# GCGLA

# **OFF-GRID SOLAR: POWERING** CLIMATE RESILIENCE











Transforming Energy



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### **ABOUT GOGLA**

GOGLA is the global association for the off-grid solar energy industry, representing over 200 members working to transform lives through clean, affordable, and high-quality solar products and services.

More than 560 million climate-vulnerable people already benefit from off-grid solar to power their homes, farms, enterprises and public infrastructure. With the right support, our industry is poised to scale rapidly, aiming to improve the lives of 1 billion people by 2030.

GOGLA drives this progress by serving as a central hub for the sector, offering vital market data, advocating for supportive policies and increased investment, and providing value-added services to our members.

Learn more at gogla.org.

### **ABOUT PRACTICAL ACTION**

Practical Action is a global development charity with a vision of a world that works better for everyone.

Working together with communities and our global partners, we're developing innovative real-world solutions to build sustainable lives and livelihoods for people living on the frontlines of poverty and climate change. We're turning surviving into thriving and overcoming injustice, especially for women and vulnerable groups.

We work alongside communities to develop holistic, locally owned solutions for agriculture, water and waste management, climate resilience and clean energy. We share what works with others, accelerating solutions that bring about big change.

### **ABOUT EFFICIENCY FOR ACCESS**

Efficiency for Access is a global coalition dedicated to advancing high-efficiency appliances to enhance clean energy access for the world's most impoverished communities. Current Coalition members have programmes and initiatives spanning 62 countries and 34 key technologies. The Coalition is co-chaired by UK aid and the IKEA Foundation and is co-funded by UK aid from the UK government, via the Transforming Energy Access platform, and IKEA Foundation; however, the views expressed do not necessarily reflect the UK government's official policies.

### **ABOUT IKEA FOUNDATION**

The IKEA Foundation is a strategic philanthropy that focuses its grant making efforts on tackling the two biggest threats to children's futures: poverty and climate change. It currently grants more than €200 million per year to help improve family incomes and quality of life while protecting the planet from climate change. Since 2009, the IKEA Foundation has granted more than €1.8 billion to create a better future for children and their families. In 2021 the Board of the IKEA Foundation decided to make an additional €1 billion available over the next five years to accelerate the reduction of greenhouse gas emissions.

Disclaimer: This material has been funded by UK aid from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.



# **KEY DEFINITIONS**

Adaptation	In human systems, the process of adjustment to actual or expected climate and its
	effects, in order to moderate harm or exploit beneficial opportunities.
Appliances	OGS Appliances are solar-powered devices that are energy-efficient and powered
	by direct current (DC). In this report, OGS appliances are categorized in the
	following way:
	Household and small business OGS appliances, which provide essential
	services to homes and small business. In this report, they include fans, radios,
	and TVs.
	Productive use OGS appliances, which are utilized for income-generating
	activities. In this report, they include solar water pumps, refrigerators, milling
	machines, and similar products.
Exposure	The presence of people; livelihoods; species or ecosystems; environmental
	functions, services, and resources; infrastructure; or economic, social, or cultural
	assets in places and settings that could be adversely affected [by climate hazards].
Hazard	The potential occurrence of a natural or human-induced physical event or trend
	that may cause loss of life, injury, or other health impacts, as well as damage and
	loss to property, infrastructure, livelihoods, service provision, ecosystems and
	environmental resources.
	Weather-and-climate-related hazards can be classified as either:
	Slow-onset events: those that usually develop gradually over time with their
	impacts often based on a confluence of several different events (e.g. drought,
	desertification, sea-level rise); or
	Extreme/rapid-onset events: those that develop quickly and are rare at a
	particular place and time of year (e.g. floods, earthquakes, landslides).
Maladaptation	Actions that may lead to increased risk of adverse climate-related outcomes,
	including via increased greenhouse gas (GHG) emissions, increased vulnerability
	to climate change, or diminished welfare, now or in the future. Maladaptation is
	usually an unintended consequence.
Off-grid solar	Off-grid solar (OGS) products are self-contained energy systems that generate
products	and store electricity for individual use, typically in homes or businesses, without
	relying on the central power grid or connection to mini-grids. For the purposes
	of this report, OGS products are categorized as either solar energy kits or OGS
	appliances, which, in turn, are divided into either household and small business
	OGS appliances or productive uses OGS appliances.

Off-grid solar	OGS companies include those involve
companies	and maintenance of OGS products. T
	of OGS products in hard-to-reach sett
	access gap, including small companie
Productive use	The World Bank defines productive u
of energy	to improve income and welfare. Note
	not the technology
Resilience	The capacity of interconnected social
	with a hazardous event, trend or dist
	ways that maintain their essential fur
	a positive attribute when it maintains
	transformation
Risk	The potential for adverse consequent
	recognizing the diversity of values an
	In the context of climate change, risk
	change as well as human responses t
Solar energy kits	Solar energy kits (SEKs) are bundled,
(SEKs)	basic electricity access to households
	electricity. The SEK category includes
	(SHS). For this report's purpose, solar
	provide below Tier 1 electricity. A ma

ed in the manufacture, distribution, operation his report focuses on the role of distributors tings who are vital for closing the energy es known as 'last-mile' distributors.

se of electricity as activities that use energy The definition is linked to the impact and

l, economic and ecological systems to cope urbance, responding or reorganizing in nction, identity and structure. Resilience is s capacity for adaptation, learning and/or

ces for human or ecological systems, ad objectives associated with such systems. s can arise from potential impacts of climate to climate change.

pre-packaged systems designed to provide s and small businesses in areas without grid s solar lanterns and solar home systems r lanterns are systems below 3Wp and that jority (83%) of smaller and larger solar home ier 1 electricity or above.

Solar home	Solar home systems (SHS) are standalone photovoltaic systems designed to
systems (SHS)	provide electricity to households, small businesses, and community facilities
	that are not connected to the central grid. Typically consisting of solar panels,
	a battery for energy storage, and an inverter, SHS can power basic appliances
	such as lights, mobile phones, radios, fans, and sometimes larger appliances like
	televisions or refrigerators, depending on system size.
	The power capacity rating of a SHS typically ranges from 3 Watt-peak (Wp) to 100
	Wp, although larger systems exist. For the purposes of this report, SHS are divided
	in the following categories:
	• Smaller SHS (capacity rating: 3 to 49.9 Wp) are solar-powered setups typically
	designed to provide electricity for multiple lights and small appliances such as fans
	<ul> <li>Larger SHS (capacity rating: 50 Wp and above) are more comprehensive solar-</li> </ul>
	powered set ups to power multiple rooms of lighting and multiple or larger
	devices such as TVs or refrigerators in homes and small businesses
Solar lanterns	Solar lanterns are compact, portable lighting devices powered by solar panels,
	primarily designed for single-point lighting and often capable of charging phones
	in off-grid areas. In this report, they are defined as having a power capacity below
	3 watts peak (Wp) and providing electricity access below Tier 1.
standalone solar	A standalone solar system is a system that uses solar photovoltaic power
system	(PV) modules to generate electricity independently of the grid. Standalone
	solar systems include SHS as well as larger installations used to power critical
	infrastructure, such as health facilities, and humanitarian operations.
/ulnerability	The propensity or predisposition to be adversely affected. Vulnerability
	encompasses a variety of concepts and elements including sensitivity or
	susceptibility to harm and lack of capacity to cope and adapt.



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# **INTRODUCTION TO THE REPORT**

685 million people still lack access to electricity, with the majority living in countries with high vulnerability to climate change and low readiness to undertake adaptation measures.<sup>1,2</sup> A significant proportion of those living without power (312 million people) also live below the extreme poverty line, with low income likely to hinder their resilience and ability to adapt to climate impacts.<sup>3</sup>

There is growing evidence that access to off-grid solar (OGS) 3. Few examples of documented best practice for products can enhance climate resilience and adaptation (R&A) for people vulnerable to climate hazards: both slow onset changes, such as drought and desertification, and rapid-onset/extreme events such as cyclones and flash floods.<sup>4</sup>

However, three key challenges hinder the integration of OGS into the broader adaptation agenda:

1. Low recognition that OGS products can contribute to resilience and adaptation by investors, donors and government representatives focused on adaptation. For example, the four climate funds with a mandate from the United Nations Framework Convention on Climate Change (UNFCCC) invest in adaptation strategies enabled or supported by electricity, including access to climate information and early warning systems.<sup>5</sup> However, only the Green Climate Fund explicitly supports electricity access as an enabler of adaptation.6

- 2. Limited research and evidence on the specific contribution that OGS products can make to resilience and adaptation. For example, understanding in what contexts and to what extent resilience outcomes can be achieved by technologies alone or whether these need to be delivered alongside or integrated with other interventions.
- intentionally investing in off-grid technologies to enhance resilience and adaptation. This includes designing company business models and government or donor-funded programmes in ways that respond to specific climate hazards and address key consideration such as maladaptation and social inclusion.



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- 1 Energy Sector Management Assistance Programme (ESMAP), Off-Grid Solar Market Trends Report 2024 (Washington: DC, 2024).
- 2 Notre Dame Global Adaptation Initiative (ND-GAIN), About, 2025.
- 3 Practical Action, Can Market Mechanisms Facilitate Energy Access for People Living in Extreme Poverty? (Rugby: Practical Action, 2023).
- 4 GOGLA, Powering Adaptation and Climate Justice: The Critical Role of Off-Grid Solar Technologies, 2023.
- 5 The four climate funds are the Adaptation Fund, Green Climate Fund, Global Environment Facility and Climate Investment Funds.
- 6 Green Climate Fund, Sectoral guide: Energy access and power generation, 2022.

### FIGURE 1: FOUR KEY IMPACT AREAS WHERE OFF-GRID SOLAR CAN **ENHANCE RESILIENCE AND ADAPTATION**

**CRITICAL INFRASTRUCTURE AND** SERVICES

**CLIMATE INFORMATION AND EARLY** WARNING SYSTEMS

**CLIMATE-RESILIENT LIVELIHOODS** 



**POST-DISASTER RESPONSE AND** RECOVERY

### **REPORT OBJECTIVE**

To address these challenges, GOGLA and Practical Action, in partnership with Efficiency for Access and supported by the IKEA Foundation, have developed the Off-Grid Solar Resilience and Adaptation Framework and the supporting Sector Guidance to help stakeholders to better understand, plan for, measure, evaluate and monitor the contribution of OGS technologies to climate resilience and adaptation. Target stakeholders include off-grid companies, governments, development organisations and impact investors.

The aim of this report is to give an overview of these resources and to demonstrate the ability of OGS technologies to contribute to climate resilience and adaptation across four impact areas:

- Critical infrastructure and services,
- Climate-resilient livelihoods,
- Climate information and early warning systems,
- Post-disaster response and recovery

The report concludes with recommendations for how stakeholders in the energy access, adaptation and related sectors can optimise the use of OGS to enhance climate resilience and adaptation, including by engaging with the resources proposed in this report.

### WHAT IS CLIMATE RESILIENCE AND **ADAPTATION?**

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as '... the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities?<sup>7</sup> Resilience in the context of climate change refers to 'The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure.'

Resilience is a positive attribute when it maintains the capacity for adaptation in response to climate change. Systems that undergo successful adaptation are likely to become more resilient. Rather than ends in themselves, resilience and adaptation (R&A) are commonly viewed as part of a necessary process to achieve impacts associated with improved wellbeing, such as better health and nutrition, education, ecosystem health, income, poverty reduction and standards of living, over the long-term despite climate change.<sup>8,9</sup>

Pathways towards resilience are highly context specific as they depend on the state of existing social, economic, and ecological systems, the specific climate risks and hazards those systems are exposed to, and the capacities of those systems to adapt. Enhancing R&A also requires interventions to be designed or implemented in ways that avoid unintended negative outcomes including maladaptation. This refers to 'Actions that may lead to increased risk of adverse climate-related outcomes,

7 Intergovernmental Panel on Climate Change (IPCC), <u>Glossary</u>, 2025.

8 Nick Brooks and Susannah Fisher, Tracking Adaptation and Measuring Development: a step-by-stepguide (London: International Institute of Environment and Development, 2014).

9 Aditya Bahadur and Florence Pichon, Analysis of Resilience Measurement Frameworks and Approaches (London: Overseas Development Institute, 2016).

including via increased greenhouse gas (GHG) emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future'.10

The complexity of defining resilience and adaptation, while avoiding potential maladaptation, contributes to making the two concepts challenging to measure, and a single set of universal indicators have so far not been established.<sup>11</sup> The Off-Grid Solar Resilience and Adaptation Framework and Sector Guidance aim to address resilience and adaptation challenges as they relate to the OGS sector.

### WHAT ARE OFF-GRID SOLAR **TECHNOLOGIES?**

Off-grid solar technologies are individual systems that bundle together solar PV with a range of efficient appliances: from low-power devices such as lights, phone chargers, radios, TVs and fans, to higher-power systems like fridges, cold rooms, water pumps, agro-processing equipment, generators and ICT devices. These products have been designed for use in homes, farms and businesses where there is no access to electricity, or where there is 'weak' or intermittent access to electricity due to prolonged or frequent blackouts which destabilise supply.

The off-grid solar industry has already helped hundreds of millions of people get first time access to electricity in energy poor communities and is powering over 10 million enterprises.<sup>12</sup> It also supports the development of improved public infrastructure, such as solar pumping for freshwater generation or power for health services. Some of the

business models developed by the industry also provide additional benefits, including the sale and distribution of other valuable products and services, such as mobile phones and efficient cook stoves, and enhancing access to financial services via consumer financing and the provision of loans.

**OFF-GRID SOLAR RESILIENCE AND ADAPTATION FRAMEWORK** 

The Off-Grid Solar Resilience and Adaptation Framework is an Excel tool to help users to understand, measure and evaluate the contribution of OGS technologies to resilience and adaptation. The tool includes general instructions and use cases as well as two key resources:

- Measurement Resource: A compendium of measurement indicators and guidance, grouped by impact area.
- **Global Dashboard:** A set of framing indicators, again grouped by impact area, that can be used by sector bodies and custodians of adaptation monitoring frameworks and indicators to track contributions made by OGS technologies to R&A at regional, national or international levels. Indicators can feed into the existing monitoring frameworks used by the four climate funds to track the impact of their investments.

The OGS Resilience and Adaptation Framework has been developed with inputs from stakeholders across the energy access sector. It will be launched in beta version and reviewed in early 2026 once it has been used in a real-world context. It will then be updated bi-annually to benefit from new knowledge and datasets.

### **OFF-GRID SOLAR RESILIENCE AND ADAPTATION SECTOR GUIDANCE**

The Off-Grid Solar Resilience and Adaptation Sector Guidance has been developed to support target stakeholders to design and implement OGS business models, projects and programmes to enhance climate resilience and adaptation. The Sector Guidance seeks to align with best practice in the R&A sector. It is broken down into three steps with accompanying information, case studies and external resources:

- be used,
- transformational adaptation.

The Sector Guidance is designed to be used jointly with the Off-Grid Solar Resilience and Adaptation Framework to support measurement and evaluation of OGS contributions. It can also support donor organisations and impact investors to evaluate funding opportunities.

Understand the context in which OGS technologies will

Be intentional in identifying goals and activities to reduce climate risk and vulnerability,

Consider how interventions might contribute to

<sup>10</sup> IPCC, <u>Glossary</u>, 2025.

<sup>11</sup> United Nations Framework Convention on Climate Change (UNFCCC), Global Goal on Adaptation, 2025.

<sup>12</sup> ESMAP, Off-Grid Solar Market Trends Report 2024 (Washington: DC, 2024).

### WHO SHOULD USE THE OFF-GRID SOLAR RESILIENCE AND ADAPTATION FRAMEWORK AND SECTOR GUIDANCE?

These resources are designed to be used by a variety of different stakeholders in different contexts. The most prominent examples are shown below with further examples detailed within the Framework.

### TABLE 1: KEY USE CASES FOR THE OFF-GRID SOLAR RESILIENCE AND ADAPTATION FRAMEWORK AND SECTOR GUIDANCE

Off-grid company	Donor or impact investor	Imp
Use cases		
Designing products and services to	Understanding OGS contributions to	Dev
boost R&A within customer base	resilience and adaptation	guio
Reaching more climate-vulnerable	<ul> <li>Grouped by key impact areas</li> </ul>	•
customers	Aligned with climate fund priorities	
<ul> <li>Identifying opportunities to</li> </ul>		•
enhance impact by combining OGS	Evaluating expected or actual OGS	
with other inputs and services	contributions	
	<ul> <li>Reviewing funding proposals</li> </ul>	Dev
Communicating OGS contributions to	Evaluating company or programme	pro
resilience and adaptation	impacts	•
<ul> <li>Engaging new customers</li> </ul>	<ul> <li>Tracking contributions by OGS over</li> </ul>	
Seeking funding	time	•
Seeking technical assistance		
	Enhancing resilience and adaptation	
Reporting product and service	impacts	Enh
impacts to donors and investors	<ul> <li>Exploring ways to enhance R&amp;A</li> </ul>	imp
<ul> <li>Receiving financial support e.g.</li> </ul>	impacts e.g. by 'linking and	•
results-based financing	layering' interventions or catalysing	
	transformational change	
Measuring and evaluating product		
and service contributions		
<ul> <li>Improving business models</li> </ul>		
<ul> <li>Improving product designs</li> </ul>		
Diversifying product ranges		
Key outputs		
Business planning and strategies,	Company or project/ programme	The
reporting documents, funding	evaluation criteria, theories of change	mor
proposals, marketing material e.g.	documents	and
product case studies		prop

### plementing organisations

### eveloping theories of change to ide projects and programmes

- Providing financial or technical assistance to companies Incorporating OGS into larger cross
- sector adaptation programmes

### eveloping project or programme oposals

- Communicating impact of OGS to donors
- Designing programmes e.g. RBF
- schemes

### hancing resilience and adaptation

### pacts

- Exploring ways to enhance R&A
- impacts e.g. by 'linking and
- layering' interventions or catalysing
- transformational change

eories of change documents, onitoring and evaluation plans, risk d vulnerability assessments, funding oposals



# **RESILIENCE AND ADAPTATION: FOUR KEY IMPACT AREAS**

This report explores the contribution of OGS products to climate resilience and adaptation across the four impact areas detailed in the R&A Framework. These were selected based on existing evidence and the goal of aligning with common adaptation priorities articulated by governments and the four climate funds. This supports alignment of OGS with existing adaptation efforts and funding streams.

The four key impact areas covered in this report are:

### **CRITICAL INFRASTRUCTURE AND SERVICES**

Critical infrastructure refers to public and private facilities that exist to ensure that communities can access supplies and services to meet basic needs such as health, education, food, water and energy access. This report focuses on the contribution that OGS technologies, such as standalone solar systems and appliances, make to increasing the resilience of such infrastructure to climate hazards through their physical properties as well as their ability to provide and improve services for vulnerable communities.

### **CLIMATE RESILIENT LIVELIHOODS**

To be climate resilient, livelihoods need to enable people to sustain and improve their incomes, opportunities and wellbeing despite climate change. This report focuses on the contribution of OGS companies and products, including solar lighting, communication, water pumps, refrigeration units and agro-processing equipment, to livelihood resilience by increasing incomes, jobs, savings, financial inclusion and food security.

### **CLIMATE INFORMATION AND EARLY WARNING SYSTEMS**

Climate information services including weather and climate projections, and early warning systems (EWS) are vital to helping people to take anticipatory action to avoid or reduce loss and damage to their lives and livelihoods resulting from climate hazards and to adapt to long-term changes. This report focuses on the role of OGS products, including solar energy kits (solar lanterns or solar home systems) and appliances such as radios, mobile phones and TVs, in enabling and improving access to climate information services.

### POST DISASTER RESPONSE AND RECOVERY

Post disaster response and recovery are vital to moderate the immediate impacts of climate disasters and to help affected communities, including displaced people, to build-back better and adapt in the medium and longterm. The report explores the use of OGS technologies by humanitarian agencies and displaced people in the immediate aftermath of climate disasters, including emergency response, and in prolonged situations of climate-induced displacement.

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## **CRITICAL INFRASTRUCTURE AND SERVICES**

Critical infrastructure is a foundational component of a functioning society that exists to ensure that communities can access supplies and services to meet basic needs such as health, education, food and water.<sup>13</sup>The Green Climate Fund defines climate-resilient infrastructure as that which serves two purposes:14

- **Infrastructure for resilience:** Infrastructure that is devised with the aim of enabling resilience for countries, societies and economies.
- **Infrastructure that is resilient:** Infrastructure that is designed to withstand multi-hazards of appropriate magnitude, based on the observed and projected effects of climate change.

Evidence shows that OGS products function as critical infrastructure that can enhance the resilience of electricity supply to communities in off-grid and weak-grid areas exposed to climate change, including the provision of power for essential services such as healthcare.

### **FAST, DURABLE ELECTRICITY INFRASTRUCTURE FOR CLIMATE VULNERABLE COMMUNITIES**

OGS products, including solar energy kits, are the leastcost option for providing first-time electricity access to 400 million people by 2030, the majority living in countries highly vulnerable to climate change.<sup>15,16</sup> OGS technologies also offer an alternative for 1.6 billion people with weak grid access, giving them the chance to achieve a more reliable electricity supply.<sup>17</sup>

As well as being the least cost option, OGS products play an important role in enhancing the resilience of electricity supply in areas exposed to climate hazards. For example, adopting OGS products can help to diversify energy sources for climate vulnerable households. This is evident in Zambia where a series of droughts associated with climate change have drastically reduced hydropower generation since 2019 with knock on impacts on electricity supply.<sup>18</sup> In 2023, drought forced the government to extend load shedding to up to 12 hours a day, and in mid-2024 load

- 13 Pippa Huddleston, Tim Smith, Iain White, Carmen Elrick-Barr, "Adapting critical infrastructure to climate change: A scoping review", Environmental Science & Policy 135, 1 (2022): 67-76.
- 14 Green Climate Fund, Annex to GCF sectoral guides: Climate-resilient infrastructure, 2023.
- 15 ESMAP, Off-Grid Solar Market Trends Report 2024 (Washington: DC, 2024).

- 16 Notre Dame Global Adaptation Initiative (ND-GAIN), About, 2025.
- 17 ESMAP, Off-Grid Solar Market Trends Report 2024.
- 18 Imaduddin Ahmed, Drought and Dams, 2022.

### **FIGURE 2: GOGLA AFFILIATE COMPANY SALES OF SHS AND** LANTERNS IN ZAMBIA, 2019-2023



shedding reached 17-hours per day.<sup>19,20</sup> Data from GOGLA affiliated companies shows that demand for small solar products in Zambia, including solar home systems and lanterns, increased by 183% between 2019 and the end of 2023 (see Figure 2).<sup>21</sup> Anecdotal evidence suggests that this is directly linked to the challenges experienced with grid power supply.

Evidence shows that the physical properties of OGS products, including greater technical simplicity and ease of repair compared to large infrastructure, also help to prevent disruption to electricity supply by climate hazards. Cyclone Ana in 2022 damaged Malawi's main hydroelectric power plant leading to power cuts and load shedding for grid-dependent households over several months while repairs were carried out.<sup>22</sup> In comparison, a recent survey of 483 OGS customers in Zambia found that over 90% of non-functioning products could be fixed at low cost with relative ease, including faulty batteries, switches and circuit boards.<sup>23</sup> This suggests that OGS products can enhance energy resilience by being easier to replace and repair than grid infrastructure in the event of damage by climate hazards, enabling electricity access to be restored more quickly.

However, OGS technologies are not immune to climate disasters, and durability should be considered during their design and installation. For example, where relevant, installation should be based on careful selection of roof or ground space to reduce technologies' exposure to extreme winds or historic flood water levels, and customers should be informed of how to protect their system(s) in the event of extreme weather events.<sup>24</sup> In addition, steps should be taken to improve repairability such as introducing more repairable designs and ensuring the availability of repair services.25

### **USING OFF-GRID SOLAR TO POWER HEALTHCARE AND OTHER PUBLIC INFRASTRUCTURE**

OGS technologies can increase the resilience of energy infrastructure needed to deliver critical services. One example is healthcare, but others include education and water services.

Climate hazards affect human health either directly through injury and loss of life in disaster events, or indirectly by affecting social and environmental factors that influence human health such as the availability of safe drinking water.<sup>26</sup> Energy infrastructure in health facilities is needed to address these challenges, for example, by powering medical equipment, such as fans, ventilators and refrigerators for vaccine storage, and enabling staff to perform duties from basic medical consultations to lifesaving procedures.

The World Health Organisation (WHO) estimates that 1 billion people are currently served by local healthcare facilities with unreliable power.<sup>27</sup> In sub-Saharan Africa alone, 25,000 healthcare facilities lack electricity access entirely, while roughly 70,000 contend with unreliable supply. At the same time, climate change is negatively impacting existing energy infrastructure in health facilities. This includes both physical damage to power sources and increased demand for applications such as cooling in response to rising temperatures, and emergency services in response to disaster events.

- 19 GET FiT Zambia, Annual Update. Year in Review 2023.
- 20 Solar Aid, Solar Lighting the Way Amid Zambia's Dual Crisis (London: Solar Aid, 2024).
- 21 From 188,718 products sold in 2019 to 534,548 products sold in 2023.
- 22 Department of Disaster Management Affairs (DoDMA), Malawi: Tropical Storm ANA-Department of Disaster Management Affairs- Situation Report- 2 (Lilongew: DoDMA, 2022).
- 23 Solar Aid, Off-Grid Solar Repair in Africa: From Burden to Opportunity (London: Solar Aid, 2023).
- 24 Sustainable Energy for All (SEforAll), Climate Resilience and Powering Healthcare in the Global South (Geneva: SEforAll, 2025).
- 25 Solar Aid, State of Repair in the Off-Grid Solar Sector (London: Solar Aid, 2024).
- 26 World Health Organisation (WHO), Climate Change, 2023.
- 27 SEforAll, State of the Market Report for Healthcare Facility Electrification (Vienna: SEforAll, 2024).

*"A climate resilient healthcare facility"* is one that is able to anticipate, respond to, cope with, recover from and adapt to climate and weather events, so as to provide ongoing and sustained healthcare to their target populations, despite an unstable climate."28

Incorporating OGS technologies into the energy infrastructure of health facilities can increase the resilience of this critical service. For example, standalone solar systems are increasingly being used as a primary source of energy, or a back-up option for grid-connected facilities to improve the reliability of electricity supply in the event of disruption to grid infrastructure.<sup>29</sup>

Specific OGS appliances designed to operate on lowervoltage direct current and with solar batteries can also enhance energy resilience for health facilities. This includes lighting, water pumps, refrigerators and freezers (including vaccine storage), water heaters and food cookers. Furthermore, energy efficient appliances such as LED lights and heating, ventilation and air conditioning units with energy recovery devices, help to reduce pressures on energy demand.

OGS technologies are expected to play a crucial role in providing first time electricity access to health facilities in climate-vulnerable countries, as well as back-up power for grid-connected facilities.<sup>30</sup> Climate resilient solutions must be integrated into this process from the outset. Sustainable Energy for All (SEforAll) has produced a set of recommendations to help stakeholders enhance the resilience of healthcare energy infrastructure.<sup>31</sup> These include using best practise across energy and healthcare sectors as detailed in WHO's Guidance on Climate Resilient Healthcare Facilities,<sup>32</sup> urging stakeholders to pursue cobenefits and identify potential trade-offs, and proactively promoting a set of 'low regrets' technologies and practices that most healthcare facilities can benefit from when facing similar climate hazards.



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- 28 World Health Organisation (WHO), Operational framework for building climate resilient health systems, 31 SEforAll, Climate Resilience and Powering Healthcare in the Global South 2015, accessed 25/02/2025.
- 29 SEforAll, Climate Resilience and Powering Healthcare in the Global South (Geneva: SEforAll, 2025).
- 30 SEforAll, State of the Market Report for Healthcare Facility Electrification (Vienna: SEforAll, 2024).

32 World Health Organisation (WHO), Operational framework for building climate resilient health systems, 2015.

### CASE STUDY: POWERING MATERNAL HEALTH

Frequent power outages threatened the quality of treatment for soon-to-be mothers at Mwenge Dispensary in Dar es Salaam, Tanzania, particularly during overnight deliveries or crises. In such cases, healthcare personnel would resort to calling ambulances to transfer them to the district hospital, located about 10 kilometres away. This frequently required pregnant mothers to endure or delay labour in a medically risky setting.

To address this challenge, Sun King, a leading off-grid solar company, installed a PowerHub hybrid solar inverter system at Mwenge Dispensary that draws power from both the electrical grid and its solar panels. The PowerHub system provides a 3.3 kW AC output along with a 5.4 kWh battery. This to enough to power 24 hours of lighting in the maternal ward and essential medical equipment, such as the centre's electric microscope and refrigerators to ensure safe storage of vaccines and medicines to support natal and maternal health as well as disease outbreak response efforts. The powerful 5.4 kWh rechargeable lithium-ion batteries stores energy for when it is needed the most, especially during power outages.

By adopting this inverter system, the Mwenga Dispensary is now better equipped to support expectant mothers at any time of day, while at the same time saving up to 50% on energy costs.



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# CLIMATE RESILIENT LIVELIHOODS

Climate change is disproportionately affecting those on the lowest incomes and increasing poverty around the world.<sup>33</sup> As a key driver of income generation, poverty reduction and improved living standards, livelihoods need to be resilient to climate hazards. Like resilient infrastructure, resilient livelihoods are those which can withstand the effects of climate hazards and enhance resilience for vulnerable households. OGS products and the industry as a whole can enhance livelihood resilience in several ways.

### **JOB CREATION**

While the primary purpose of increasing access to OGS products is to improve living standards for users, increased employment within the off-grid industry itself is a significant co-benefit that can enhance climate resilience in areas vulnerable to climate change. In 2022, Power for All found that across Kenya, India, Ethiopia, Nigeria and Uganda the off-grid solar industry employs 83,000 people, including company staff and field agents, and supports a further 62,000 people through informal work.<sup>34</sup> Tens of thousands of additional roles within the industry are being supported across Africa and Asia.

Jobs are also being generated by users of OGS. For example, income.<sup>38</sup> amongst off-grid solar users, in East Africa, an estimated 21 full time equivalent (FTE) informal roles are created for each 100 solar home systems sold, with 8 FTE and 4 FTE created per 100 systems in West Africa and South Asia respectively.<sup>35</sup>

Larger systems and agricultural appliances, such as solar irrigation and cold storage, also have a significant potential to unlock job creation. Recent analysis found that the solar irrigation sector has the potential to create more than 115,000 jobs by 2030 in India and Kenya alone, providing higher incomes and better job opportunities for rural communities.<sup>36</sup> Of these, 22,000 people would be employed directly within the off-grid solar irrigation sub-sector, while more than 93,000 people would be employed indirectly and in the value chain.<sup>37</sup>

Job creation has the potential to enhance people's climate resilience by increasing incomes and diversifying income streams, thereby providing households with greater capacity to absorb climate impacts and invest in longterm adaptation strategies. For example, the Power for All survey found that 50% of those employed in the distributed renewable energy sector in Kenya, Ethiopia, Nigeria, Uganda and India worked in sales, operation and customer service roles. The average annual salary for a sales agent (USD 6,000) was higher than the average rural wage in each country. This is especially significant for resilience in rural areas where farming opportunities are limited and there is high youth unemployment, as sales jobs can increase opportunities and enable households to diversify their

- 33 IPCC, Chapter 8: Poverty, Livelihoods and Sustainable Development, IPCC Sixth Assessment Report Impacts, Adaptation and Vulnerability, 2022.
- 34 Power for All, Analysis of underlying data from the Power for All, Powering Jobs Census 2022: The Energy Access Workforce (San Francisco: Power for All, 2022).
- 36 Efficiency for Access, Green Jobs for Rural Youth: Unlocking Renewable Energy's Potential in Agriculture.
- 37 GOGLA, Powering Opportunity, 2020
- 38 Efficiency for Access, Green Jobs for Rural Youth: Unlocking Renewable Energy's Potential in Agriculture

35 GOGLA, Powering Opportunity, 2020.

### FIGURE 3: NUMBER OF PEOPLE CURRENTLY USING A SOLAR ENERGY KIT TO UNDERTAKE MORE ECONOMIC ACTIVITY (MILLION PEOPLE)



Source: GOGLA, 2025. Based on sales from GOGLA affiliate companies.

# FIGURE 4: ANNUAL SALES OF SOLAR WATER PUMPS AND REFRIGERATION UNITS REPORTED BY GOGLA AFFILIATES



However, employment opportunities in the OGS sector are not evenly distributed between men and women. While they often bear the brunt of climate change, women continue to be underrepresented in the OGS workforce. For example, Power Africa report that women made up less than 50% of the distributed renewable energy workforce in Kenya, Ethiopia, Nigeria, Uganda and India, with representation especially low in the latter two countries (28% and 21%, respectively). Improving women's representation within the industry can help to address this inequality. It can also improve the commercial performance of OGS companies, with more gender diverse OGS companies found to perform better in areas such as customer acquisition, retention and sales.<sup>39</sup>

### **POWERING ENTERPRISE**

Around the world, millions of micro-enterprises are already using OGS technologies to support their operations. Data from GOGLA affiliated companies shows that sales of solar energy kits have helped customers to generate over USD 9 billion in additional income between 2010 and 2024, by providing power for local businesses, mobile charging stations and agricultural activities.

Figure 3 shows how the number of people using solar energy kits to undertake more economic activity, including working longer hours in an existing activity or supporting informal activities inside or outside of the home, has evolved since 2016, reaching almost 5.9 million in 2023. This highlights the potential contribution that these products can have to income generation. The overall potential is likely to be higher as GOGLA data focuses on the impact of solar energy kits and does not currently capture additional economic activity generated using standalone productive appliances such as solar refrigeration units or water pumps. Although the market is at an early stage (see Figure 4), solar refrigeration units can raise incomes for small businesses. For example, a study of over 1,500 off-grid refrigerator customers in Kenya, Tanzania and Uganda between 2018 and 2022, found that 48% reported increased income and 24% reported business growth.<sup>40</sup> Solar refrigeration units contribute to income generation by reducing the perishability of processed food and drink products (dairybased drinks, juices etc) as well as unprocessed milk, meat, fruit and vegetables, helping to maintain quality.<sup>41</sup> Along with improving the quality of existing products, solar refrigerators also enable enterprises to diversify their product offerings, for example to include chilled or frozen products such as cold drinks, ice-cream, ice and frozen food, and to access new markets.

Solar water pumps (SWP) can also increase income for smallholder farmers, primarily by increasing the amount of water available during crop production and increasing yields. This can enhance income for farmers as they benefit from more abundant crops and more frequent and longer cropping periods generating more produce to eat and sell.<sup>42</sup> Furthermore, greater water supply can enable greater diversity of crop types (including higher value crops) in comparison to rainfed agriculture where crop production is more restricted by rainfall.

Research by 60 Decibels exploring the experience of nearly 1,200 SWP customers across East and Southern Africa found that 90% reported increased income due to ownership of the product with 47% seeing a significant increase and 43% a slight increase.<sup>43</sup> Reasons for this included being able

to increase the number of products sold, reduce farming costs and increase the amount of land under cultivation. If these results were true across all customers of GOGLA affiliated companies, almost 46,800 farmers would have seen a significant increase in the money they earned from their farm due to owning a SWP, and 42,800 a slight increase.<sup>44</sup> This shows that solar powered irrigation has significant potential to enhance income. However, without additional measures, impact may not be equal for all users, with a small subset of surveyed customers reporting no change in income (6%) or a slight decrease (4%). The report further highlighted that several customers experienced challenges with their systems which could account for some instances where income was not enhanced. The ability of farmers to increase their incomes and resilience through SWP will also depend on the broader agricultural system in which products are used including the type and diversity of agricultural practices supported, water demand management and access to markets and other agricultural inputs.

### **INCREASING THE POTENTIAL FOR** SAVINGS

Households with greater savings are more capable of buffering negative impacts, such as disruption to livelihoods, without using negative coping mechanisms such as selling assets and reducing food consumption.<sup>45</sup> Households can also use savings to invest in long-term adaptation. Evidence shows that purchasing solar energy

kits has the potential to increase household savings by reducing energy expenditure. For example, it is estimated that products sold by GOGLA affiliated companies between 2010 and 2024 have helped customers to save USD 16 billion on energy expenditure. This has been achieved by replacing more costly kerosene fuels and batteries used for lighting and phone charging, respectively. While this depends on other spending requirements, it is likely that many households experiencing reduced energy expenditure as a result of OGS products have increased their savings, providing them with an additional resource to respond to climate impacts.

### **INCREASING FINANCIAL INCLUSION**

Financial inclusion is also recognised as an important pillar of resilient societies. However, 1.4 billion adults remain excluded from the financial system with more than 80% living in the most climate vulnerable countries.<sup>46</sup> Financial services enhance resilience by enabling households to:

- advance of disasters;

- 40 Efficiency for Access and 60 Decibels, Uses & Impacts of Off-Grid Refrigerators Insights from Kenya, Tanzania and Uganda, 2022.
- 41 Efficiency for Access, Impact Assessment Framework Refrigerators, 2022.
- 42 Efficiency for Access, Impact Assessment Framework Solar Water Pumps, 2022.
- 43 Efficiency for Access Coalition and 60 Decibels, <u>USES & IMPACTS OF SOLAR WATER PUMPS</u>, 2021.
- 44 Analysis using GOGLA affiliate sales data and insights from the Uses and Impacts of Solar Water Pumps report. Analysis undertaken in 2025.
- 45 Elisa Sandri and James Robinson, Savings and climate resilience A review of successes and challenges in current programming (Brighton: ITAD, 2021).
- 46 Peter Zetterli, Climate Adaptation, Resilience, and Financial Inclusion (Washington DC: CGAP, 2023).

Insure assets such as homes, shops, crops and cattle in

Deploy savings and access external support such as cash transfers and remittances when disasters occur; and

Borrow to invest in long-term adaptation strategies.



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Evidence shows that OGS products are improving financial inclusion in remote settings where physical and digital services are limited. Many of the customers served by OGS companies have poor or no credit histories. However, successfully paying for products through a pay-as-you go (PAYGo) consumer financing model can improve customers<sup>3</sup> credit ratings, enabling them to qualify for loans and other types of financial support.<sup>47</sup> This can potentially be used to invest in adaptation strategies. Data from GOGLA affiliated companies shows that 17 million customers have benefited from PAYGo financing since 2018. Surveys conducted in Benin and Côte d'Ivoire by the Global System for Mobile Communication (GSMA) also found that use of PAYGo can increase trust and confidence in mobile money and the number of transactions made.<sup>48</sup> People with digital accounts tend to receive more financial support from government and humanitarian sources following disasters due to the ease of distribution.<sup>49,50</sup>

Savings and financial inclusion are necessary but not sufficient to enhance resilience. Their contribution to resilience will also depend on the extent to which financial services are tailored to different circumstances and resilience needs, for example, seasonal and irregular cash flows, and the existence of ancillary services, such as the integration of mobile money with new or existing social protection systems.<sup>51</sup> Nevertheless, more investment is needed to establish financial inclusion as a pillar of resilient societies. Investing in OGS companies can contribute to this as they are already increasing financial inclusion in remote settings.

### **INCREASING FOOD SECURITY**

Food security refers to people having physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.<sup>52</sup> Livelihood resilience is crucial for increasing and sustaining food security in the face of climate change by improving both the physical availability of food, as well as its physical and economic accessibility. By contributing to income generation, OGS products help to improve the affordability of food products. In addition, there is emerging evidence that specific appliances can contribute to food security within agricultural systems.

Research shows that purchasing solar-powered refrigeration units can increase food security for households that previously lacked access to cold storage. Solar refrigeration improves food security in three main ways:

- reducing fuel costs;
- people's diets; and

The impact on diet is evident from a survey of 36 OGS refrigeration customers in Uganda with 28 reporting that

- 47 Practical Action, Can Market Mechanisms Facilitate Energy Access for People Living in Extreme Poverty? (Rugby: Practical Action, 2023).
- 48 Global System for Mobile Communications (GSMA), The growth of mobile money: Driving financial inclusion for the underserved, 2023.
- 49 Tavneet Suri and William Jack, The long-run poverty and gender impacts of mobile money, Science, 6317 (2016): 1288-1292.
- 50 Cecilia Costella, Anna McCord, Maaten van Aalst, Rebecca Holmes and Jonathan Ammoun with Valentina Barca, Social protection and climate change: scaling up ambition (London: DAI Global, 2021).
- 51 Peter Zetterli, Climate Adaptation, Resilience, and Financial Inclusion.
- 52 World Bank, What is Food Security? 2025.

Reducing expenditure: food can be bought and cooked less frequently and in bulk generating time savings and

Reducing the risk of food poisoning and improving

Increasing incomes by reducing post-harvest losses and improving storage for transport to markets.

adoption had led them to modify their diet to include more fresh fruit, juice and dairy products.<sup>53</sup>

Solar water pumps can enhance food security by increasing water availability and crop production for those previously using manual methods or reliant on rainfed agriculture, especially where rainfall is low or unreliable. For example, a study in northern Benin compared the experience of small-scale farmers growing vegetables from handwatered pots with those using solar-powered drip irrigation (applying water directly to plant roots). Those using SWPs experienced an increase in vegetable production, thereby increasing the physical availability of food, as well as income compared to those watering crops by hand.<sup>54</sup> Higher incomes also made food more economically accessible as farmers were able to purchase more staples, pulses and protein in the dry season and oil in the rainy season.

There is significant potential to scale solar-powered irrigation in Africa where only around 6% of the total cultivated area (13 million hectares of arable land) is currently irrigated, compared to 37% in Asia and 14% in Latin America.<sup>55</sup> However, expansion must be responsible to avoid maladaptive outcomes. Of sub-Saharan Africa's groundwater-dependent ecosystems, 92% are at risk of overexploitation if solar water pumping is used without controls.<sup>56</sup> However, risk varies when using different technologies and is low for small-scale (less than 1kW) pumps in the near term.<sup>57</sup> The proportion of available

(replenished) groundwater resources abstracted by small SWPs within the 2020's is estimated to be between 0.4 and 0.6% for sub-Saharan Africa as a whole. If local conditions are taken into account, it should be possible to expand the use of water pumps to millions of customers without adversely affecting the availability of groundwater supplies; with Efficiency for Access estimating that the SWP market in sub-Saharan Africa will serve as many as 2.8 million households by 2030.58

Nevertheless, ongoing assessments of water recharge and use of water efficient practices such as drip irrigation in areas at risk of overexploitation should be undertaken to avoid any unintended negative consequences. In addition, there is increasing interest in the potential of OGS technologies to support more regenerative agricultural practices to enhance incomes and food security while improving ecosystem health. For example, a recent study by Efficiency for Access identified opportunities for OGS to support regenerative practices in Kenya's coffee, rice, maize, livestock and horticulture value chains.<sup>59</sup> This included combining water pumps with rainwater harvesting and using solar panels to power seed nurseries and milling and threshing equipment. Practical Action is also working to test and scale viable models of regenerative farming involving OGS products.<sup>60</sup> Further research and support for programmes is needed to develop and scale this approach and explore it affects climate resilience.



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- 53 Michael Maina, Siena Hacker and Hannah Blair, Do Off-Grid Refrigerators Benefit Consumers Long-Term? 2020.
- 54 Jennifer Burney, Lennart Woltering, Marshall Burke, Rosamond Naylor and Dov Pasternark, Solarpowered drip irrigation enhances food security in the Sudano-Sahel, PNAS, 5 (2010): 1848-1853.
- 55 German Development Institute (DIE), Unlocking the Irrigation Potential in Sub-Saharan Africa: Are Public-Private Partnerships the Way Forward? (Bonn: DIE, 2017).
- 56 Guillaume Zuffinetti and Simon Meunier, <u>Mapping the Risk Posed to Groundwater-Dependent</u> Ecosystems by Uncontroled Access to Photovoltaic Water Pumping in Sub-Saharan Africa (Washington DC: World Bank Group, 2024).
- 57 Efficiency for Access, Sustainable Expansion of Groundwater-based Solar Water Pumping for Smallholder Farmers in Sub-Saharan Africa, 2021.
- 58 Efficiency for Access, Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, 2019.
- 59 Efficiency for Access, How can energy access practitioners energise regenerative agriculture settings? 2023.
- 60 Practical Action, Regenerative Farming, 2025.

### CASE STUDY: POWERING FOOD PRODUCTION

Sunculture is the largest distributor of solar-powered irrigation technology for smallholder farmers in sub-Saharan Africa. Its solar irrigation pump technology is designed to replace manual and polluting diesel pumps and to be combined with drip irrigation to enhance water efficiency.

60 Decibels conducted a survey of Sunculture customers in Kenya in September 2024. Of the 284 customers surveyed, 93% reported that solar irrigation products had increased crop production and 87% that using the technology had enhanced household income.

The adoption of solar irrigation products was also found to improve farmers' perceived resilience to climate hazards. Of the surveyed farmers, 73% felt that adoption of solar irrigation products had had a positive effect on their ability to adapt to hazards including drought and severe lack of rain and irregular weather patterns in the previous 24 months.



© SunCulture

![](_page_20_Picture_0.jpeg)

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# **CLIMATE INFORMATION AND EARLY WARNING SYSTEMS**

Climate information refers to the collection and interpretation of weather and climate observations and simulations of past and future periods.<sup>61</sup> Climate information services provide such information in ways that assist people in making decisions around climate change adaptation. Information is often collected and interpreted via weather stations and distributed via appliances requiring electricity access such as radios, mobile phones, laptops and televisions. OGS products with the capacity to charge such appliances can help to increase access to climate information in off-grid settings.

### ACCESS TO CRITICAL ADAPTATION INFORMATION

Both weather and climate projections are crucial for helping people to adapt to climate change and variability.<sup>62</sup> For example, with access to timely rainfall forecasts, smallholder farmers can make more informed planting decisions throughout the growing season. Seasonal forecasts also help farmers to make better choices about crop types and varieties and how to time land preparation and planting. OGS products can play a critical role in the

transfer of climate information as well as other information that supports adaptation by powering radios, phone charging and other communication devices.

For example, a survey of farmers in Zambia's Eastern and Southern Provinces in 2021 found that radio was the preferred source of climate and agricultural information for both men and women.<sup>63</sup> The non-profit FHI 360 was able to reduce crop losses for Ugandan farmers by up to 65% by using mobile phones and radios to distribute seasonal and short-term weather forecasts, weekly market information and guidance on drought-resilient livelihood strategies.<sup>64</sup>

61 CARE, <u>Climate Information Services</u>, 2025.

62 Forecasting weather or climate conditions up to around two weeks and a few years, respectively

63 Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), <u>The potential of using radio as a</u> <u>communication channel for climate services</u> (Bonn: GIZ, 2023).

### **FIGURE 5: SALES OF OFF-GRID PRODUCTS THAT HAVE CAPACITY TO CHARGE MOBILE PHONES,** 2019 - 2023.66

Source: GOGLA, 2025. Based on sales from GOGLA affiliate companies.

![](_page_21_Figure_2.jpeg)

Those with no or unreliable access to electricity, and therefore device charging, will find it difficult if not impossible to access such information.

The off-grid market is providing households with better access to devices capable of receiving and sharing climate information and adaptation services. For example, in 2023 alone, GOGLA affiliated companies sold almost 5.9 million

solar energy kits able to charge mobile phones (see Figure 5). In the same period, affiliate companies with diverse product offerings reported selling 340,000 TVs and 250,000 radios. Taking into account average household sizes, these outputs combined have enabled improved access to information for over 25 million people. In addition, OGS distributors are increasingly offering smartphones to their customers and partnering with mobile operators with limited reach in remote, rural settings.<sup>65</sup> Therefore, OGS companies not only have a role in powering devices but also in providing devices directly to climate-vulnerable communities.

### **ACCESS TO EARLY WARNING** INFORMATION

Early warning systems (EWS) are another climate information service vital to enhancing climate resilience which can be enabled and improved using OGS technologies. This refers to integrated systems of '... hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enable individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events'.67

The Early Warning for All initiative aims to ensure universal coverage of EWS by the end of 2027, especially systems that address multiple hazards occurring alone, simultaneously

or with cascading and cumulative effects. Vital to achieving this is improving the dissemination and communication of authoritative, timely, accurate and actionable warning messages. The United Nations Office for Disaster Risk Reduction (UNDRR) and World Meteorological Organisation (WHO) have called for more investment to reach the 'final mile' of early warning including ensuring that warning messages are disseminated and communicated in ways that are inclusive of all groups vulnerable to climate hazards. The potential of technological solutions to support this goal is evident from the World Risk Poll 2023 which states that 'among people who experienced a disaster in the past five years, the most common way of receiving a warning was through radio, TV, or newspapers (53%)' with 46% also receiving warning from the internet/social media.68

As with climate information, OGS products are vital to enabling the dissemination and communication of early warning messages in off-grid areas exposed to climate hazards, as they provide the energy needed to charge appliances through which messages can be shared. This is evident from surveys that have found that off-grid customers use OGS-powered devices to access information relevant to climate hazards and early warning. For example, in a study of 500 households in Bangladesh, 95% agreed that their access to information through a mobile phone, TV or radio had improved by owning a solar home system; for 92%, watching TV or listening to the radio had made them more informed about climate-related hazards including tornados and cyclones.<sup>69</sup>

### 64 United Nations Climate Change, Enabling Farmers to Adapt to Climate Change Uganda, 2023.

- 65 Global System for Mobile Communications (GSMA), The growth of mobile money: Driving financial inclusion for the underserved, 2023.
- 66 Analysis based on sales of OGS products by GOGLA affiliates that have one or more outlets through which they can charge mobile phones and/or other appliances.
- 67 United Nations Office for Disaster Risk Reduction (UNDRR) and World Meteorological Organisation (WMO), Global Status of Multi-Hazard Early Warning Systems 2024 (Geneva: WMO, 2024).
- 68 Loyd's Register Foundation (LRF), World Risk Poll 2024 report: resilience in a changing world (London: LRF, 2024).
- 69 Tania Urmee and David Harries, Determinants of the success and sustainability of Bangladesh's SHS program, Renewable Energy, 11 (2011): 2822-2830.

### ENHANCING ACCESS TO EARLY WARNING SYSTEMS USING OFF-GRID SOLAR

While the flagship '<u>Global Status of Multi-Hazard Early</u> <u>Warning Systems in 2024</u>' highlights challenges such as poor network coverage and mobile affordability to achieving universal coverage of Early Warning Systems (EWS) by 2027, there is no mention of limited access to electricity as a potential barrier to communication and dissemination via electronic devices in off-grid areas. This suggests that electricity access challenges are underprioritized in the disaster risk reduction community.

As highlighted in this report, off-grid solar plays a key role in powering communication devices that can support distribution of early warning messages to those who currently lack access to electricity and would otherwise have no or very limited access to such information. Distribution companies also support access by selling devices directly to remote communities. Therefore, efforts to accelerate the roll out of EWS across the world are unlikely to succeed unless there is also integration of support for the OGS sector.

![](_page_22_Picture_3.jpeg)

© Getty Images

# **POST-DISASTER RESPONSE AND** RECOVERY

Climate-related disasters are increasing displacement around the world, increasing the need for post-disaster response and recovery to support affected populations.<sup>70</sup> Most climate-related displacement occurs within countries rather than across national borders. Considering only the effect of slow-onset changes, it is estimated that climate change could contribute to the movement of around 216 million people within their own countries by 2050 unless action is taken.<sup>71</sup> The majority of movement is expected to take place in the poorest and most climate-vulnerable regions, with 40% in sub-Saharan Africa. This means that displaced people will continue to be exposed to climate hazards.

Post-disaster response refers to actions taken in the immediate aftermath of a disaster, while recovery involves efforts to 'build back better' over the short and long term. Energy access is an important enabler of both phases. However, while energy is recognised by the United Nations High Commissioner for Refugees (UNHCR) as a 'basic need for everyone' it has historically been underprioritized in the humanitarian sector.<sup>72</sup> This is notable from its exclusion as a distinct cluster within the humanitarian cluster system, despite the diverse role it plays in support of all aspects of humanitarian planning (as shown in Figure 6).<sup>73</sup>

![](_page_23_Picture_3.jpeg)

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- 70 United Nations High Commissioner for Refugees (UNHCR), Climate change and displacement: the myths and the facts, 2023.
- 71 World Bank Group, Groundswell Part 2: Acting on Internal Climate Migration (Washington DC: World Bank Group, 2021).
- 72 UNHCR, UNHCR, the Environment & Climate Change (Geneva: UNHCR, 2015).
- 73 Peter Hames, Matthew Thomas, Sarah Rosenberg-Jansen and Aimee Jenks, Moving beyond informal action: sustainable energy and the humanitarian response system, Journal of International Humanitarian Action, 6 (2021): 1-20.

### FIGURE 6: THE HUMANITARIAN CLUSTER SYSTEM WITH EXAMPLE ENERGY USES

Source: Hames et al, 2021

![](_page_24_Figure_2.jpeg)

Cookstoves and energy supporter materials for nutrition

Torches and cooking pans in emergency kits

Solar lanterns and public streetlighting

![](_page_25_Picture_0.jpeg)

© Bethany Laird (Unsplash)

### **POST-DISASTER EMERGENCY** RESPONSE

OGS technologies can improve emergency response efforts led by humanitarian agencies. When used as primary or back up sources of electricity, standalone solar systems can improve the reliability of electricity access needed to power appliances used in coordination, logistics and communication activities. This includes lighting and ICT devices. In addition, the small-scale and modular nature of OGS technologies such as solar lanterns and home systems, means that they can be deployed quickly in disaster settings and can be easily transported by agencies and displaced people.

In some cases, local OGS companies have worked directly with humanitarian agencies to support post-disaster response. For example, following Cyclone Idai in 2019, SolarWorks!, Zonful Energy, and SolarAid provided local aid agencies in Malawi, Mozambique and Zimbabwe with solar lights and solar home systems to rapidly electrify humanitarian operations and emergency relief shelters to accommodate those made homeless by the disaster.<sup>74</sup> While in Assam, India, the local government and NGOs have prioritised the use of off-grid solar systems within flood shelters.75

### **POST-DISASTER RECOVERY**

Displaced people, especially those in protracted crises, require more diverse energy sources and services to support long-term recovery efforts than the basic technologies (solar lanterns and improved cookstoves) traditionally provided by humanitarian agencies.<sup>76</sup> This includes OGS technologies to enhance livelihood and infrastructure resilience and to provide other household and communal energy services such as access to information (including climate information), street lighting, education and healthcare.

For example, Practical Action's Climate Resilient Farming for Refugees project has supported both refugees and hostcommunities in Rwanda to adopt solar-powered irrigation and regenerative farming practices to enhance resilience in areas vulnerable to drought.<sup>77</sup> The project has improved soil health and water availability, enabling farmers to earn higher incomes through more diverse crop production. Failing to address the needs of both displaced and host communities, who often have similar levels of climate exposure and vulnerability, can undermine adaptation efforts, for example, by creating conflict over scarce resources in fragile ecosystems.<sup>78</sup>

- 74 GOGLA, Adaptation and Resilience in the Face of Climate Disasters in Mozambique: The Role of Off-Grid 77 Practical Action, Climate-resilient farming success for Rwandan refugees and farmers, 2024. Solar and Energy Access (Amsterdam: GOGLA, 2023).
- 75 Vois Planet, Case Study on Perennial Assam Floods and Innovations in Shelter Ecosystems 2022
- 76 Peter Hames, Matthew Thomas, Sarah Rosenberg-Jansen and Aimee Jenks, Moving beyond informal action: sustainable energy and the humanitarian response system, Journal of International Humanitarian Action, 6 (2021): 1-20.

78 UNHCR, How climate change impacts refugees and displaced communities, 2024.

Providing reliable electricity access in displacement settings can be logistically challenging as refugee camps are often located in remote areas and humanitarian staff often lack specialist knowledge and rely heavily on diesel generators, creating the risk of fuel shortages.<sup>79</sup> OGS companies are increasingly involved in providing energy access to both humanitarian agencies and displaced people. Based on data from GOGLA affiliates, it is estimated that at least 4.5 million OGS products have been sold in displacement settings (excluding Ukraine and Turkey) since 2016. This is increasing the reliability of electricity access and the range of energy services available to displaced people. New business models are also being adopted to reduce financial and operational risks affecting energy infrastructure used by humanitarian agencies. This includes bulk procurement where agencies buy electricity in bulk from a local provider operating a standalone system supplying the local grid and/ or host communities and outsourcing of operation and maintenance to specialised OGS companies.<sup>80</sup>

To improve post-disaster response and recovery, more needs to be done to integrate humanitarian assistance with approaches to increase electricity access and enhance resilience and adaptation. Despite growing displacement linked to climate change, refugees and IDPs are widely overlooked by national climate policies and plans.<sup>81</sup> Integrating more effective and sustainable forms of electricity access within the humanitarian system and displacement settings is also an ongoing challenge. However, there are some examples of where these three overlapping issues are being tackled together such as the Climate Action at the Last Mile project.

### **CASE STUDY: THE CLIMATE ACTION AT THE LAST MILE PROJECT (AUGUST 2023 - JULY** 2027)

The Climate Action at the Last Mile project, implemented in partnership with the IKEA Foundation with support from UNEP and Last Mile Climate, convenes stakeholders from across the climate, sustainable energy, development, and humanitarian communities to drive progressive action on addressing the climate crisis in displacement settings. This is driven by two partnerships:

- SOLCO is a climate action partnership led by Last Mile Climate focused on enabling affordable access to solar electric cooking for displaced families and their host communities. The partnership aims to transition over 250,000 households to solar cooking by 2027.
- EcoAdapt is a platform for collaboration among governments, NGOs, communities and private sector companies focused on largescale climate adaptation through nature-based solutions in refugee-hosting areas. It aims to combine indigenous knowledge with scientific advancements for reforestation, regeneration and land restoration aligned with host country climate policies and priorities.

![](_page_26_Picture_6.jpeg)

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# **CONCLUSION AND RECOMMENDATIONS**

The report set out to demonstrate the contribution of offgrid solar solutions to climate resilience and adaptation across four key impact areas: critical infrastructure and services; climate resilient livelihoods; climate information and early warning; and post-disaster response and recovery.

### **KEY FINDINGS**

Off-grid solar products can increase the climate resilience of electricity supply and provide crucial electricity infrastructure. This is either by providing a primary energy source to communities that currently lack access, or an alternative or back-up source of power. Offgrid products' physical properties also enhance energy resilience as they are portable, small scale and distributed - reducing hazard exposure. Nevertheless, OGS products are not immune to climate related impacts including damage by floods and extreme winds. Steps must also be taken to reduce products' exposure and vulnerability during design, installation, operation and maintenance.

**Off-grid solar products contribute to household and community resilience in diverse ways.** For example, solar home systems with charging capacity are being used to power communications devices through which families can receive critical climate adaptation and early warning information; solar-powered refrigeration units and water pumps are enhancing resilience by increasing incomes and food security, and solar home systems can reduce energy expenditure, creating the potential to increase household savings with which to buffer climate impacts. The role of off-grid solar in powering the resilience of energy poor communities should be better explored and supported. Resilience and adaptation outcomes can be optimised by linking and layering access to off-grid solar solutions with other interventions. For example, solar water pumps have the potential to significantly increase food security for small-scale farmers, but enhancing crop yields could reduce soil quality or lead to the overuse of the ground water supply. Linking the use of solar water pumps to sustainable or regenerative agricultural practices can help to improve resilience outcomes for households and the environment. Energy access via off-grid solutions can provide a critical input to climate resilience and adaptation but this can be optimised through linkages with other measures.

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### RECOMMENDATIONS

We urge greater recognition by climate funds, governments and other influential stakeholders of the role that off-grid solar solutions can play in enhancing climate resilience and adaptation. Many adaptation strategies - from accessing climate information services, to making livelihoods more resilient - require access to energy. Where communities are living with no, or limited, access to electricity this can often be achieved most rapidly via off-grid solar solutions. We encourage those working on resilience and adaptation efforts to engage more with the off-grid solar industry.

To enhance the contribution of OGS products to<br/>resilience and adaptation, we call for donors and<br/>investors to increase adaptation finance, and channel<br/>more funding to the off-grid solar sector. For example,<br/>adaptation finance could be used to support subsidies<br/>to help climate vulnerable communities access solar<br/>energy kits that can power access to climate information<br/>or appliances that support income generation and food<br/>security. Concessional debt and equity finance is needed<br/>to help off-grid companies to improve and expand their<br/>operations to reach more climate vulnerable customers,<br/>while innovations such as agro-climatic insurance and debt<br/>for climate swaps could be explored as mechanisms to help<br/>support energy access and security for the poorest.

We recommend that the off-grid industry continues to build new partnerships with those in adjacent sectors to 'link and layer' business models and interventions that increase resilience and adaptation. For example, a collaboration by actors working respectively on energy access, connectivity and early warning systems could prove transformational in ensuring that all people exposed to climate hazards can get the information they need to reduce the impact of extreme weather events. We encourage actors working within the energy access and climate adaptation sectors to explore new partnerships.

Finally, we invite stakeholders in the off-grid solar, adaptation and related sectors to use the resources accompanying this report to improve outcomes for climate vulnerable communities.

- The Off-Grid Solar Resilience and Adaptation Framework: A compilation of indicators and guidance, grouped by impact area, that can be used to understand, measure and evaluate the contribution of off-grid solar technologies to resilience and adaptation.
- **The Off-Grid Solar Resilience and Adaptation Sector Guidance:** A companion to the Framework which provides users with additional information to design and implement off-grid solar business models, projects and programmes to enhance climate resilience and adaptation. This includes guidance on assessing climate vulnerability, taking more intentional action to enhance resilience and adaptation and exploring how interventions can lead to transformational impact.

![](_page_28_Picture_7.jpeg)

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![](_page_29_Picture_0.jpeg)

The Voice of the Off-Grid Solar Energy Industry