mapped under current and future scenarios (RCP4.5 and RCP8.5) across the project area, which seeks to **improve accessibility for 105,000 people and strengthen socio-economic connectivity** between the port of Neves and the rest of the island along 27 km of coastal roads and Lagarto Bay. Because the port is the main fuel entry point for electricity generation, maintaining climate-resilient road access is essential for national energy security and service continuity. The assessment indicates intensifying hazards: by 2050, extreme temperatures may rise by 1.5-2°C, extreme rainfall increase by about 10%, and coastal flooding emerge as the dominant threat to road continuity, alongside river flooding, landslides, and rockfall.

Based on this evidence, GCA helped **prioritise engineered, nature-based, and operational adaptation measures** (summarised in the key hazards, impacts, and prioritised measures table). These were grouped into adaptation packages, including community-based maintenance and design improvements, road realignment, and asset protection, providing a phased pathway to strengthen corridor resilience while delivering social and environmental co-benefits. Economic performance was assessed using quantified impacts (summarised in the table below), demonstrating strong value for money across road sections, solution types, and climate scenarios.

Findings were presented and validated in three multi-stakeholder dialogues, where national agencies and technical partners confirmed key risk drivers and endorsed proposed solutions. In parallel, GCA delivered an online Masterclass on Climate-Resilient Infrastructure PPPs, training national stakeholders in resilient road design, project preparation, and financing to strengthen institutional capacity.

INDICATOR	RESULT / TARGET
Direct and indirect losses	Baseline direct climate-related damage is €1.4 million/year and baseline indirect damages are €0.2 million/year. Without adaptation, direct damages are projected to increase by 33% by 2050 under RCP8.5, while indirect damages are projected to rise by >165% by 2050 under RCP8.5 due to longer and more frequent road closures.
Benefit-cost ratios (BCR) of adaptation investments	BCR 2 to 5+ depending on the road section, type of solution, and climate scenario.

Climate hazards, impacts, and prioritised adaptation measures:

KEY CLIMATE HAZARDS	IMPACTS ON INFRASTRUCTURE, SERVICES AND USERS	PRIORITISED ADAPTATION MEASURES
Coastal flooding & overtopping	**Infrastructure:** Overtopping and wave action damage low-lying coastal road sections, causing erosion and loss of pavement and embankments; largest driver of physical asset risk. **Services:** Extended road downtime during coastal events disrupts national connectivity. **Communities:** Loss of access along the main transport artery affects livelihoods, schooling, healthcare, and food security for communities dependent on coastal roads.	Heightening seawall/retaining wall; shore-perpendicular permeable groynes; vertical road realignment; road realignment; paved surfacing in high-risk sections
Pluvial flooding	**Infrastructure:** Culvert blockage, surface flooding, and pavement damage from intense rainfall. **Services:** Temporary closures and traffic disruption during storm events. **Communities:** Short-term isolation and restricted access to essential services, particularly in low-lying and poorly drained areas.	Installation of drainage; perforated drains; routine clearing of crossroad culverts; community maintenance of drains and road shoulders
Fluvial flooding	**Infrastructure:** Erosion at river crossings and damage to bridges and embankments, increasing risk of asset failure and prolonged downtime. **Services:** Disruption of goods movement and emergency access during high river discharge. **Communities:** Isolation of settlements near river crossings during flood periods	Rigid walls; installation of drainage; routine clearing of culverts; design cover for steel reinforcements
Extreme heat	**Infrastructure:** Accelerated deterioration of pavements and bridges as high temperatures weaken materials and expand structures. **Services:** Increased maintenance needs and higher likelihood of service interruptions over time. **Communities:** Gradual decline in road reliability affecting access to markets and services.	Design cover for steel reinforcements; corrosion painting; paved surfacing in high-risk sections
Landslides	**Infrastructure:** Slope failures and debris cause localized damage and frequent blockages. **Services:** Recurrent disruptions requiring clearance and emergency response. **Communities:** Repeated access interruptions, particularly affecting remote and marginalized settlements.	Bio-engineered slopes with gabions, geocells and vegetation reinforcement; vegetation management; rigid walls

KEY LESSONS

LESSON 1

Community-based maintenance as a core adaptation strategy in small island and resource-constrained contexts

Children playing by a river crossing, São Tomé and Príncipe (credit: GCA)

WHAT WE HAVE LEARNT

Community-based maintenance through GIMEs - Grupos de Interesse para Manutenção de Estradas (community road maintenance groups) emerged as a core resilience strategy in the small island context of São Tomé and Príncipe, strengthening road serviceability where institutional capacity and access to heavy equipment are limited. Crucially, this demonstrates that effective climate adaptation is not limited to hard infrastructure investments, but also depends on governance, skills, and locally led systems that include an efficient financing mechanism. GIMEs provide a practical, low-cost adaptation pathway by delivering routine maintenance and rapid response using locally available tools and knowledge (including debris and vegetation cleaning, gabion basket walls installation or road repairs with stone pavement) , helping ensure service continuity during and after extreme events. With approximately half of members being women, GIMEs also support inclusive employment while building long-term local capacity. Economic analysis confirmed this approach delivers the highest benefit–cost ratio, significantly reducing flood-related disruption and damage.

REPLICABILITY

This approach is particularly well suited to small island and other equipment- and resource-constrained contexts, where maintenance budgets are limited but community engagement is strong. It is most effective when local groups can be mobilized, roles and responsibilities are clearly defined, and predictable funding supports routine upkeep. Successful replication requires adapting the model to local labor realities and incentives, investing in skills development, and fostering strong partnerships between communities and road authorities. When these conditions are met, community-based maintenance can provide a reliable, low-cost means of protecting infrastructure, building local ownership, and sustaining long-term resilience.

LESSON 2

Including nature-based solutions expands adaptation options and enables climate finance

WHAT WE HAVE LEARNT

Integrating nature-based solutions alongside engineered measures expanded the range of adaptation options, particularly in São Tomé and Príncipe's constrained and vulnerable coastal environment. Rather than being an environmental add-ons, NbS provided practical, context-specific resilience solutions and strengthened the investment case for mobilizing climate finance. The assessment identified coastal flooding and overtopping as the dominant risk drivers, accounting for more than 60% of expected annual damages. Adaptation packages combining coastal protection with bioengineered slopes and improved drainage achieved substantial reductions in climate risk. At high-risk locations, these measures are assumed to reduce landslide and rockfall risks by up to 75% and delay flood-related damage until rainfall thresholds are approximately 15% higher. These packages show benefit-cost ratios (BCR) ranging from around 1.1 in lower-traffic sections to above 2.7 in more critical segments. While these packages were less cost-effective than community-based maintenance alone, they delivered the greatest overall resilience benefits, including reduced frequency and duration of road closures, improved access to essential services, lower long-term maintenance needs through improved slope stability and drainage performance, and environmental co-benefits such as enhanced vegetation cover and reduced erosion. These outcomes strengthen project bankability by reducing physical and operational risks, lowering lifecycle costs, and delivering social and environmental co-benefits, creating a clear business case for climate finance.

REPLICABILITY

This approach is particularly well suited to small island and coastal contexts, where transport corridors are largely confined to low-lying coastal areas and serve as critical links for communities exposed to concentrated climate hazards. Successful replication relies on identifying NbS opportunities early and integrating them into project design and financing from the outset. It also depends on robust baseline ecosystem assessments, alignment with national climate priorities, and strong stakeholder engagement to ensure both feasibility and local acceptance.

Coastal road, São Tomé and Príncipe (credit: GCA)

Actionable insights for MDBs

THEME	PRIORITISED ADAPTATION MEASURES
Maintainability and service continuity	MDBs should prioritize maintainability alongside asset strengthening by embedding sustainable financing mechanisms for local community-based maintenance groups into project design. In small island contexts with limited reconstruction capacity, resilience depends as much on routine upkeep and rapid response as on engineering solutions.
Local capacity and institutional coordination	Investments should support local maintenance systems, capacity building, and institutional coordination as integral elements of resilience, ensuring service continuity, maximizing social co-benefits, and delivering greater value for money
Integration of nature-based solutions	MDBs can expand adaptation impact by integrating NbS directly into core infrastructure investments, rather than treating them as standalone or ancillary components.
Hybrid adaptation approaches	Early identification and screening of NbS opportunities allows these measures to be embedded in project design and financing from the outset. Combining NbS with engineered solutions through scalable adaptation packages helps balance cost, risk, and implementation capacity, while strengthening the investment case for climate finance.
Phased investment and learning	Coordinated, phased approaches also enable learning over time and support the delivery of both resilience outcomes and environmental co-benefits.