GOGLA

OFF-GRID SOLAR: RESILIENCE AND ADAPTATION SECTOR GUIDANCE

A guide to enhancing the climate resilience and adaptation impacts of off-grid solar businesses, projects and programmes

COMPANION TO THE OFF-GRID SOLAR RESILIENCE AND ADAPTATION FRAMEWORK

IKEA Foundation

Practical ACTION

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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 innovate 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 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.

INTRODUCTION

685 million people worldwide lack access to electricity, with the majority living in countries with high vulnerability to climate change and low readiness to undertake adaptation measures.[1,2] A significant number of those without access to electricity (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.[3]

Access to off-grid solar (OGS) products has the potential to enhance climate resilience and adaptation (R&A) for off-grid consumers across a range of impact areas, including powering critical infrastructure and services, climate-resilient livelihoods, climate information and early warning systems, and post-disaster response and recovery. Without reliable electricity supply and key appliances, such as water pumps to increase crop production or communications devices to relay emergency information, highly vulnerable communities lack the tools they need to combat climate hazards and adapt to changing conditions.

This Sector Guidance aims to help companies, climate funders, investors, development organisations and governments to design and implement off-grid solar (OGS) products, services, investments and programmes in a more intentional way to enhance R&A for climate vulnerable communities.

The guidance can be used jointly with the Off-Grid Solar Resilience and Adaptation Framework – a compendium of indicators and metrics – and as a standalone resource.

KEY USE CASES FOR THE OFF-GRID SOLAR RESILIENCE AND ADAPTATION FRAMEWORK AND SECTOR GUIDANCE

Off-grid company	Donor or impact investor	Implementing organisations
Use cases		
Designing products and services to boost R&A within customer base • Reaching more climate-vulnerable customers • Identifying opportunities to enhance impact by combining OGS with other inputs and services **Communicating OGS contributions to resilience and adaptation** • Engaging new customers • Seeking funding • Seeking technical assistance **Reporting product and service impacts to donors and investors** • Receiving financial support e.g. results-based financing **Measuring and evaluating product and service contributions** • Improving business models • Improving product designs • Diversifying product ranges	**Understanding OGS contributions to resilience and adaptation** • Grouped by key impact areas • Aligned with climate fund priorities **Evaluating expected or actual OGS contributions** • Reviewing funding proposals • Evaluating company or programme impacts • Tracking contributions by OGS over time **Enhancing resilience and adaptation impacts** • Exploring ways to enhance R&A impacts e.g. by 'linking and layering' interventions or catalysing transformational change	**Developing theories of change to guide projects and programmes** • Providing financial or technical assistance to companies • Incorporating OGS into larger cross sector adaptation programmes **Developing project or programme proposals** • Communicating impact of OGS to donors • Designing programmes e.g. RBF schemes **Enhancing resilience and adaptation impacts** • Exploring ways to enhance R&A impacts e.g. by 'linking and layering' interventions or catalysing transformational change
Key outputs		
Business planning and strategies, reporting documents, funding proposals, marketing material e.g. product case studies	Company or project/ programme evaluation criteria, theories of change documents	Theories of change documents, monitoring and evaluation plans, risk and vulnerability assessments, funding proposals

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).

It seeks to align with best practice for designing and measuring resilience and adaptation business plans, programmes and other interventions and their impacts, as well as the common priorities and criteria used by donors and impact investors when funding and evaluating R&A interventions. These include steps recommended in the World Bank's Resilience Rating System and the Global Impact Investing Network (GIIN) IRIS + tool.[4,5]

Please note that this guidance is not exhaustive, and stakeholders are expected to use it appropriately based on their roles and capacities.

The Sector Guidance is structured around three key steps / sections:

1. **Understand the climate vulnerability context in which off-grid solar technologies will be used:** This step is the basis for identifying how OGS technologies can reduce climate risk and vulnerability and enhance resilience, both in general and in relation to specific hazards.

2. **Be intentional in identifying goals and activities to reduce climate risk and vulnerability:** This step is designed to help stakeholders to improve the ways that OGS business activities, projects or programmes can enhance resilience and adaptation outcomes and to avoid maladaptation. It can also help stakeholders to measure and evaluate R&A contributions and communicate them to key audiences.

3. **Consider how interventions might contribute to transformational adaptation:** This step helps stakeholders to consider how interventions can enhance resilience at greater speed, scale and depth. For example, by addressing root causes of vulnerability and tackling systemic barriers to energy access.

Each section contains case studies and resources to promote the application of Gender Equality and Social Inclusion (GESI) and Locally Led Adaptation principles and approaches. This is in recognition that the knowledge, needs and priorities of local communities – and within them, women and girls and other marginalised groups who are particularly vulnerable – can be better addressed both in energy access and resilience and adaptation efforts.

4 World Bank Group, Resilience Rating System (RRS) (Washington DC: World Bank Group, 2021).

5 Global Impact Investing Network (GIIN), IRIS+ System, About, 2025.

STEP 1: UNDERSTAND THE CONTEXT IN WHICH OFF-GRID SOLAR TECHNOLOGIES WILL BE USED

The first step in any resilience or adaptation intervention is to understand the current and anticipated climate hazards affecting households and communities in each context, and their different levels of exposure and vulnerability. For providers of OGS technologies, this will be the basis for determining whether and to what extent specific technologies and supporting activities can reduce exposure and vulnerability to climate hazard, and to ensure that interventions are reaching the target audience.

UNDERSTANDING KEY CONCEPTS: CLIMATE RISK, HAZARDS, VULNERABILITY AND MALADAPTATION

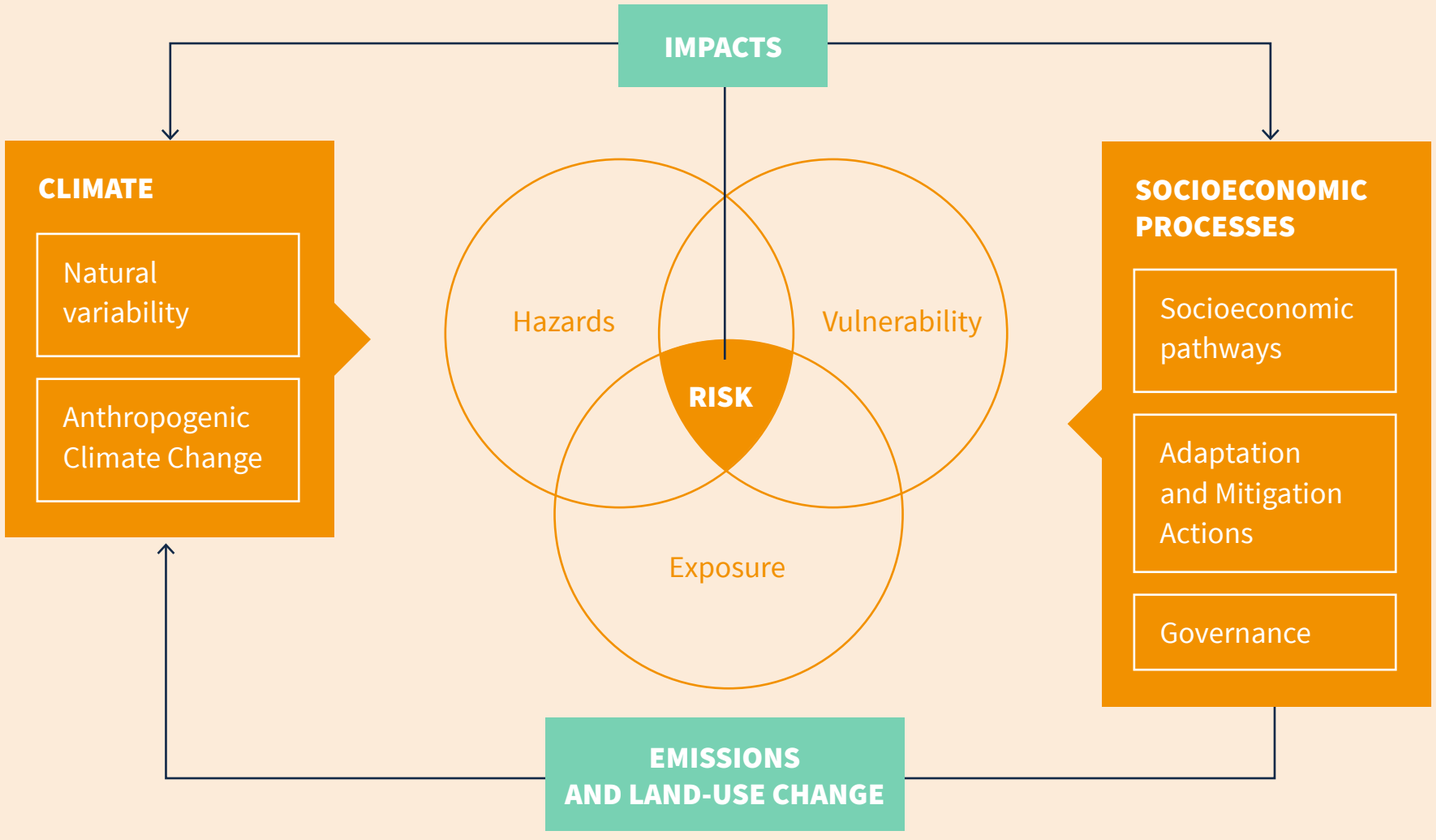
CLIMATE RISK

The Intergovernmental Panel on Climate Change (IPCC) defines climate risk as 'The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems'.[6] It is widely viewed as a function of the hazard(s) to which individuals are exposed and their vulnerability to adverse consequences (as shown in Figure 1).[7]

Risk will be higher or lower depending on the nature and severity of the climate hazard and the individual's degree of exposure and vulnerability. Exposure and vulnerability will be higher or lower depending on the capacity that individuals have to prepare for and respond to the hazard i.e. their resilience.

FIGURE 1: ILLUSTRATION OF THE CORE ELEMENTS OF CLIMATE RISK

Source: IPCC, 2014



6 Intergovernmental Panel on Climate Change (IPCC), Glossary, 2025.

7 IPCC, Assessing and Managing the Risks of Climate Change, 2014.

CLIMATE HAZARDS, EXPOSURE AND VULNERABILITY

Hazards are defined as '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'.[8]

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).

Whether and to what extent people are impacted by hazards is determined by their:

- 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'; and

- Vulnerability: 'The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and level of capacity to cope and adapt. Various social, economic, political factors create vulnerability acting at different scales and over different time periods.[9]

Climate risk and vulnerability assessment is a key step in identifying potential adaptation opportunities. It is also crucial for reviewing, and mitigating, the potential for interventions that have unintended negative outcomes, including maladaptation.

MALADAPTATION

Maladaptation refers to 'Actions that may lead to increased risk of adverse climate-related outcomes, 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'.[3] In such a scenario, an intervention reinforces or redistributes climate vulnerability or creates new sources of vulnerability within a given context.[11]

Maladaptation is more likely to occur if drivers of climate risk and vulnerability (social, political, economic and environmental) are poorly understood or if interventions are guided by top-down design making or elite capture. Here, the needs of some social groups may be prioritised over the needs and priorities of others, such as women, girls, refugees and people in extreme poverty, who may be disproportionately affected by climate hazards or unable to benefit from interventions due to existing power structures and social norms.[12]

ASSESSING CLIMATE VULNERABILITY

UNDERSTANDING CLIMATE RISK AND VULNERABILITY

Organisations will have different capacities to assess climate risk and vulnerability. While larger off-grid solar companies may have developed their own tools and resources, most are likely to struggle to conduct in-depth assessments and will require support from funders, development organisations and researchers. Stakeholders can use the questions and resources below to support the process of assessing risk and vulnerability and identify if support is needed.

GUIDING QUESTIONS

Questions to help off-grid companies and development organisations:

- What climate hazards are affecting people in your target context (both current hazards and projected future hazards and impacts)?

- How might climate hazards affect the financial health of customers/end-users of technologies and their ability to pay?

- Is climate risk greater for certain individuals or groups based on their exposure (i.e. location) and vulnerability, for example, due to factors such as gender, income and disability?

- Do you require additional support to assess climate risk and vulnerability, for example, from an investor, donor or development organisation?

8 IPCC, Glossary, 2025.
9 Kimberley Thomas, R Dean Hardy, Heather Lazrus, Michael Mendez, Ben Orlove, Isabel Rivera-Collazo et al, "Explaining differential vulnerability to climate change: A social science review", *Wiley Interdisciplinary Reviews*, 2 (2019).
10 Ibid
11 Siri Eriksen, E. Lisa F. Schipper, Morgan Scoville-Simonds, Katherine Vincent et al, "Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance?", *World Development*, 1 (2021): 1-16.
12 Kevin Johnstone and Sam Green, Energising adaptation: key considerations for coupling energy access with climate adaptation and resilience (London: IIED, 2024).

RESOURCES TO SUPPORT CLIMATE RISK AND VULNERABILITY ASSESSMENTS

There are several resources available to support climate risk and vulnerability assessments. As a minimum, we recommend that stakeholders use a recognised tool, such as the ND-GAIN Annual Country Index, to identify whether the country or countries in which they operate are assessed to have high vulnerability to climate change.

National level assessment tools

- The ND-GAIN Annual Country Index Index can be used to assess the level of climate vulnerability and readiness for adaptation at the national level within countries in which stakeholders operate. The index ranks over 180 countries annually, measuring across 45 indicators to assess the country's level of vulnerability to climate change and readiness to successfully implement adaptation solutions. Indicators include those for electricity access, disaster preparedness, and agricultural technological capacity including the proportion of land equipped for irrigation.

- The World Bank's Climate Change Knowledge Portal is a 'one stop shop' for global data on historic and future climate trends, vulnerabilities and sectoral climate impacts.

Local level assessment tools

Where feasible, stakeholders should then use a more regionally specific tool, such as ThinkHazard!, to identify specific climate hazards that are likely to affect end users of technologies in more localised regional areas.

- ThinkHazard! supported by the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR), provides hazard-level ratings for all countries and sub-national units. It covers 73 rated hazards—including extreme heat, water scarcity, flooding, earthquakes, landslides, tsunamis, cyclones, and wildfires—and can help identify a location's baseline exposure to risks.

- Nithio, a climate fintech platform providing concessional debt to OGS companies, developed its own Climate Vulnerability Index (CVI) to help investors to understand how best to reach climate-vulnerable communities. The CVI is a geospatial measurement tool that assesses the susceptibility of communities to the compounding effects of extreme weather conditions and socioeconomic disadvantages and has data on countries including Kenya and Nigeria.

- Other climate-related geospatial mapping resources developed by organisations operating in the energy access sector, such as the climate intelligent infrastructure tool developed by VIDA.

National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs)

Countries own plans around resilience, adaptation and mitigation can also include valuable insights on climate risks, hazards and vulnerabilities.

- National Adaptation Plans and Nationally Determine Contributions, where available, contain national-level climate risk and vulnerability assessments and reference the national studies and reports that inform these assessments. National meteorological organizations and universities can often provide more localized hazard and climate risk information.

Consultation with sector experts

Sector experts, including universities and climate-focused organisations or national bodies, can provide key guidance and knowledge around climate risk and vulnerability, including where this relates to adjacent sub-sectors such as health, energy, agriculture, and water.

Local, participatory, and multi-stakeholder assessments

Approaches which develop climate risk and vulnerability assessments at the local level require experience and resources. However, participatory approaches have the added advantage of tapping into local knowledge and using the process of engagement with local communities to get buy-in for the design, implementation, and evaluation of interventions. This aligns with the principles of Locally Led Adaptation. Well-designed participatory processes will also promote GESI.[13] Examples include:

- Practical Action's Missing Voices Approach which aims to capture the perspectives of marginalized people to inform disaster risk management including the design of people-centred early warning systems. Anonymity, privacy, and confidentiality are prioritized. Interviews are conducted with marginalised people aiming to build understanding of pre-identified themes, with open questions and active listening to understand the issues, challenges, and opportunities that each individual wants to talk about.

- The Climate Vulnerability and Capacity Assessment (CVCA) is a community-level tool that integrates climate change into wider participatory vulnerability analysis. The CVCA can support gender-responsive assessment, and learning is supported both through self-guided and customized training through the CARE Climate and Resilience Academy. Assessment approaches like the CVCA also include consultation with national and local experts to integrate climate data.

13 CARE, Orientation Guide on Gender Equality and Adaptation, 2019.

GENDER EQUALITY AND SOCIAL INCLUSION

Gender Equality and Social Inclusion (GESI) refers to approaches that recognize that different people, such as women and girls, people living with disabilities, indigenous populations, and refugees, often have different vulnerabilities and needs, and may experience barriers in their inclusion in decision-making processes and access to opportunities.

- Gendered responsibilities may mean that women and girls are more exposed to hazards such as heat stress when outside or walking long distances to collect water and energy resources

- People with disabilities hindering their mobility are likely to be more exposed and vulnerable to rapid-onset events such as flash floods

Assessing climate risk and vulnerability in an inclusive way will increase the likelihood that interventions involving OGS technologies are effective and appropriate for all and do not lead to unintended or maladaptive outcomes for certain groups.

STEP 2: BE INTENTIONAL IN IDENTIFYING GOALS AND ACTIVITIES TO REDUCE CLIMATE RISK AND VULNERABILITY

Once climate risk and vulnerability have been assessed, the next step is to consider how off-grid solar business activities, projects and programmes can be used to enhance climate resilience and adaptation outcomes.

UNDERSTANDING KEY CONCEPTS: ADAPTATION, RESILIENCE AND THE 3 'A'S

Climate change adaptation refers to '…the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities'.[14]

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.[15] Systems that undergo successful adaptation are likely to become more resilient to climate hazards. Enhancing resilience and undertaking adaptation are not ends in themselves but part of a necessary process to achieve impacts associated with improved wellbeing and sustainable development, such as better health and nutrition, education, ecosystem health, incomes, poverty reduction and standards of living, over the long-term despite climate change.[16, 17, 18]

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.[19] This contributes to making resilience to climate change challenging to measure; a single set of universally recognised indicators have so far not been established.[20] However, several frameworks and tools exist to assess, diagnose and evaluate adaptation and changes in resilience within social, economic and ecological systems.[21] While imperfect, these frameworks address conceptual and practical challenges to measurement including the critique that resilience can only be said to have been enhanced when tested by a hazard event.

THE 3 A'S: BUILDING CAPACITY

Resilience can be conceptualised as containing three interrelated capacities:[22]

- **Anticipatory capacity:** the ability of social systems to anticipate and reduce the impacts of climate hazards through prior planning and preparation. This is demonstrated through proactive and targeted responses to known hazards before they happen to avoid or reduce negative impacts e.g. weather forecasting to assess the duration and strength of storms and hurricanes.

- **Absorptive capacity:** the ability of social systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. This is demonstrated through the ability to access and deploy tangible assets, such as savings, and intangible assets, such as social networks, to cope with the immediate impacts of disasters such as injury or damage to assets.

- **Adaptive capacity:** the ability of social systems to adjust to, moderate, and recover from potential hazards, to continue to function without major qualitative changes. This is demonstrated through the ability to build and sustain incomes and other assets and make livelihood decisions, such as investing in new equipment or diversifying activities, to reduce climate risk. This capacity is typically apparent and strengthened during non-emergency periods.

14 IPCC, Glossary
15 Ibid
16 Nick Brooks and Susannah Fisher, Tracking Adaptation and Measuring Development: a step-by-step-guide (London: International Institute of Environment and Development, 2014).
17 Aditya Bahadur and Florence Pichon, Analysis of Resilience Measurement Frameworks and Approaches (London: Overseas Development Institute, 2016).
18 IPCC, FAQ 6: What is Climate Resilient Development and how do we pursue it? 2025.
19 Aditya Bahadur and Florence Pichon, *Analysis of Resilience Measurement Frameworks and Approaches*
20 United Nations Framework Convention on Climate Change (UNFCCC), Global Goal on Adaptation, 2025.
21 Aditya Bahadur and Florence Pichon, *Analysis of Resilience Measurement Frameworks and Approaches*.
22 Aditya Bahadur, Katie Peters, Emily Wilkinson, Florence Pichon and Thomas Tanner, The 3As: tracking resilience across BRACED (London: Overseas Development Institute, 2015).

An advantage of the using the capacities approach to assess R&A is that resilience, including the capacity for adaptation, can be measured at any time without waiting until hazard impacts occur.[23] An increase in one or more resilience capacity indicates reduced exposure or vulnerability and increased likelihood of successfully responding to a climate hazard. As a result, it is possible to assess how interventions, including access to OGS technologies, contribute to resilience by examining contributions to the development of specific capacities.[24]

To assess the contribution of off-grid solar technologies to resilience and adaptation, we recommend assessing changes to one or more of the 3 'A' resilience capacities within households and communities. However, stakeholders should keep in mind that household and community resilience will also be influenced by social, economic, political and environmental factors unrelated to energy access in the broader context, including other adaptation initiatives.[25]

BEING INTENTIONAL: DEVELOPING A THEORY OF CHANGE

Stakeholders, including off-grid solar companies and development organisations, can develop a theory of change (ToC) to help plan, measure, monitor and evaluate the contribution of OGS products and services to climate resilience and adaptation. The development of a ToC also allows for intentional exploration of whether an intervention can be enhanced to increase its impact on resilience and adaptation.

A ToC is a 'description of a sequence of events that is expected to lead to a particular desired outcome'.[26] At the design stage, stakeholders should explore how OGS technologies, alone, alongside or integrated with other activities, can enhance one or more of the 3 'A' capacities. This will be predictive based on an understanding of the context in which OGS technologies will be used (developed through a risk and/or vulnerability assessment) and existing evidence of positive impact.

HOW TO DEVELOP A THEORY OF CHANGE

The first step in developing a ToC is to identify clear inputs, outputs, outcomes and impacts:

- Input: Action to deliver access to OGS technologies alone e.g. sale of OGS irrigation system, where relevant, alongside or integrated with other activities that can enhance R&A e.g. sale of drought resistant crops.
- Outputs: Activities, products and services produced or improved by interventions.
    - Outputs suggest the potential for OGS technologies to contribute to resilience e.g. number of farmers with access to improved irrigation and drought resistant crops.
- Outcomes: Short-or-long-term changes such as individual, household and/or collective actions, benefits, and unintended consequences, resulting from outputs.

EXAMPLE INDICATORS TO MEASURE OGS CONTRIBUTIONS TO RESILIENCE AND ADAPTATION

OUTPUT LEVEL:

- Number of OGS products sold (GOGLA Impact Metric)
- People using products to support enterprises (GOGLA Impact Metric)

OUTCOME LEVEL:

- Number of people experiencing an annual increase in business income of at least 30% due to owning a refrigerator (Efficiency for Access Impact Framework)
- Number of people who perceive the use of the appliance improves food security (Efficiency for Access Impact Framework)

23 Nick Brooks, Simon Anderson, Ian Burton, Susannah Fisher, Neha Rai and Ian Tellam, An operational framework for Tracking Adaptation and Measuring Development (TAMD) (London: IIED, 2013).

24 Andrew Scott, Leah Worrall, Jesper r Hörnberg and Long Seng To, How solar household systems contribute to resilience (London: Overseas Development Institute, 2017).

25 Kevin Johnstone and Sam Green, Energising adaptation: key considerations for coupling energy access with climate adaptation and resilience (London: IIED, 2024).

26 Rick Davies, Criteria for assessing the evaluability of Theories of Change, 2012.

- Positive outcomes are proxies for changes to one or more resilience capacity e.g. number of farmers increasing yields because of better irrigation and drought resistant crops.

- Unintended negative outcomes that enhance climate risk are considered maladaptive.

- Stakeholders have less control over outcomes compared to outputs as outcomes are often the result of multiple factors.

- Impacts: Long-term positive and negative changes in the context of climate change contributed to by outputs and outcomes.

  - Positive impacts include improved health and nutrition, poverty reduction, education, livelihoods and standards of living despite climate change.

  - Impacts are long term and may take significant resources to measure and monitor.

Identifying the inputs, outputs, outcomes and intended impacts of an intervention via a ToC will help stakeholders to plan interventions and identify the role and limitations of OGS products.

Importantly, it should not be assumed that outputs will contribute to outcomes in a linear 'if x, then y' logic as this is often influenced by enabling and constraining factors. For example, it should not be taken as given that the use of solar water pumps to support irrigated agriculture (an output) will translate into enhanced drought resilience (outcomes) if the local water supply is vulnerable to over-extraction. In this context, adopting more water-efficient pumps and combining technologies with additional measures such as water demand management will be needed to reduce maladaptation risks. Once outputs and outcomes have been identified, stakeholders can adopt or develop corresponding indicators to measure the contribution of OGS products. Example indicators and further guidance for measuring contributions can be found in the accompanying Off-Grid Solar Resilience and Adaptation Measurement Resource.

Alongside indicators, stakeholders should develop supporting narratives to make explicit the assumed causal links between outputs, outcomes and impacts.[9] This will be predictive at the design stage based on understanding of the context and past use cases. At the measurement and evaluation stage, stakeholders should capture the experiences of those using or benefitting from distributed OGS products and supporting activities. Combining these with data from output and outcomes indicators will allow stakeholders to evaluate whether the links between OGS technologies and resilience outcomes that were predicted at the design stage were realistic or achieved during implementation, or whether changes need to be made to improve OGS contributions or to avoid unintended outcomes in future. A ToC should be evolving, as learning and contexts evolve.

WHAT DOES A THEORY OF CHANGE LOOK LIKE IN PRACTICE?

This an example of a ToC to guide interventions to enhance livelihood resilience in an agricultural setting which combines access to solar water pumps and more resilient farming methods.

GUIDING QUESTIONS TO HELP STAKEHOLDERS DEVELOP A THEORY OF CHANGE

Core questions:

- What resilience and adaptation outcomes do you want to achieve? Think about the 3 'A' resilience capacities that need to be enhanced to reduce levels of exposure and vulnerability to climate change in your context.

- To what extent can OGS products and services contribute to these outcomes by enhancing one or more resilience capacity?

- Can you achieve greater impact by combining OGS products with other products, services or supportive measures, including through partnership with other organisations?

- How many customers can benefit from expected changes (female/ male)?

Gender equality and social inclusion

- Is access to and control over OGS products and services likely to be different for different groups? How will this influence the distribution of resilience benefits?

- Can products and services, business models and company operations be adapted to be more inclusive of the needs of specific groups e.g. women and girls?

Locally led adaptation:

- Can OGS products and services be delivered in ways that better address and prioritise customers' resilience needs?
- Can product and service financing mechanisms (e.g. PAYGo or Energy as a Service) be provided in a more patient, flexible and accessible way to help customers in uncertain and evolving contexts?
- Can the capacities of local stakeholders to manage interventions to enhance resilience in the long term be strengthened?

Addressing maladaptation risks

- Is there a risk that using OGS technologies will lead to unintended or maladaptive outcomes?
- Can maladaptation risks be reduced by combining OGS products with supportive measures? This includes other outputs provided by companies themselves or by partner organisations.

LOCALLY LED ADAPTATION

The Global Commission on Adaptation has developed a set of 8 principles for Locally Led Adaptation to guide organisations in developing and implementing interventions.

1. Devolving decision making to the lowest appropriate level
2. Addressing structural inequalities faced by different groups
3. Providing patient and predictable funding that can be accessed easily
4. Investing in local capabilities
5. Building a robust understanding of climate risk and uncertainty
6. Flexible programming and learning
7. Ensuring transparency and accountability
8. Collaborative action and investment

FURTHER READING ON THE OGS CONTRIBUTION TO RESILIENCE AND ADAPTATION

Examples of how OGS technologies can contribute to climate resilience and adaptation alone, alongside or integrated with other activities can be found in various reports, including:

- Off-Grid Solar: Powering Climate Resilience (GOGLA, 2025)
- Powering Adaptation and Climate Justice: The Critical Role of Off-grid Solar Technologies (GOGLA, 2023).
- Energising adaptation: key considerations for coupling energy access with climate adaptation and resilience Johnstone and Green (2024)
- Bracing for Climate Impact: Renewables as a climate change adaptation strategy (IRENA, 2021)
- How solar household systems contribute to resilience Scott et al (2017)
- Literature Review on Energy Access and Adaptation to Climate Change (Perera et al, 2015)
- Energy and Adaptation: Exploring how energy access can enable climate change adaptation (Practical Action, 2013)

INCREASING RESILIENCE WITH SOLAR WATER PUMPS
EXAMPLE THEORY OF CHANGE

IMPACTS: SUSTAINABLE DEVELOPMENT GOALS ARE ACHIEVED DESPITE CLIMATE CHANGE

- Increased incomes & food security reduce poverty & improve living standards
- Increased incomes & food security reduce hunger & improve health outcomes
- Adoption of sustainable farming practices & water demand management improve ecosystem health

OUTCOMES: FARMERS' CLIMATE RESILIENCE IS INCREASED

- Solar irrigation increases agricultural yields. Crops are diversified & drought resilient
- Higher yields & better access to markets increase farmers' incomes
- Drought impacts are moderated & farmers avoid negative coping mechanisms
- Farmers can invest income in improving & diversifying livelihoods

OUTPUTS: SMALL-SCALE FARMERS ADOPT SOLAR WATER PUMPS & RESILIENT FARMING PRACTICES

- Farmers purchase efficient solar irrigation pumps
- Farmers manage water extraction sustainably
- Farmers use drought tolerant crops & sustainable practices
- Farmers have better access to markets & other inputs

INPUTS: OGS COMPANIES REACH CLIMATE-VULNERABLE CUSTOMERS & NGOS PROVIDE ADDITIONAL SUPPORT

STEP 3: CONSIDER HOW INTERVENTIONS CAN SUPPORT TRANSFORMATIONAL ADAPTATION

As part of an intentional approach, stakeholders may consider how interventions can go further and support 'transformational' change for target households and communities.

UNDERSTANDING KEY CONCEPTS: TRANSFORMATIONAL ADAPTATION

The IPCC defines transformational adaptation as 'Adaptation that changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts'. This includes efforts to holistically and fundamentally 'build, reshape and enhance' the three resilience capacities: anticipatory, absorptive and adaptive.[28] It also includes looking for system-wide, long-term changes or questioning the effectiveness of existing systems, including social injustices and power imbalances that produce and maintain climate vulnerability.[29]

Each of the four climate funds prioritise investments to support transformational adaptation. For example, the Green Climate Fund (GCF) interprets projects and programmes as transformational if they catalyse a *paradigm shift* for target stakeholders, institutions, geographies and processes.[30] This refers to the degree to which an investment can catalyse impact into medium or long-term sectoral change beyond a one-off investment.

Key characteristics of transformational adaptation as defined by the GCF are:

- **Depth:** the degree to which an intervention has been embedded within the target group or system. It involves changes that cut across sectors, levels, and generations, altering behaviours, cultures, decision making power dynamics, and structures (markets, laws, institutions, and social norms)
- **Scale:** the degree to which there has been a significant increase in results beyond the scope of the project.
- **Speed:** how quickly transformations can be achieved. The urgency of the climate crisis makes outcomes achievable in 5-10 years (the 2030 goal) especially important as each 'missed year' increases the size and complexity of the challenge.

EXPLORING HOW INTERVENTIONS IN THE OGS SECTOR SUPPORT TRANSFORMATIONAL ADAPTATION

Transformational adaptation is unlikely to be achieved by individual OGS products and services as it requires broader changes to the contexts in which technologies are used.[31] However, governments, development actors and impact investors may find it useful to consider how investments in OGS technologies can contribute to transformational adaptation by supporting changes at depth, scale and speed. While companies could consider how they might partner or engage with other resilience and adaptation interventions to optimise the R&A impact of the technologies they sell.

MOBILISING FINANCE AT SCALE

The Green Climate Fund (GCF) views interventions as supporting paradigm shifts or tipping points towards clean energy generation and access, recognizing the potential for climate mitigation and adaptation, if they address systemic barriers.[32] For example, a lack of working capital and affordable finance for OGS companies hinders their ability to improve and scale their operations to reach new customers. To address this barrier, the fund aims to mobilise investment to support companies, including a mix of private and public finance with which to de-risk investments, unlock local capital, provide liquidity and deepen access to commercial finance for energy investments. This aligns with a focus on achieving transformation by enhancing the speed and scale at which adaptation outcomes, in this case access to clean, decentralised energy sources, can be achieved.

One example of how the GCF seeks to mobile finance at speed and scale is through its co-financing of Acumen's Hardest to Reach Initiative.[33] This initiative prioritises OGS

28 Aditya Bahadur, Katie Peters, Emily Wilkinson, Florence Pichon and Thomas Tanner, The 3As: tracking resilience across BRACED (London: Overseas Development Institute, 2015).
29 Kate Lonsdale, Transformational adaptation: what it is, why it matters and what is needed, 2015.
30 Green Climate Fund, Sectoral guide: Energy access and power generation, 2022.
31 Kevin Johnstone and Sam Green, *Energising adaptation: key considerations for coupling energy access with climate adaptation and resilience*
32 Green Climate Fund, Sectoral guide: Energy access and power generation, 2022.
33 Acumen, Acumen Launches New Hardest-to-Reach Initiative to Achieve Universal Energy Access, 2024.

solutions for achieving both mitigation and adaptation and providing affordable first-time electricity access in remote and underserved areas. It will deploy USD 250 million of blended finance (debt, equity, grants) to OGS companies (65 million from the GCF) along with technical assistance to enable 72 million people to access electricity across 16 countries in Africa.

Governments, development actors and investors can explore how their interventions can help to achieve resilience and adaptation tipping points, including by 'crowding in' additional financing that can rapidly enhance the speed and scale of impact.

LAYERING AND LINKING INITIATIVES

Another way to approach transformational adaptation is to consider how a project or programme can achieve change at greater depth by altering practices and working across sectors. Funders and implementors of resilience programmes have often adopted the concept of *sequencing*, *layering*, and *integrating* a series of investments to enhance resilience (USAID Resilience Policy, 2019) or *layering* and *linking* activities to improve outcomes towards enhanced resilience.[34] This could include exploring how combining investments in access to OGS technologies with other investments can enhance resilience benefits generated by multiple solutions.

Digital tools increasingly play a role in enabling people to prepare for, respond to and recover from climate-related disasters.[35] For example, the Zurich Climate Resilience Alliance provides communities with a web-based tool and mobile app to evaluate and measure their resilience and identify interventions that can be taken to enhance R&A.[36] Similarly, AtmoGo, a non-profit organisation, also provides a digital platform to people in Indonesia and Puerto Rico which can be used to share hazard and early warning information and offer support.[37] Digital financial services are also increasingly seen as vital to enhancing resilience by providing access to remittances, loans and cash assistance with which to buffer and adapt to climate impacts.

Accessing such digital tools in remote, off-grid areas requires a linked and layered ecosystem of technologies and services including access to mobile phones, charging capacity provided by OGS technologies, data and sufficient training. Given this dependence, increasing the scale and speed with which people benefit from such R&A solutions in off-grid settings would require a linked and layered intervention incorporating multiple investments and collaboration across sectors and stakeholders. This includes efforts to improve mobile network coverage, mobile phone affordability and access to OGS technologies needed to charge devices. Evidence shows that OGS companies are contributing to financial inclusion by improving mobile account ownership and customers' credit histories, and by providing consumer financing to communities previously excluded from financial services.[38] In such cases, they could play an important role in linked and layered programmes to enhance financial inclusion, energy access and resilience in remote areas.

Layering and linking interventions, including via partnerships between OGS companies and operators in adjacent industries and multi-faceted programmes developed by governments and development actors, can lead to transformational R&A outcomes.

GENDER EQUALITY AND SOCIAL INCLUSION

From a depth perspective, transformational adaptation should also address root causes of climate vulnerability. One way to approach this is to consider how vulnerability varies for different groups. There are often differences in disaster outcomes between women and men, shaped by differences in social roles and access to technology, information, and services.[39] Mobile phones and internet access are key to accessing climate information services, including early warning. However, women remain 15% less likely than men to use mobile internet across low-and middle-income countries.[40] More broadly, women tend to have less control over household expenditure and decision making, restricting their ability to purchase technologies.[41]

Gender Equality and Social Inclusion plans can be used to address gender gaps in access to and ownership of technologies and services that enhance women's agency

34 Jennifer Leavy, Edward Boydell, Stephen McDowell and Barbora Sladkova, Resilience Results BRACED Final Evaluation (Brighton: ITAD, 2018).

35 Kathryn E. Anthony, Steven J. Venette, Andrew S. Pyle, Brandon C. Boatwright, Carrie E. Reif-Stice, "The role of social media in enhancing risk communication and promoting community resilience in the midst of a disaster", in *Risk Communication and Community Resilience*, ed. Bandana Kar and David M. Cochran, Jr. (London: Routledge, 2020).

36 Climate Resilience Alliance, Climate Resilience Measurement for Communities, 2025.

37 Miguel Aguirre, Can Mobile Phones Improve Disaster Preparedness? 2018.

38 Global System for Mobile Communications (GSMA), What is the value of pay-as-you-go solar for mobile operators? (London: GSMA, 2020).

39 Alvina Erman, Sophie Anne De Vries Robbé, Stephan Fabian Thies, Kayenat Kabir and Mirai Maruo, Gender Dimensions of Disaster Risk and Resilience (Washington DC: World Bank Group, 2021).

40 Global System for Mobile Communications (GSMA), The Mobile Gender Gap Report 2024 (London: GSMA, 2020).

41 University of Oslo, TERI, Seacrester Consulting and Dunamai Energy, Women's empowerment and electricity access: How do grid and off-grid systems enhance or restrict gender equality? (The Hague: Hivos, 2019).

and resilience. From a depth perspective, such a plan might seek to alter behaviours, cultures and power dynamics by shifting government policy and market systems towards gender equality:

- **Gender mainstreaming through policy:** Kenya's Ministry of Energy Gender Policy, launched in 2019 requires the energy needs and implications of energy access planning at all levels to be assessed for both men and women. Progress towards the development of the policy was achieved through multi-stakeholder efforts, including gender audits, and sensitization of government agencies and the energy industry to the importance of prioritising the needs and perspectives of women and girls.[42]

- **Gender mainstreaming through market systems:** The Global Distributors Collective shares lessons learned for gender inclusion for OGS companies, noting that gender-diverse companies are found to be more productive and perform better including in customer acquisition and retention, and improved sales to women customers.

EXPECTED OUTPUTS: WHAT DOES APPLYING TRANSFORMATIVE ADAPTATION HELP YOU TO DO?

Viewing activities, investments and programmes through a transformational lens can help stakeholders to identify opportunities to contribute to adaptation at greater depth, scale and speed. However, given the limited application of transformational adaptation in practice,[43] there is little technical guidance around how to design for transformation.

A first step is to review the key characteristics of transformative adaptation and consider how they can be applied in practice to increase the pace and scale of R&A outcomes enabled by off-grid solar solutions. This will require a strong commitment to intentionality, either in mobilising finance to scale up proven solutions, or in developing multi-faceted partnerships and programmes that can 'layer and link' initiatives and mainstream inclusive approaches.

FURTHER READING ON TRANSFORMATIONAL ADAPTATION

- Transformational Adaptation: what it is, why it matters & what is needed (Lonsdale, K., Pringle, P. & Turner, B. 2015)

- Sectoral guide: Energy access and power generation (GCF, 2022)

42 Practical Action, Mainstreaming Gender in National Energy Policy and Plans: Learning from Kenya's Journey and Success, 2023.

43 Sonja J. Vermeulen, Dhanush Dinesh, S. Mark Howden, Laura Cramer and Philip K. Thornton, "Transformation in Practice: A Review of Empirical Cases of Transformational Adaptation in Agriculture Under Climate Change", *frontiers in Sustainable Food Systems*, 1 (2018): 1-17.

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