

PROJECT EXEMPLAR

Embedding Climate Resilience in Mozambique's Electricity Transmission and Distribution System



GLOBAL
CENTER ON
ADAPTATION

KEY PROJECT INFORMATION



Country / Region

Mozambique, East Africa



Sector

Energy



Investment Value

\$96 million



Implementation Period

2023-2024



Key Partners

African Development Bank (AfDB),
Electricidade de Mocambique (EDM)



Beneficiaries

6 million people



THE ADAPTATION STORY

Context and adaptation challenge

Mozambique's electricity sector is undergoing rapid transformation as the country seeks to expand access, strengthen its position as a regional energy hub, and support inclusive economic growth. Across many emerging economies, electricity systems are being reshaped by rising demand, infrastructure expansion, and increasing exposure to climate risks, trends that are particularly pronounced in Mozambique. **Only 31.5% of the population currently has access to electricity, with demand rising rapidly as the government pursues universal access by 2030.**

Mozambique's central provinces face growing climate-related shocks that threaten the reliability of electricity supply. The transmission network spans long distances and operates with limited redundancy and uneven infrastructure coverage, making it especially vulnerable to disruptions. **Transmission assets are increasingly exposed to extreme heat, flooding, landslides, cyclones, and wildfires, which collectively drive most projected direct impacts.** Extreme heat reduces conductor capacity and accelerates equipment degradation, while flooding and landslides can undermine tower foundations and restrict access for maintenance. Wildfires heighten the risk of physical damage and outages. Beyond direct asset losses, climate-related power disruptions generate cascading socio-economic impacts, affecting health services, education, food security, and vulnerable communities, with differentiated effects across gender and income groups.

Without a systematic approach to climate risk screening and adaptation planning, these hazards threaten energy security and risk undermining Mozambique's electrification ambitions, highlighting the urgent need to embed climate resilience and social vulnerability considerations into utility planning at a system-wide level.



What was GCA's role?

GCA, through the African Acceleration Adaptation Program (AAP) co-developed with the African Development Bank (AfDB), provided technical assistance to strengthen climate resilience in Mozambique's electricity transmission system, working in partnership with the Electricidade de Moçambique (EDM). **GCA delivered climate risk analysis at both project and national levels to identify socio-economic vulnerabilities of power disruptions, estimate potential losses, and prioritize cost-effective adaptation measures that protect service reliability and long-term investment value.** This included climate risk screening of transmission and distribution networks nationwide, detailed asset-level assessments, and the development of a flexible appraisal tool and national technical guidelines to integrate resilience into design, operations, and maintenance. Beyond technical analysis, GCA focused on institutionalizing these approaches by building capacity within EDM and AfDB, supporting the mainstreaming of climate resilience across Mozambique's energy sector, and reinforcing knowledge through targeted training, including a masterclass on climate-resilient PPPs.



Location or caption (credit: xxx)

Results and impact

Climate risk analysis for the Songo-Matambo transmission line assets compares historical conditions with future projections under RCP4.5 and RCP8.5 scenarios, revealing a clear intensification of hazards affecting electricity transmission infrastructure, particularly under the high-emissions pathway. Extreme heat, flooding from intense rainfall, landslides, and wildfires emerge as the dominant risks, together accounting for 94% of projected direct climate impacts.

Beyond physical damage to assets, the assessment explicitly considers the wider socio-economic consequences of climate-induced power disruptions.

These include impacts on health services, education, household welfare, food security, and local economic activity, with particular attention to gender and social vulnerability. Power outages can trigger cascading effects, disproportionately affecting elderly people, children, pregnant women, healthcare workers, and agriculture-dependent households. To address these risks, **adaptation options were evaluated across both design and operational dimensions, using criteria that consider risk reduction potential, cost-effectiveness, feasibility over the asset lifecycle, and implications for long-term monitoring and maintenance.**

GCA translated these findings into action by embedding climate resilience within EDM's planning processes through national technical guidelines, a flexible appraisal tool, and targeted capacity building.

INDICATOR	RESULT / TARGET
Direct and indirect losses	Without adaptation, cumulative losses could reach up to €10 million (up to 11% of asset value), while indirect losses from revenue disruption could reach €12 million (up to 12.5% of expected revenue over 30 years).
Benefit-cost ratios (BCR) of adaptation investments	Priority measures demonstrate strong economic returns, including HTLS conductors (BCR up to 4.1), Emergency Restoration Systems (BCR 4.9-12.4), and slope stabilization (BCR 5.5-13.7), confirming the cost-effectiveness of resilience investments.

Climate hazards, impacts, and prioritised adaptation measures:

KEY CLIMATE HAZARDS	IMPACTS ON INFRASTRUCTURE, SERVICES AND USERS	PRIORITIZED ADAPTATION MEASURES
 Extreme heat	Infrastructure: Reduced conductor capacity, accelerated degradation of transmission equipment, shortened asset lifespan. Services: Lower network performance and increased outage risk, particularly during peak demand periods. Communities: Disruptions to healthcare, food storage, education, and livelihoods, especially for vulnerable groups.	Adaptation measures include upgrading conductor specifications to withstand higher operating temperatures, including adoption of high-temperature low-sag (HTLS) conductors, which improve performance and reduce sag-related risks under hotter conditions. Real-time monitoring (e.g., conductor temperature sensors) is also recommended to support operational decision-making
 Flooding	Infrastructure: Destabilized tower foundations, damaged substations, and restricted maintenance access. Services: Prolonged power interruptions and delayed restoration. Communities: Disruption to essential services, heightened vulnerability in flood-prone districts.	Adaptation measures include avoiding flood-prone areas for tower locations where feasible. Where it is not possible, options include raising tower foundations above flood levels or applying piled foundations, combined with improved drainage and protection of access roads to maintain maintenance connectivity during extreme events.
 Landslides	Infrastructure: Structural damage to towers and transmission lines. Services: Extended outages due to difficult access for repairs. Communities: Isolation of rural areas and disruption to everyday activities.	Adaptation measures include routing and siting towers to reduce exposure, supported by geotechnical assessment, alongside slope stabilisation and nature-based solutions (NbS) such as vegetating slopes to reduce runoff and erosion. In addition, Emergency Restoration Systems (ERS) is recommended to accelerate repairs after extreme events and reduce outage duration.
 Wildfires	Infrastructure: Physical damage to lines and substations. Services: Sudden outages and operational safety risks. Communities: Threats to nearby settlements and agricultural land.	Adaptation measures include strengthened vegetation management along the right-of-way and around substations, complemented by trained response capacity and equipment to protect critical assets and restore service rapidly.

KEY LESSONS

LESSON

1

Integrating a social vulnerability analysis into utility planning results in more equitable adaptation outcomes



WHAT WE HAVE LEARNT

Integrating social vulnerability into climate risk assessments provided additional insights for defining adaptation priorities. Beyond physical risks to transmission assets, GCA assessed how power disruptions affect health services, education, food security, household welfare, and livelihoods, highlighting districts where even short outages generate disproportionate impacts on women, elderly people, children, and agriculture-dependent households. While data limitations required informed assumptions, the process demonstrated the value of starting with available datasets and refining approaches over time. By embedding these insights into national technical guidelines and a flexible appraisal tool, GCA helped institutionalize consideration of indirect socio-economic impacts within EDM's planning processes, strengthening its ability to target resilience investments where both infrastructure and communities are most vulnerable.

REPLICABILITY

This approach is highly transferable to other utilities and MDB-supported investments. Combining climate hazards with socio-economic indicators enables identification of high-consequence outage zones. The methodology, guidelines, and appraisal tools developed for EDM provide a practical template for embedding equity considerations into infrastructure planning across sectors, helping ensure adaptation investments deliver tangible benefits to vulnerable communities.

LESSON

2

Linking project-level hotspot analysis with national climate risk screening enables a scalable assessment framework and better prioritization of resilience investments

WHAT WE HAVE LEARNT

Pairing detailed project-level diagnostics with national climate risk screening proved essential for moving from isolated interventions to system-wide resilience planning. Asset-level analysis identified specific vulnerabilities and cost-effective adaptation options, while national screening mapped transmission and distribution hotspots across Mozambique, revealing where climate risks and socio-economic impacts converge. These approaches demonstrate how combining local diagnostics with broader screening can form a scalable assessment framework for resilience planning. A key outcome was the development of national technical guidelines and practical tools that allow EDM to repeat the process independently for future projects. As highlighted in stakeholder dialogues and the Climate-Resilient PPP Masterclass, hands-on engagement was critical for supporting the translation of analysis into emerging institutional practices, shifting the focus from a one-off study toward building lasting internal capacity for climate-informed decision-making.

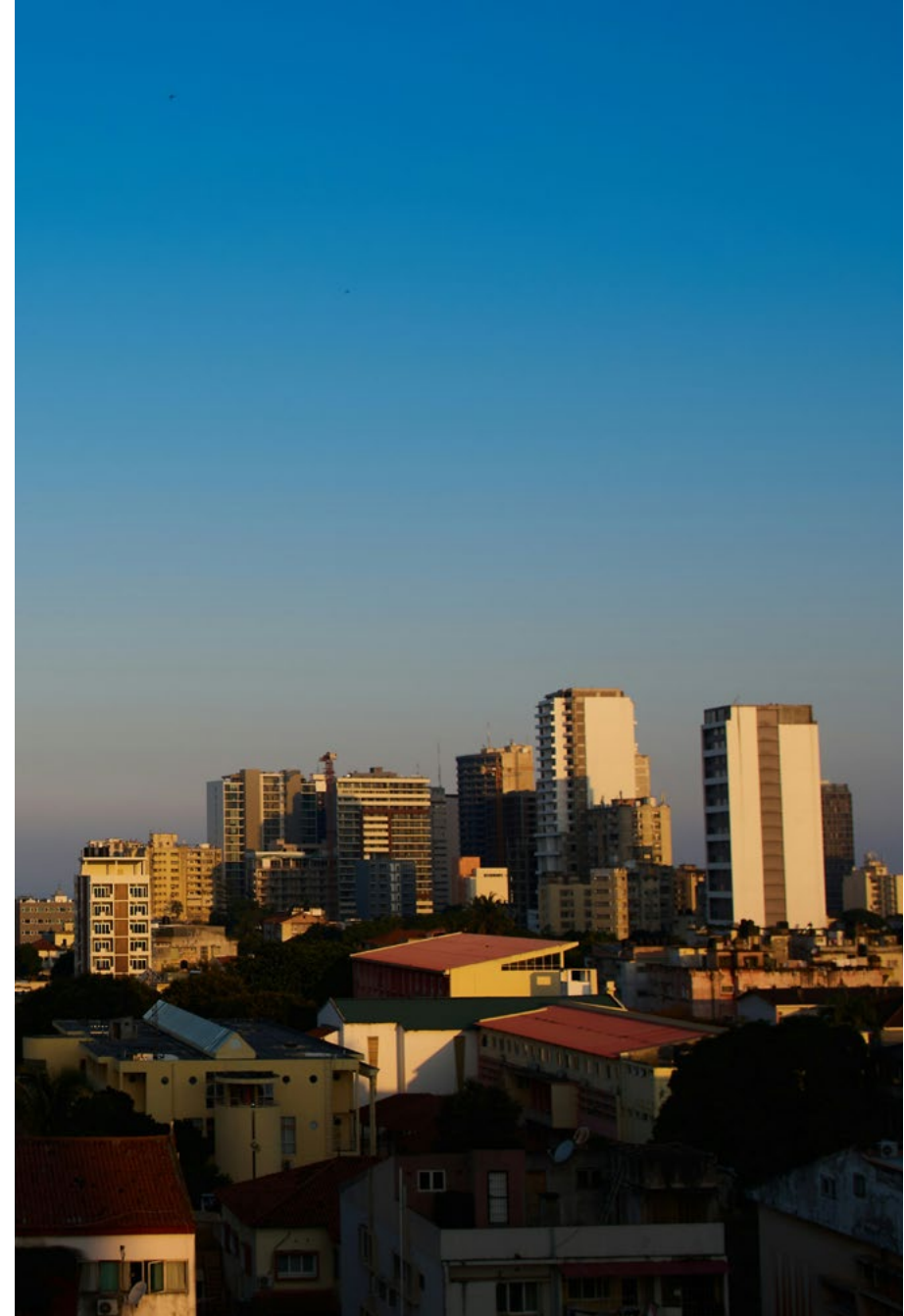
REPLICABILITY

The multi-scale methodology offers a replicable model for MDB-supported infrastructure portfolios. MDBs and utilities can combine project hotspot analysis with national screening to guide investment sequencing and avoid fragmented adaptation. GCA's guidelines, appraisal tools, and capacity-building approach provide a scalable framework that supports consistent, evidence-based prioritization of resilience investments across energy and other networked sectors.



Actionable insights for MDBs

THEME	INSIGHTS
Embed social vulnerability in investment appraisal	Require climate risk assessments to go beyond asset impacts by incorporating socio-economic vulnerability (health, education, livelihoods, gender). MDBs can standardize this by integrating simple vulnerability indicators into project appraisal and prioritization frameworks, ensuring adaptation finance targets areas where outages create the highest human and economic costs.
Link project diagnostics with system-wide screening	Pair project-level climate risk analysis with national or portfolio-level hotspot mapping to avoid fragmented adaptation. MDBs can support utilities to develop system-wide risk baselines and use these to sequence investments strategically, maximizing resilience benefits across entire systems rather than isolated assets.
Prioritize institutional capacity over one-off studies	Move from standalone climate assessments to building lasting client capability through technical guidelines, appraisal tools, and hands-on engagement. MDBs should finance capacity building alongside infrastructure, supporting utilities to independently apply climate screening to future projects and embed resilience into routine planning and O&M processes.



GLOBAL
CENTER ON
ADAPTATION

Developed in collaboration with



Visit gca.org for more information