

PROJECT EXEMPLAR

Embedding Climate Resilience into Decentralized Solar Energy Investments in Ghana



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KEY PROJECT INFORMATION



Country / Region

Ghana, West Africa



Sector

Energy



Investment Value

USD 85.18 million



Implementation Period

2022-2027



Key Partners

African Development Bank (AfDB),
Government of Ghana



Beneficiaries

84,000 people from 59 communities across
63 villages



THE ADAPTATION STORY

Context and adaptation challenge

Ghana has made significant progress in expanding electricity access over the past decade, yet rural and remote communities, particularly in northern and lake-adjacent regions, continue to face persistent energy gaps due to difficult terrain, dispersed settlements, and high grid extension costs. **Nationally, electricity generation remains dominated by natural gas and hydropower, leaving the power system exposed to climate variability, especially droughts that constrain hydropower output and exacerbate supply shortages.**

At the same time, Ghana is experiencing accelerating climate impacts. Average temperatures have already risen by about 1°C since the 1960s and are projected to increase further, alongside more frequent heat extremes, prolonged dry spells, intense rainfall, flooding, and wildfire risk. These hazards threaten the operational reliability and design life of electricity infrastructure, increase maintenance costs, and disrupt service delivery. **Embedding climate adaptation into energy planning, infrastructure design, and operations is therefore essential to safeguard assets, sustain reliable electricity access, and build long-term resilience in Ghana's most climate-vulnerable regions.**



What was GCA’s role?

Under Ghana’s Scaling Up Renewable Energy Program (SREP), implemented with support from the African Development Bank (AfDB), **solar mini-grids (SMG), standalone solar home systems (SHS), and net-metered rooftop photovoltaic (PV) are being deployed to expand clean electricity access in remote communities where grid extension is not viable.** GCA supports this initiative through the Africa Adaptation Acceleration Program (AAP), providing targeted technical assistance to embed climate adaptation across the project lifecycle.

In a context where many project locations are exposed to increasing climate hazards, **GCA’s role has been to ensure that resilience considerations inform how renewable energy investments are planned and delivered.** Working alongside national partners and the AfDB, GCA helped translate climate risk evidence into practical guidance that could shape infrastructure decisions, linking hazard modelling, geospatial analysis, and field insights to the realities faced by communities across the target regions.

GCA’s technical assistance focused on embedding climate risk information directly into project preparation and implementation. Community-level risk profiles and climate-resilient technical guidelines for both SMG and SHS supported asset siting, technical design choices, and operations and maintenance planning, helping reduce exposure to climate impacts and strengthen the reliability of energy services over time. Alongside this technical work, GCA delivered masterclasses on resilient infrastructure to strengthen institutional capacity and equip practitioners with practical tools to integrate adaptation into energy infrastructure planning and implementation.

Results and impact

GCA’s climate risk screening confirmed that many of the communities targeted under Ghana’s SREP investment are located within fragile ecosystems and climate hazard hotspots, with floods and landslides projected to occur at relatively high frequency across the project regions. These hazards pose material risks to solar infrastructure by shortening asset lifespans, increasing system breakdowns and maintenance needs, and reducing annual energy generation.

GCA’s technical assistance translated climate risks into actionable guidance for infrastructure delivery, embedding adaptation across solar asset siting, system design, and operations and maintenance. This will strengthen the resilience of planned investments by systematically addressing exposure and vulnerability to extreme heat, flooding, drought, wildfire, wind, and dust, key stressors affecting asset performance and service continuity.

By integrating climate considerations early in project preparation, GCA helped reduce vulnerability to physical climate risks while supporting more reliable energy service delivery over the lifetime of the assets. **Adaptation measures were developed based on community-level climate risk profiles, linking specific hazards to targeted resilience actions for each project location.**

Building on this risk-informed approach, the project supports the deployment of decentralized solar infrastructure, including 35 solar mini-grids (SMG) serving 60 communities, 12,000 roof-mounted solar photovoltaic (PV) systems, and up to 11,000 standalone solar home systems (SHS) reaching 500 communities, helping strengthen the reliability and durability of expanded electricity access in Ghana’s climate-vulnerable regions.

INDICATOR	RESULT / TARGET
Direct and indirect losses	Climate hazards are projected to cause direct physical damage to solar assets and supporting structures, alongside indirect losses from service downtime, increased maintenance and repair needs, reduced annual energy generation, and site inaccessibility. These impacts collectively shorten asset design life and reduce system reliability across beneficiary communities.
Benefit-cost ratios (BCR) of adaptation investments	Prioritized adaptation measures developed for solar mini-grids (SMG) and solar home systems (SHS) show BCRs ranging from 5 to 10 across all districts.

Climate hazards, impacts, and prioritised adaptation measures:

KEY CLIMATE HAZARDS	IMPACTS ON INFRASTRUCTURE (SMG AND SHS) AND COMMUNITIES	PRIORITIZED ADAPTATION MEASURES FOR SMG AND SHS
 Extreme heat	SMG: Reduced asset productivity due to overheating; accelerated degradation of system components. SHS: Battery and system under-performance when exposed to extreme temperatures. Communities: Heat stress reduces community capacity for system operation and maintenance.	SMG: Design measures to reduce asset exposure to high temperatures; siting of components away from extreme heat. SHS: Housing batteries and switches in cool, dry locations free from extreme temperatures.
 Flooding and excessive rainfall	SMG: Asset and supporting structures damage; site inaccessibility; downtime due to excessive rainfall. SHS: Damage to panels and indoor components from dampness and flood exposure. Communities: Disrupted access roads, drainage failure, and increased health risks after flooding.	SMG: Proper site selection; elevated installation of critical components; drainage improvements; adaptation measures to reduce flood impacts. SHS: Avoid flood-prone siting; ensure indoor components remain dry; household-level protection from flooding.
 Drought	SMG: Reduced water availability for panel cleaning and cooling; dust accumulation affecting performance. SHS: Reduced system efficiency due to dust deposition. Communities: Water stress affecting livelihoods and maintenance capacity.	SMG: Operations and maintenance practices addressing dust deposition and reduced water availability. SHS: Regular cleaning of PV panels; user guidance on system upkeep during dry periods.
 Wildfire	SMG: Asset and supporting structures damaged by wildfire. SHS: Risk of panel and wiring damage where systems are installed near vegetation. Communities: Safety risks and disruption to livelihoods.	SMG: Vegetation management around sites; siting away from high fire-risk areas. SHS: Maintain clear areas around installations; community awareness on fire risks.
 Extreme winds	SMG: Damage to mounting structures and system components; service interruptions. SHS: Roof-mounted panels at risk of displacement. Communities: Broader housing damage affecting access to electricity.	SMG: Robust mounting structures and appropriate site selection. SHS: Secure rooftop installations and periodic inspection of fixings.

KEY LESSONS

LESSON

1

Translating climate risk analysis into actionable engineering and implementation guidance allows adaptation to be embedded directly into project delivery.



Photo credit: Thai Thi Minh/IWMI

WHAT WE HAVE LEARNT

Rather than treating climate risk assessment as a standalone diagnostic, the project translates hazard analysis into practical guidance for solar asset siting, technical design, and operations and maintenance. Community-level risk profiles link specific climate hazards to tailored adaptation measures, ensuring that climate information directly informs engineering and implementation decisions. This bridges a common gap in infrastructure projects, where climate screening often stops at high-level risk identification without influencing how assets are designed or operated. By producing technology-specific guidelines for both solar mini-grids and solar home systems, the project demonstrates how climate science can be operationalized across multiple asset types. This integrated approach strengthens project readiness, supports climate-informed procurement and installation, and helps ensure that resilience considerations are addressed early, when design choices and implementation plans can still be adjusted at relatively low cost.

REPLICABILITY

MDBs can replicate this model by requiring climate risk assessments to produce engineering-ready guidance, rather than reports alone, and by embedding hazard-linked adaptation measures into technical specifications, procurement documents, and implementation plans across distributed energy portfolios.

LESSON

2

Operations and maintenance should be treated as a core climate adaptation strategy to help sustain asset performance under changing climate conditions.

WHAT WE HAVE LEARNT

The project recognizes that long-term performance of decentralized solar systems depends as much on operations and maintenance as on upfront design. Climate hazards are explicitly linked to O&M practices, including panel cleaning to address dust, protection of batteries and electrical components from heat and moisture, and maintaining site accessibility during extreme weather. Risk profiling also considers access roads, drainage, and local maintenance capacity, acknowledging that service continuity relies on whether technicians can reach sites and communities can support basic upkeep. This lifecycle perspective moves beyond conventional infrastructure resilience approaches that focus primarily on construction standards. By integrating climate considerations into day-to-day asset management, the project addresses common causes of system underperformance and premature failure. The result is a more practical approach to resilience, one that aligns climate adaptation with routine operational decision-making rather than treating it as a separate or one-off intervention.

REPLICABILITY

MDB-financed projects can adopt this lesson by incorporating climate-informed O&M requirements into project design, contracts, and capacity-building activities, ensuring maintenance planning explicitly reflects local climate risks and access constraints.



Actionable insights for MDBs

THEME	INSIGHT
From climate diagnostics to delivery	Require climate risk analysis to be integrated with engineering workflows by translating hazard findings into siting, design, and O&M guidance, so climate information can inform technical specifications, procurement, and implementation during appraisal.
Operations and maintenance as adaptation	Incentivize climate-informed O&M planning by ensuring financing frameworks account for routine maintenance needs linked to climate hazards, helping reduce service downtime and long-term OPEX.
Localized risk for distributed assets	Support localized climate risk profiling to inform investment decisions, enabling adaptation measures that reflect site-specific exposure and access constraints, with implications for both CAPEX and OPEX.



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