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FOSTERING LIVELIHOODS WITH DECENTRALISED RENEWABLE ENERGY

AN ECOSYSTEMS APPROACH

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. www.irena.org

About SELCO Foundation

SELCO Foundation is an open-source, not-for-profit organization, that is dedicated to innovating and replicating sustainable energy solutions that address poverty alleviation and climate change. Using sustainable energy as an enabler, SELCO Foundation has improved livelihood opportunities by empowering nano and micro enterprises with energy efficiency and affordable, modern energy solutions, strengthened the last mile health infrastructure and improved access to modern learning environments in some of the most under-resourced geographies. Its ecosystem approach and deep understanding of the needs of the poor has led to the development of sustainable models for partners who disseminate these renewable energy based solutions, new financial products that serve low income households and bottom-up policies that encourage equity and improved ownership at the bottom of the pyramid. It was founded in 2010 and is headquartered in Bangalore, India. www.selcofoundation.org

Contents

Figures

Boxes

Table

Executive summary

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Access to modern energy is a pre-requisite for socio-economic development. Yet, over 750 million people continued to live without electricity access in 2019 and many more had to contend with unreliable supply. The consequent economic and social cost is significant and a key argument for mobilising urgent action and investments to reach universal access by 2030 – as targeted under Sustainable Development Goal 7. An integral part of achieving the 2030 Agenda and building back better from the COVID 19 pandemic will be steps to catalyse rural economies, create local jobs and ensure resilient public infrastructure. Access to modern energy should be a central pillar of such recovery and will contribute to a more inclusive and just energy system in the long-term.

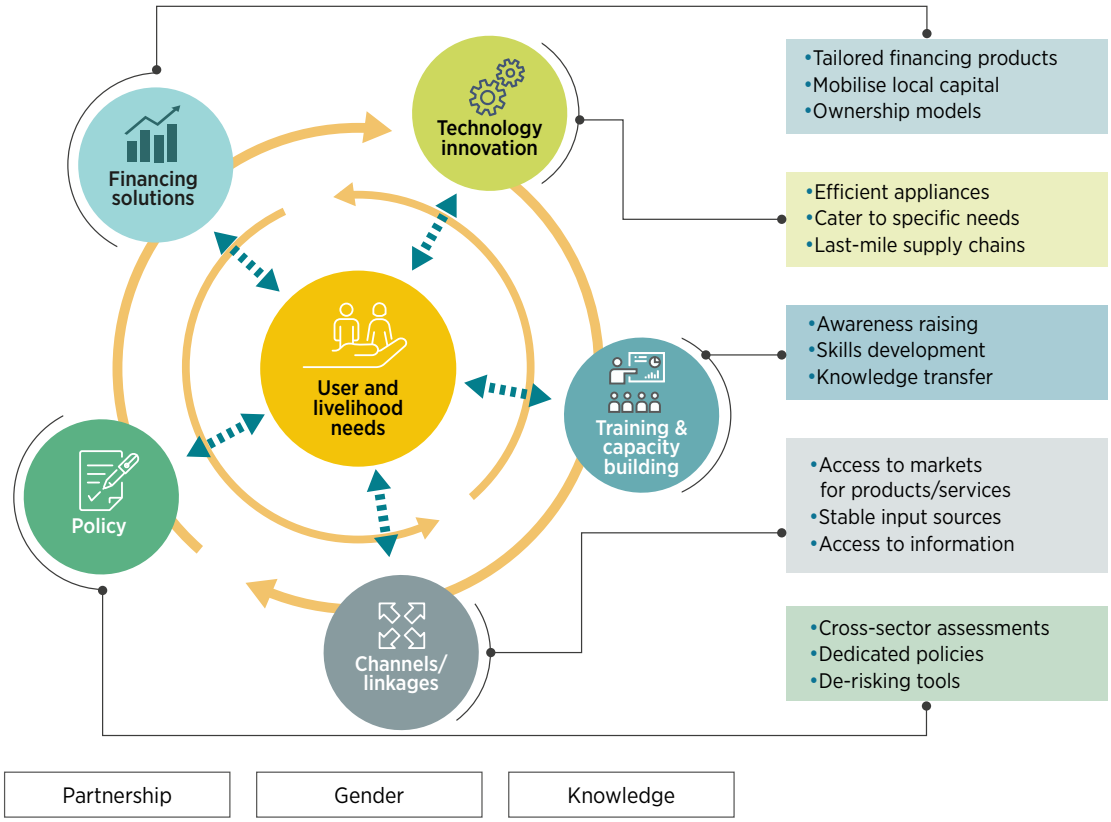
Decentralised renewable energy solutions promise to play an essential role in reaching universal energy access in a timely manner. Linking decentralised renewables with livelihoods is an important step. It offers the opportunity to translate investments in electricity connections and kilowatt-hours into higher incomes for communities and enterprises, local livelihood opportunities and well-being for large populations in rural and peri-urban areas. However, it is not the only pre-requisite. Achieving this transformative change requires greater efforts than simply deploying decentralised systems or delivering units of electricity. It requires investing in an ecosystem that positions the diversity of people's livelihoods (rather than technological solutions) at the centre of energy access efforts, and delivers tailored energy solutions, the financing, capacity and skills, market access and policy support to realise the full benefits of decentralised renewable energy.

Components of an ecosystem for supporting livelihoods with decentralised renewables

This brief discusses the 'ecosystem' necessary for linking electricity services through decentralised renewable energy with people's livelihoods. Building on case studies and examples from different regions and contexts, it outlines how energy access programmes and initiatives are tackling the various ecosystem components to sustain and strengthen existing livelihood activities or facilitate new ones. The ecosystem's critical components are as follows (Figure ES.1):

1. *Technology innovation*: deliver tailored energy solutions to meet energy needs for livelihoods; development, availability and accessibility of efficient appliances; supply chains via manufacturers and enterprises to provide solutions, operation and maintenance services till the last-mile.
2. *Financing solutions:* facilitate access to cash-flow-based financial products; targeted public financing support for end-users and enterprises; appropriate delivery models for financing, including engagement of intermediaries; and technical assistance funds for market development.
3. *Backward and forward linkages (market access):* establish stable supply chains of inputs/raw materials; strengthen market access for increased output and new goods and services; increased awareness and partnerships for demand generation, including through aggregation.
4. *Training and capacity building:* support business and skills development; training modules on technology use and operation and maintenance, demonstration labs; mentorship and increased awareness among end-users on technology and financing available.
5. *Policies:* advance cross-sector planning and policy making; standards and quality assurance; promotion of enterprise development; financing targets for renewables for livelihoods promotion and incentives to develop energy-efficient machinery and delivery channels to rural areas.

Figure ES.1. Ecosystem needs for livelihood-centric approach



The absence of any one of the above components of the ecosystem compromises the sustainability of the whole. There are also strong interconnections between the parts. The efficiency of technology, for instance, influences the overall energy needs and viability of solutions, which in turn affect the appropriate ownership models and suitable cash-flow-based financial products. Delivering on such an ecosystem in a given area requires co-ordinated efforts across stakeholders.

Certain cross-cutting elements – relevant to each ecosystem component – must also be in place for optimal and inclusive outcomes. These include inclusive partnerships, a gender lens and knowledge sharing across communities, countries and regions.

Actions to build the enabling ecosystem

The brief identifies five key action areas for building the ecosystem based on lessons learnt from ongoing initiatives across the developing world.

Consider productive end uses in energy access plans and strategies. Local enterprise development should be explicitly targeted in addition to household and public institution access backed by cross-sector policy making and co-ordination. For example, in the Philippines, the Department of Energy and Department of Agriculture in 2021 announced the Renewable Energy Program for the Agri-Fishery Sector to promote renewable energy technologies in agri-fisheries. Working across sectors could also provide crucial productive loads for justifying investments in electrification initiatives. In Zambia, a cluster-based approach to agricultural electrification through "farm blocks" is equipped with basic infrastructure and complemented by industrial cluster zones for agricultural processing. Targeted efforts are usually needed to inform decision-making on energy supply for existing and new livelihood applications, including data and information, incentives for appropriate technology design, financing, market linkages and capacity building.

Mobilise accessible, affordable financing for end-users and enterprises. Access to affordable and funding tailored for end-users and enterprises is a critical part of the ecosystem. In India, loans offered by local banks with staggered payment tenure aligned with customers' typical cash-flow patterns enables small-holder farmers to adopt milking machines and reduce manual labour. Financial incentives for productive end-uses

(*e.g.* results-based financing for appliances) should be targeted and offer support, particularly in early-stages of market development; however (over the long term) local financial ecosystem must be strengthened. In Cambodia, for instance, a dedicated Clean Energy Revolving Fund was established, capitalised by development capital, to offer tailored financing products to agri-enterprises to adopt renewable energy solutions. Well-capitalised grassroots financing institutions and intermediaries will play a particularly crucial role in channelling funds and ensuring the accessibility of tailored products for end-users and enterprises. Public financing is also needed to build the ecosystem (*e.g.* raising awareness, improving data and information access) that has a long-term sustainability impact.

Support technology innovation and adaptation processes. Technology innovation and adaptation processes are crucial for linking renewable energy solutions and energy-efficient productive appliances with local end-user and value chain needs. In the case of millet processing, for instance, coupling renewables with a high-efficiency grader could bring down costs by 60-70%, making it more accessible and affordable for the last-mile. Targeted measures are needed to facilitate a participatory technology innovation and adaptation process and end-of-life management. These include encouraging local technology developers and R&D institutes to partner and innovate with access to early-stage, high-risk financing and platforms for experience and knowledge sharing through south-south co-operation platforms. The Hydropower Empowerment Network (HPNET), for instance, is a collective of over 50 practitioner entities from South and Southeast Asia facilitating exchange on technical know-how on adapting and localising large segments of the micro-hydro value chain thereby improving sustainability and benefits for livelihoods promotion.

Expand incubation support and skills development. Adequate capacity needs to be built across the ecosystem to ensure sustainable and rapid scale-up of decentralised renewable energy solutions linked to livelihood applications. Vocational training centres, especially in the rural areas, need to be upgraded to become centres of innovation and entrepreneurship in sustainable livelihoods. The Energy Change Lab in the United Republic of Tanzania, for example, has partnered with a mini-grid developer and the Vocational Educational Training Authority to train community productive end-use champions to overcome the local skills gap. Long-term partnerships with training entities, tailoring training modules for off-grid applications and innovation in distance learning platforms are essential to strengthen local skills. Local enterprises, including those delivering energy solutions and those benefiting from adoption, can be supported through tailored incubation and mentorship efforts.

Mainstream gender across the ecosystem. Women and men engage in different income-generating activities and face varying challenges to secure decentralised renewable energy solutions for livelihood applications. Each ecosystem component must integrate a gender lens to ensure that traditional challenges to accessing financing, skills and mentorship do not hinder equitable access to renewable energy opportunities. Technologies and other support services (*e.g.* training, financing) must be accessible for women-led enterprises equally. In this context, dedicated funding channels, or earmarking quotas within existing funds, for women-led households and enterprises and facilitating access to training and skills development programmes should be considered. The Economic Community of West African States Certification of Sustainable Energy Skills (ECSES) certification programme, for instance, offers financial support in the form of scholarships for female applicants through a Women's Technical Exchange Program. Further, showcasing women-led enterprises as role models could encourage other women and challenge gender stereotypes.

Delivering on the action areas highlighted here will require the involvement of a variety of stakeholder groups. These include different levels of government (from local to national) with mandates cutting across various sectors; finance institutions ranging from international donors to intermediaries and local banks; enterprises in the energy and other livelihood sectors as well as non-governmental entities (i.e. fulfilling various enabling functions such as incubation support, advocacy, etc.). Investing in a co-ordinated approach and looking beyond a technology-centric approach will likely reap significant long-term dividends for advancing socio-economic development objectives and ensuring a just and inclusive energy transition.

1 Introduction

Access to affordable, modern and reliable energy services is a pre-requisite to support sustainable livelihoods[1] and advance socio-economic development. In recent years, political and financial commitment towards universal energy access has grown, catalysed in part by the adoption of a dedicated target under Sustainable Development Goal 7 of the 2030 Agenda for Sustainable Development. Falling costs and improved reliability of decentralised energy solutions have provided further impetus to energy access efforts with the stronger involvement of communities, local entrepreneurs and the private sector.

The convergence of these factors has resulted in an increase in modern energy access,[2] in particular of electricity. The share of the world's population living without electricity access shrank from 17% in 2010 to 10% in 2019, with absolute numbers falling from 1.2 billion to about 759 million during the same period (IEA, IRENA, UNSD, World Bank and WHO, 2021). However, at the current pace of electrification, nearly 660 million are still expected to remain without access in 2030, predominantly in Sub-Saharan Africa. The COVID-19 pandemic has hampered progress towards the universal access objective. In 2020, the number of people without electricity access was expected to rise in Sub-Saharan Africa. Further, growth in poverty levels is likely to make basic electricity access unaffordable for more than 100 million people with access today (IEA, 2020).

Lack of access to modern energy affects people's lives and well-being in different ways. It reduces time available for studying and for leisure, inhibits communication and lessens public safety, especially for women and children. Importantly, it hinders delivery of public services like health care, water supply and education that contribute to the development long-term human capital. Further, it impedes efforts to sustain and strengthen existing livelihood activities or develop new ones, with implications for both socio-economic development and poverty alleviation.

As emerging economies look to recover from the COVID-19 crisis aligned with the 2030 Agenda for Sustainable Development and climate agenda, a dual focus on expanding energy access and supporting resilient livelihoods has become imperative (IRENA, 2020). New investments in energy infrastructure must also ensure resilience to long-term shocks, such as those caused by climate change, that are increasingly threatening to erode the basic needs and capabilities of vulnerable communities.

Ensuring a stronger link between energy supply, income-generating livelihood activities and public services is critical to realise the complete spectrum of benefits that energy offers across several SDGs, including those related to poverty eradication, economic growth, decent work, gender equality and climate. However, both literature and on-the-ground experiences show that the entire spectrum of benefits do not accrue immediately, or automatically, when access to modern energy becomes available or is improved, particularly in the context of catalysing income-generating activities. This begs the question – how can energy infrastructure be planned and enacted to maximise its impact in terms of alleviating poverty for the widest possible cross-section of the population while stimulating sustainable economic and livelihood development?

The discourse on decentralised renewables, in particular, has been dominated by a focus on technology and its deployment: How do we deploy more solar home systems? How do we install more

[1] *Livelihoods can be understood in different ways. Development professionals commonly define a livelihood as a composite of the capabilities, assets (including both material and social resources) and activities required for a means of living (Chambers and Conway, 1991). This definition applies across all social spectrums. Often the poor have compromised capabilities, assets and activities as they often have to make choices of one over the other.*

[2] *There is no universally agreed upon definition of access. It is increasingly recognised though that it is multi-dimensional in nature covering also aspects related to affordability, quality and sufficiency of supply. The Energy Sector Management Assistance Program's (ESMAP) Multi-Tier Framework captures seven attributes of energy access measuring electricity and clean cooking access for households and enterprises across six tiers (see Box 6 for details).*

mini-grids? How do we scale up these solutions? The need to encourage productive end uses[3] and strengthen their impact on livelihoods is often seen through the lens of demand stimulation, project sustainability and ex-post evaluations.

This report emphasises that an end-use-centric approach is equally needed – one that positions the diversity of people's needs and livelihoods at the centre of the energy access ecosystem. Such an approach is likely to reap significant long-term dividends for poverty alleviation and resilience to environmental, economic, social and climate shocks – two pressing issues that need consideration especially in the present context of COVID-19 recovery efforts and objectives of a just and inclusive energy transition.

Advancing an end-use-centric approach requires greater efforts than simply deploying decentralised systems or delivering units of electricity. An ecosystem[4] needs to be developed that addresses unmet quality and affordable energy needs for livelihood activities along with a range of other non-technology support to realise the full benefits of interventions. Such an ecosystem hinges on policies and programme design, training and capacity building, access to financing, technology innovation, and market access.

The main objective of this brief is to present and discuss the 'ecosystem' necessary for linking electricity services through decentralised renewable energy with people's livelihoods. While any electrification mode (*e.g.* grid, mini- grid or stand-alone system) can be used, the analysis and case studies presented in this

BOX 1. IRENA'S WORK ON THE USE OF DECENTRALISED RENEWABLES TO ENHANCE ACCESS AND SOCIO-ECONOMIC DEVELOPMENT

IRENA's analytical work on decentralised renewable energy has identified the following priorities:

- Elaborate the social, economic and environmental case for integrating decentralised renewables in energy access strategies (IRENA, 2019a).
- Analyse the different components of the enabling environment to accelerate deployment based on regional and national best practices and lessons learnt (IRENA, 2012a, 2015, 2017).
- Support policy and regulatory design for decentralised renewable energy solutions, in particular, mini-grids (IRENA, 2016a).
- Bridge the knowledge gap on the socio-economic impacts of decentralised renewables, including jobs (IRENA, 2012b, 2013), gender (IRENA, 2019b) and cross-sector applications (IRENA, 2016b, 2016c, 2019b).
- Highlight technology innovation opportunities to achieve cost reductions and improve reliability and quality of services delivered by decentralised renewables (IRENA, 2016d).

Most of IRENA's analytical work has tackled the socio-economic dimension of decentralised renewable energy solutions (*e.g.* jobs, income) from an impact standpoint. This technical brief addresses how such solutions can be deployed for livelihood development, thus maximising the impacts.

[3] *For the purposes of this brief, a productive end use of energy is a direct input for the production of goods and services, specifically with the purpose of income generation.*

[4] *The term "ecosystem" is used in this brief to refer to the existence of, and interaction between, some key drivers of decentralised renewables' deployment in a given context (e.g. policy and regulatory frameworks, financing landscape, skills and capacity, access to markets and technology solutions). Collectively these provide enabling conditions for the deployment of renewable energy solutions for livelihood applications.*

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brief largely pertain to decentralised renewable energy solutions which can be deployed in both grid-connected contexts (when services are unreliable or inaccessible) and off-grid contexts to support livelihood applications. Chapter 2 elaborates on the case for the integration of energy supply and livelihoods, while chapter 3 addresses the holistic ecosystem needed – covering technology, finance, access to markets, training and capacity building, and policies and programme design. The chapter offers examples from diverse contexts and stakeholders around the world. The final chapter puts forth key recommendations for policy makers seeking to strengthen rural livelihoods and advance socio-economic objectives.

This brief builds on IRENA's growing body of work on decentralised renewable energy solutions that enhance energy access and socio-economic development (Box 1), and draws on the experience of the SELCO Foundation (Box 2) in the successful implementation of the ecosystem approach in various states in India and, through partners, in parts of sub-Saharan Africa.

BOX 2. SELCO FOUNDATION'S WORK ON ECOSYSTEM DEVELOPMENT FOR SUSTAINABLE ENERGY SOLUTIONS

SELCO Foundation seeks to inspire and implement socially, financially and environmentally inclusive solutions by improving access to sustainable energy. SELCO Foundation's key objectives are to:

- Systematically identify diverse needs of the poor and understand and define the role of sustainable development, poverty alleviation and decentralised energy in meeting those needs (SELCO Foundation, 2020a).
- Create and deploy innovative solutions that positively affect well-being, health, education and livelihoods towards the alleviation of poverty (SELCO Foundation, 2019, 2020b, 2020c).
- Foster the development of enabling conditions through a holistic process involving technology, finance, entrepreneurship and policy (SELCO Foundation, 2014, 2020d).

SELCO's analysis and evidence for change are based in its work as a practitioner. This brief leverages this implementation experience in varied contexts across India and Africa.

2 Linking decentralised energy supply to livelihoods

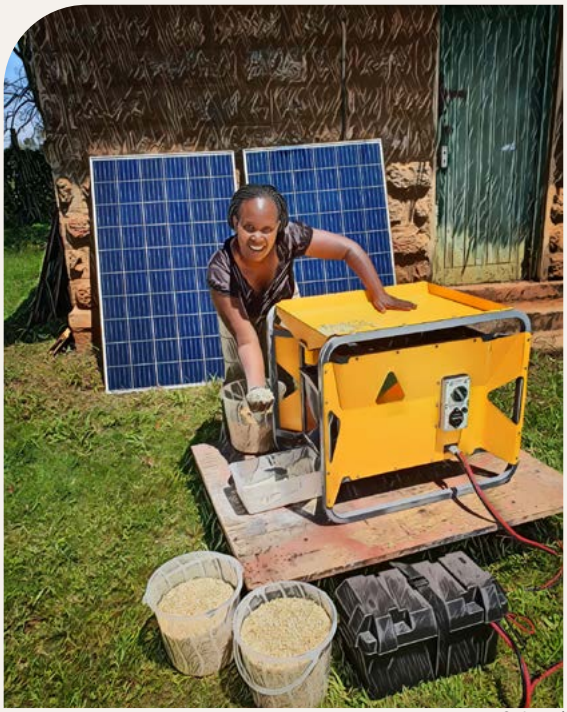
Decentralised renewable energy solutions promise to play an important role in reaching universal electricity access in a timely manner. Linking deployment of such solutions to people's livelihoods can translate into improved incomes, reduced drudgery, greater resilience and long-term social security, thus contributing to multiple SDGs. This chapter first discusses the evolution of livelihoods' perspective in the rural development context and highlights the implications for decisions around energy supply. It then outlines the progress made to date, and key gaps to be addressed to maximise benefits.

2.1. POVERTY, LIVELIHOODS AND ENERGY ACCESS

Poverty is a persistent challenge that has been understood and measured in different ways over the past several decades. Since the 1990s, the conceptual thinking has evolved to encompass poverty's economic, ecological, social, cultural and political dimensions. Although different approaches emphasise different aspects of poverty at the individual or collective level – such as income, capabilities and quality of life – poverty is generally seen as multi-dimensional (UNDP, 2020).

Improvements in livelihoods offer a pathway out of poverty and towards long-term social security for billions of people globally. The agriculture sector supports the livelihoods of the majority of the rural poor in emerging economies. Advancing the sector is thus crucial for poverty alleviation efforts. In fact, productivity growth in the agriculture sector is estimated to be nearly three times as effective in reducing poverty as is such growth in other sectors (Banerjee *et al.*, 2017). Beyond the agriculture sector, diverse economic value chains support livelihoods in ways that vary across contexts (*e.g.* urban and rural areas, plains and mountains). Within each economic value chain, the socio-cultural norms that govern people's participation in income-generating activities – some of which have evolved over generations – also vary.

Sector-specific approaches to rural development and poverty alleviation are being increasingly challenged, and the need for integrating livelihood-centric and bottom-up approaches into development planning is becoming a priority. At the centre of this shift lies the recognition that people make a living in different and dynamic ways that may cut across specific sectors and activities (*e.g.* agriculture, small-scale enterprise, wage employment) (Scoones, 2009). In the case of mountain communities in the Hindu Kush Himalayan region, for instance, the past three decades have seen a shift from solely agro-pastoral work to its increasing combination with subsistence labour. Mountain households increasingly rely on livelihoods that combine farm work with non-farm activities (Gioli *et al.*, 2019), including wage labour, tourism and rural industries such as bamboo. In the United Republic of Tanzania, farming households increasingly have multiple income streams from off-farm activities, including wages and self-employment, to supplement inconsistent agricultural incomes (Johnstone, Perera and Garside, 2020). Diversity is a central determinant of livelihood security, and non-farm livelihoods are increasingly pivotal to the sustainable future of mountain communities.



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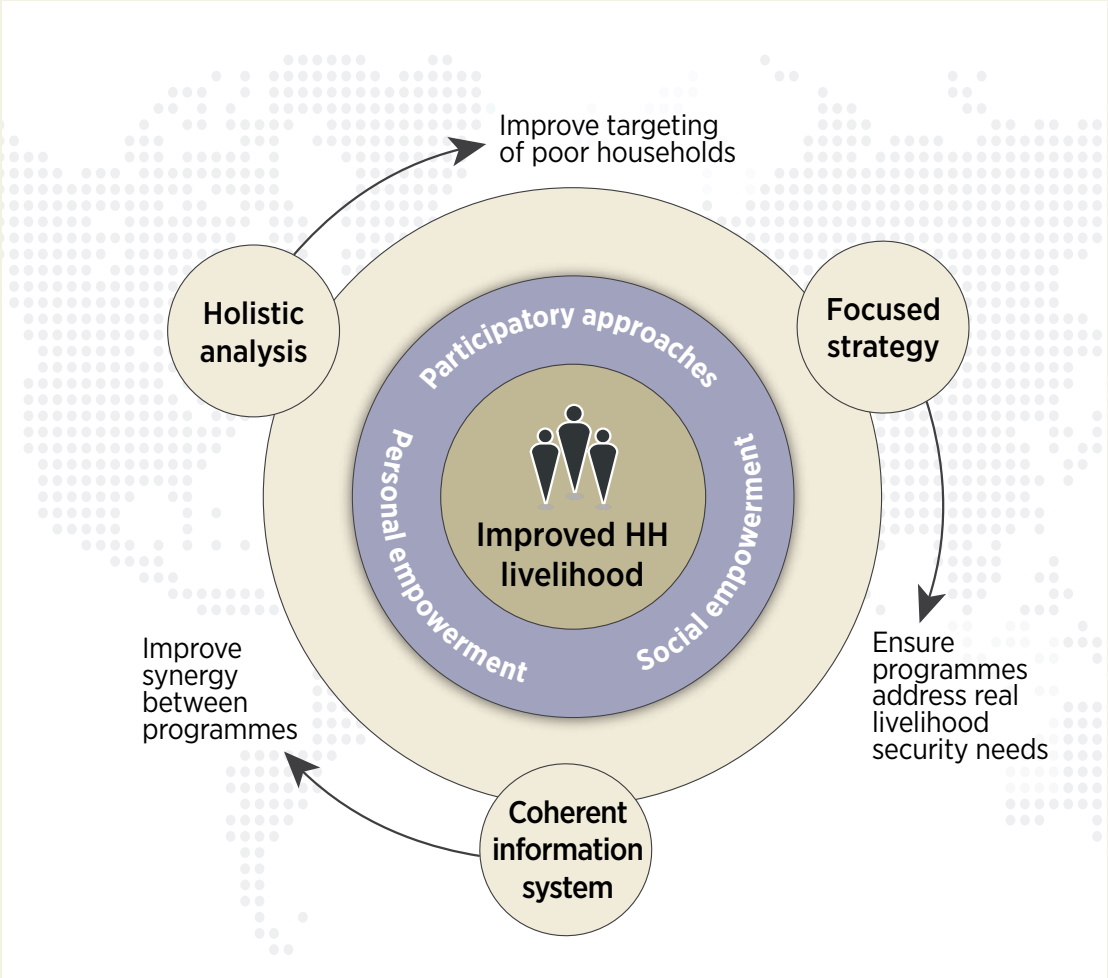
Recognising the diversity and dynamics of livelihood opportunities at the local level, non-governmental organisations (NGOs) and donor agencies over the past few decades have designed their interventions using a people-centred participatory approach (see Box 3 for examples). Since the 1980s and 1990s, the comparative advantages of a bottom-up, grassroots, or "process" approach

BOX 3. AN END USER-CENTRED, PARTICIPATORY APPROACH TO LIVELIHOOD INTERVENTIONS

The policy shift towards participatory approaches recognises rural communities and the poor as actors that best know their own situations and needs. Of the different approaches that have emerged since the late 1990s, most reject a sector-specific entry point and focus on engaging community members in planning and programme design. Approaches used by CARE and the UK Department for International Development (DFID) (now Foreign, Commonwealth and Development Office, FCDO) are briefly discussed below.

CARE, an international non-governmental organisation, has adopted a Household Livelihood Security framework to analyse, design, monitor and evaluate its development programmes and relief work (Figure 1). It emphasises a capacity-building approach that considers beneficiaries as active agents in constructing their own livelihoods as opposed to being passive recipients of external support.

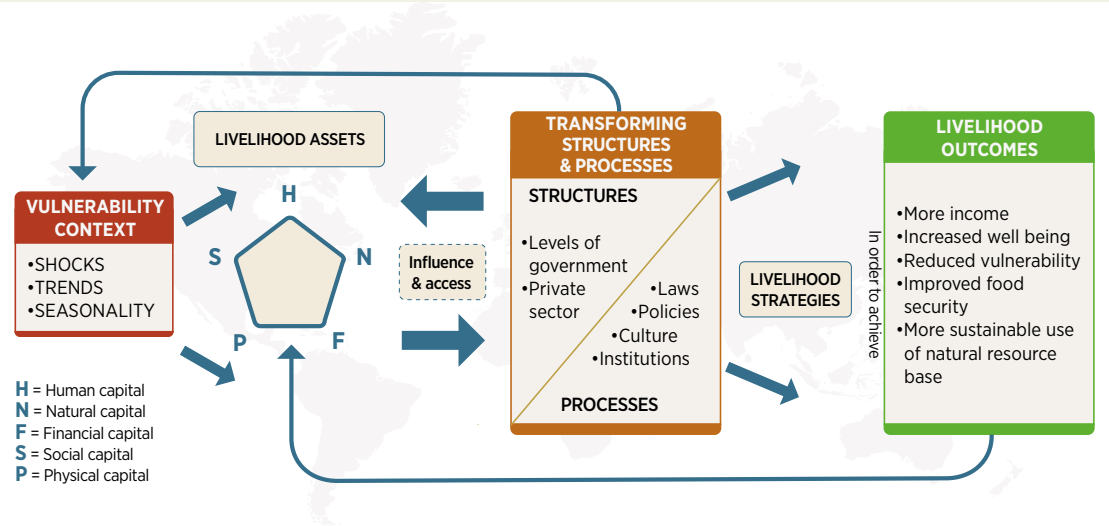
Figure 1. Livelihood approach adopted by CARE



Source: Hussein, 2002.

DFID (now FCDO)'s Sustainable Livelihoods Framework (Figure 2) adopts a systems approach to understand and analyse livelihoods of the poor (for this purpose, livelihoods involve the skills, assets and approaches that people utilise to make a living). To gauge sustainability, the framework examines whether people and communities can cope with stress/crisis, and that they are able to maintain, and even improve, skills and assets without undermining the natural resource base. The framework puts people at the centre of development and recognises that poverty alleviation can be achieved when support is structured in a way that aligns with people's current livelihood strategies, social environment and aspirations. It is one of the most widely used livelihoods frameworks in development practice.

Figure 2. Sustainable Livelihoods Framework



Source: Krantz, 2001; GLOPP, 2008; UNDP, 2017.

to development has been noted compared to a top-down or "blueprint" approach characterised by external technologies and national-level policies (Ellis and Biggs, 2001). This has paved the way for a growing consensus on the importance of sustainable livelihoods, and an approach that rests on the core principles of being people-centred, responsive, participatory, multi-level and dynamic (Ashley and Carney, 1999). This acknowledges the diverse goals to which people aspire and the livelihood strategies they adopt to achieve these. In a new paradigm for rural development policy, the cross-sectoral and multi-occupational diversity of rural livelihoods is central (Scoones, 2015).

The case for tailored energy services to support diverse livelihoods. The interconnections among poverty, livelihoods and energy are increasingly well known and established. A lack of access to reliable, affordable and sufficient energy remains a critical infrastructure gap in many emerging economies that hinders people's ability to strengthen existing or explore new livelihood opportunities. Access to energy enables opportunities that can help people reduce drudgery, improve productivity, raise incomes and enhance resilience to external shocks and stresses. The indirect benefits are also multi-fold in terms of improved access to education, health care and information. In the agriculture sector, for instance, which supports livelihoods of over 2.5 billion people globally (FAO, 2016), growth in energy use for various activities is directly linked to improved yields, incomes, resilience and food security outcomes (FAO, 2000). The provision of affordable and reliable energy services at each stage of the value chain – primary production to post-harvest processing to consumption – can bring substantial benefits for farmers' and other stakeholders' incomes, productivity and resilience (IRENA, 2016b; IRENA and FAO, 2021).

BOX 4. EXPANDING ENERGY SERVICES TO FARM AND NON-FARM SECTORS

The rural economy can broadly be divided into the farm and non-farm sectors depending on the source of primary income and livelihood. In the farm sector, mechanisation is prompted by increasing demand for food, need for productivity, and efforts to reduce drudgery and manual work. Overall, farm mechanisation in India stands at about 40% to 45%, in stark contrast to countries such as the United States (95%) and Brazil (75%). Ownership of farm machineries is often concentrated among large farmers, with small-scale farmers facing challenges related to asset ownership, including high capital costs.

Across Sub-Saharan Africa, mechanisation rates are even lower, impeding efforts to improve agricultural productivity and incomes. About 60% to 80% of cultivated land is worked manually, without the use of animals or mechanical tools. On-farm and beyond farm-gate, energy services (electricity, heating/cooling and transport) are crucially important to support mechanisation and gain resulting benefits. The non-farm sector also faces significant energy access challenges. In India, a survey of non-agricultural enterprises in over 100 districts found that more than half of micro-enterprises highlighted lack of reliable electricity supply as a key challenge.

Both the farm and non-farm sectors have large unmet energy needs resulting in growing dependence on fossil-fuel-based solutions (*e.g.* diesel). The dominant focus of electrification programmes on households leaves behind both farm- and non-farm-based enterprises, a gap that can be filled by tailored decentralised renewable energy solutions.

Source: Waray, Patnaik and Jain, 2018; Piesse, 2019.

The diversity of livelihoods that people pursue involve varied energy needs, requiring tailored solutions (Box 4). A historical view of the evolution of electricity access in many developed and emerging markets illustrates how livelihood-centric sectors served as important anchors for new electricity infrastructure development. In the United States, farm households were a cornerstone of the rural electrification programme initiated in the 1930s, bringing substantial improvements in agricultural productivity with the use of more than 100 different types of farm machinery (Lewis and Severnini, 2017).

Similarly, in 15 years, the Republic of Korea went from providing only 12% of rural households with electricity to 98% in 1979. A guiding principle of the electrification programme was Saemaul undong – a bottom-up initiative in which local communities took ownership of rural development activities (Park, 2009). Communities productively engaged in economic activities that required electricity access, such as sericulture and light manufacturing, backed by government support (Gevelt, 2014; Yim, Park and Lee, 2012). The initiative combined top-down planning and funding with bottom-up initiatives.

A key element of India's rural electrification programme focused on the agriculture sector, in particular, expanding irrigation services. Government policies in the 1960s and 1970s, including subsidised tariffs for agriculture, incentivised farmers to adopt electric pumps for irrigation (Banerjee *et al.*, 2015). India's experience also offers important lessons for aligning incentives with broader environmental sustainability considerations such as groundwater use. Subsidised energy for pumping formed part of a broader set of ecosystem measures that drove the green revolution in India, including the creation of rural development banks, training institutions, and agriculture research and development (R&D) centres.

Across Sub-Saharan Africa, the successful integration of agriculture and power infrastructure development in rural areas is seen as an effective way to maximise the impact of electrification on rural economies (Banerjee *et al.*, 2017). In Ethiopia, for instance, linking agriculture and rural electrification could unlock an estimated annual USD 4 billion for small-holder farmers from agricultural productivity and processing. Further, communities could save another USD 120 million annually in fuel costs and achieve a revenue stream of USD 22 million for utilities (Borgstein, Wade, and Mekonnen, 2020).

Yet a focus on sectoral silos and technology persists. Despite the clear benefits of focusing on livelihoods, much of the energy access discourse ignores the topic, irrespective of delivery mode (centralised or decentralised). In the off-grid context, the focus on sectoral silos continues. Several programmes, for instance, focus on the adoption of decentralised technologies across specific sectors, including agriculture, water or health. Meanwhile, the technocratic approach usually followed for grid electrification planning fails to capture the aspirations of local stakeholders and does not have the capacity to capture productive loads and integrate with livelihood opportunities (Bhattacharyya and Palit, 2019). Electrification through centralised grid-based solutions also raises important questions around accessibility, especially for rural enterprises and marginalised population segments (*e.g.* women-headed households).

In India, for instance, where grid coverage has expanded rapidly over the past few years, a survey of over 10000 rural households and 2000 rural enterprises across four states – Bihar, Uttar Pradesh, Odisha and Rajasthan – finds that while household coverage was high, only 65% of surveyed rural enterprises were grid connected (SPI and ISEP, 2019). Where grid access exists, often the service is unreliable and unaffordable. In Bangladesh, a survey of over 1500 commercial enterprises in rural areas found that for each hour of power outage, revenues fall by 4.6% and profits by 6% (Samad and Portale, 2019). In Benin, a study found that the financial burden of the cost of connection and subsequent electricity bills can even reduce firms' profitability (GIZ, 2013). Furthermore, gender-disaggregated electricity access data from Bangladesh, Cambodia, Ethiopia, Myanmar and Rwanda find that female-headed households have lower access rates (World Bank, 2019).

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The case for linking decentralised renewables with livelihoods. Decentralised renewable energy solutions offer the opportunity to scale up electricity access in a more inclusive and timely manner, but also enable various tailored delivery models suited to meet the energy needs of diverse livelihoods. The modular nature of the technologies allows them to be scaled down to the level of individual needs; micro, small and medium enterprises; as well as villages. Importantly, renewable solutions tap into locally available energy resources, thus improving energy security and strengthening the resilience of value chains for various products and services when designed with the understanding of local contexts (social, cultural and environmental).

Productive use of energy increases capacity utilisation, enhances end users' ability to pay and provide a predictable revenue stream for system upkeep. A lack of focus on productive use of energy, coupled with measuring impacts through households covered and kilowatts generated, could result in energy infrastructure being heavily under-utilised as seen from the early experience of micro-hydro development in Nepal (Perera, Johnstone and Garside, 2020).

Just as not all forms of access yield the same socio-economic outcomes, not all approaches to decentralised renewable energy development result in the same level of livelihood improvements. Growing evidence points to the fact that while energy access is a key infrastructure support, the development of local enterprises requires a broader enabling ecosystem (Peters, Sievert and Strupat, 2015; Peters, Sievert and Vance, 2011; Brew-Hammond, 2010). Even the organic growth of productive uses can be slow or limited, with opportunities unevenly distributed across communities (IEA, IRENA, UNSD, World Bank and WHO, 2019). Therefore, a conscious, focused effort is needed to not only accelerate the pace of renewables deployment,[5] but also strengthen the linkages with livelihoods and put in place holistic measures to maximise the benefits of access.

2.2. CURRENT APPROACHES TO DECENTRALISED ENERGY SOLUTIONS

The adoption of decentralised renewable energy solutions (stand-alone systems or mini-grids) has grown rapidly in recent years. By 2019, over 176 million people globally had access to some form of electricity from decentralised renewable solutions, representing an eight-fold increase compared to 2011 (IEA, IRENA, UNSD, World Bank and WHO, 2020, 2021; IRENA, 2018a) (Figure 3). Reductions in costs, improvements in technology, innovations in delivery and financing models, and stronger policy support are expected to drive future deployment. Decentralised solutions now represent an integral part of national electrification strategies in a growing number of countries faced with large access deficits such as Nigeria, Rwanda and the United Republic of Tanzania (IRENA, 2019a).

Decentralised renewables have traditionally provided basic electricity access. Close to 138 million people of the total 176 million benefited from solar lighting solutions in 2019 (below Tier 1 of the Multi-Tier Framework; see Box 5) (IEA, IRENA, UNSD, World Bank and WHO, 2019). While even basic access offers immediate socio-economic and environmental benefits in terms of reduced expenditure on kerosene lamps for lighting, additional study and work hours, and health and safety benefits, a substantial gap remains between this and the level required for productive uses (GOGLA, 2018; Haney *et al.*, 2019). Larger decentralised systems, including solar home systems and mini-grids, that provide Tier 1+ electricity services to at least 35 million people, offer additional opportunities for supporting existing and new productive end uses.

[5] *Earlier work by IRENA (2019a) has analysed the different components of the enabling environment for accelerating the deployment of off-grid or decentralised renewable energy solutions: namely, policies and regulations, institutional framework, delivery and financing models, technology, capacity building and cross-sector linkages.*

BOX 5. A MULTI-DIMENSIONAL FRAMEWORK TO MEASURE ELECTRICITY ACCESS

The Multi-Tier Framework (MTF) captures multiple dimensions of energy access – seven attributes to be precise* – across six tiers, each with minimum requirements. For electricity access, the lowest level (Tier 1) refers to limited access to small quantities of electricity for a few hours per day, enabling the household to use electric lighting and charge mobile phones. Higher tiers of access are defined by greater capacity and longer duration of supply, enabling the use of medium- and high-load appliances (*e.g.* refrigerators, water pumps).

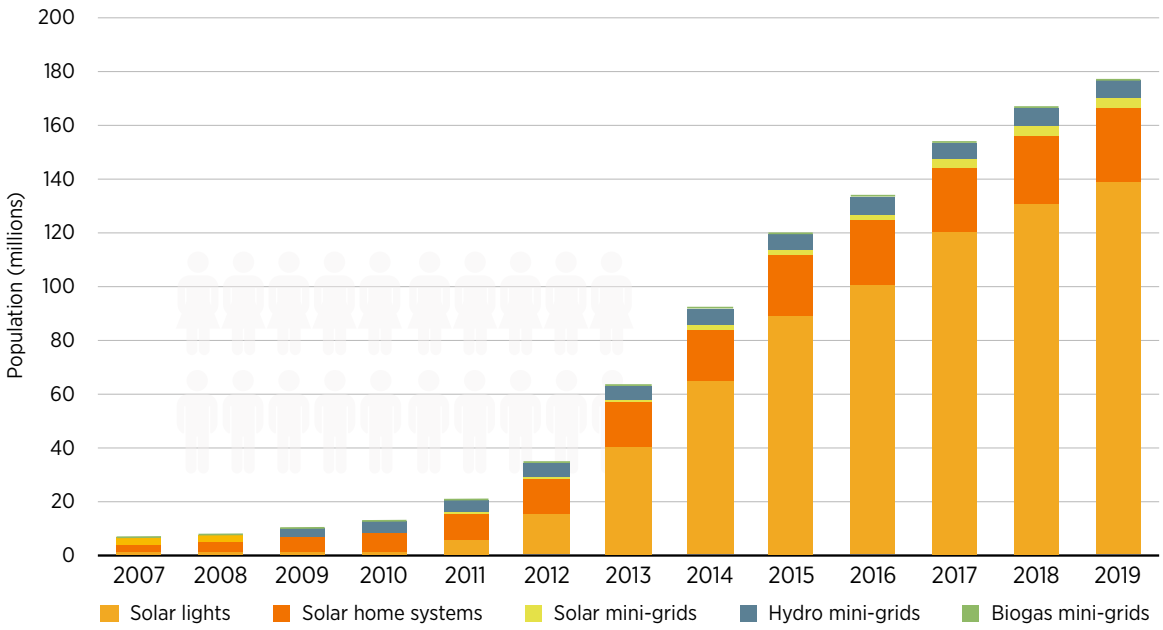
As part of the MTF, country-level data are gathered on both qualitative and quantitative aspects of access for a more nuanced understanding of electrification. The MTF also gathers data from public institutions including health and education as part of the household survey. In 2018, for instance, the MTF survey compiled data from public institutions in Cambodia, Ethiopia, Kenya, Myanmar, Nepal and Niger, finding that 60% of educational and 25% of health facilities have no access to electricity.

Source: Bhatia and Angelou, 2015; IEA, IRENA, UNSD, World Bank and WHO, 2020.

**Attributes covered include peak capacity (power and daily capacity or services), duration, affordability, reliability, legality, health and safety, and quality.*

Approaches to deploying decentralised renewables for livelihoods. Integrating a livelihood-focused perspective in the early stages of formulating and designing decentralised renewable energy solutions can play a crucial role in maximising socio-economic development outcomes. At the core is the need for a tailored, integrated approach to reach universal access in a timely manner and deliver electricity services necessary to maximise socio-economic outcomes (SEforALL, 2019; Bhattacharyya and Palit, 2019). The integration must occur at several levels: technology (involving the use of all available solutions: grid, mini-grids, stand-alone systems), actors (involving the public and private sectors, and communities), and end uses (linking electricity supply with productive uses) (GCEEP, 2020).

Figure 3. Population served by decentralised renewable energy solutions globally, 2008 - 2019



Source: IRENA.

Note: Data on the number of people with access to these forms of electricity supply are gathered by IRENA based on sales of solar panels, project reports and other publicly available sources.

In practice, this entails mapping out energy flows throughout relevant economic value chains (from production to consumption/consumer), identifying existing or potential income-generating activities where energy can enable value, assessing current landscape of access to financing and skill levels and assessing opportunities where decentralised renewables could be introduced in a viable manner.

It is important to emphasise that while the topology of value chains, whether for agriculture or handicrafts or tourism, may be the same, the energy needs at each step vary from context to context depending on the scale and mechanisation of processes, existing market linkages and access to energy. A dairy farmer in Kenya, for instance, likely requires energy solutions for lighting, water pumping and chilling at the farm level. But in India, which has a well-developed milk collection system, chilling need not be done at the farm level (REEEP, 2017).

It is equally important to look at the entire value chain to ensure that the productivity improvements and new products/services that result from access to modern energy translate into income for rural populations (Banerjee *et al.*, 2017). Solar-powered irrigation solutions that improve the yields of small-holder farmers, for instance, need to be accompanied by interventions that improve agri-extension services, allow the storage of excess produce, facilitate access to markets (*e.g.* transportation), participate in setting market signals (*e.g.* pricing to influence cropping patterns) and improve water use efficiency (IRENA, 2016c).

Beyond the provision of electricity, targeted efforts are usually needed to support productive end uses. Key actions include stimulating demand, developing product and service value chains (*e.g.* agriculture, handicrafts), raising awareness, building capacity, supporting the development of micro-businesses, facilitating access to financing for assets and enterprises, and supporting the availability of affordable and efficient appliances (Contejean and Verin, 2017). For the success of such efforts, various cross-sector stakeholders need to be engaged, given the diversity of livelihoods in rural areas and the holistic nature of support needed to develop both existing and new income-generating activities (*e.g.* market access, skills development). Depending on the structure of projects and the way they are financed, developers and operators of decentralised systems could lack the incentives and incentives to provide long-term support for strengthening rural enterprises (IIED, 2019), thus necessitating partnerships between

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energy companies and other technology providers, communities, governments and NGOs to improve linkages with livelihoods.

Globally, a number of initiatives are underway to strengthen the linkages of decentralised solutions with income-generating activities across multiple sectors. Some are sectoral in nature (*e.g.* USAID's Powering Agriculture programme, the Water & Energy For Food initiative), while others are end-use centric (*e.g.* the Global LEAP Off-Grid Cold Chain Challenge), or take on a customised ecosystems approach (*e.g.* Hivos/IIED Energy Change Lab, Energising Development programme[6]). SELCO Foundation, for instance, has documented the experience of deploying 65 livelihood-focused applications of decentralised solar across sectors, such as textiles, agriculture, animal husbandry, food processing, pottery and cottage industries, in different contexts (SELCO Foundation, 2019). GIZ has published a catalogue of appliances available for decentralised solar across various applications covering livestock breeding, food production, processing and storage, tailoring, workshop tools and energy services (GIZ, 2016).

To substantially scale up the deployment of decentralised renewables to support livelihoods, a broader ecosystem is needed so that tailored, cross-sector solutions can be devised and deployed depending on end-user needs. Drawing on examples from diverse countries, the next chapter delves deeper into factors that would foster the needed ecosystem. While specifics may vary from context to context, the analysis aims to provide decision makers and practitioners with key pre-requisites.

[6] *GIZ's Energising Development programme supports a holistic or 'ecosystem' approach to promotion of productive end-uses. This includes specific support measures focusing on enabling market growth (e.g. quality standards, policies and regulations, financing, monitoring and evaluation framework), stimulating demand (e.g. demand assessment, supporting adoption) and increasing supply (e.g. Research and Development (R&D) for technology, grant and business development support). Implementation by practitioners requires increased co-ordination and collaboration between stakeholders (EnDev, 2021).*

3 An enabling ecosystem for supporting livelihoods with decentralised renewables

Creating long-term, resilient livelihood opportunities for under-served populations requires an inclusive approach with solutions and policies that are customised to local conditions and conducive to local entrepreneurship and innovations. Over the past decades, across geographies, most efforts to foster livelihoods focus on the poor as a labour force. The labour opportunities provided have often led to the destruction of inter-generational rural livelihoods and facilitated migration to urban areas. Such opportunities are often in the informal sector, involve mismatched skills sets and generally involve working arrangements that do not advance decent work conditions (Suttie and Vargas-Lundius, 2016).

Perceived barriers to the large-scale creation and sustenance of grassroots-based livelihoods include a lack of financing and skills, insufficient access to support ecosystem for local entrepreneurs and community leaders, unreliable access to energy and other infrastructure services, inefficient and outdated technology, and high transaction costs for market linkages. Decentralised renewables offer opportunities for local ownership, innovation and entrepreneurship in an effective manner, allowing tailored access at the grassroots level. Improving efficiency of existing appliances make energy solutions more affordable, thus reducing drudgery and in many cases catalysing socio-economic development. To realise these benefits and have a sustained impact, an inclusive ecosystem approach is needed for decentralised renewables. Such an approach is detailed in this chapter, supported by practical examples of implementation.

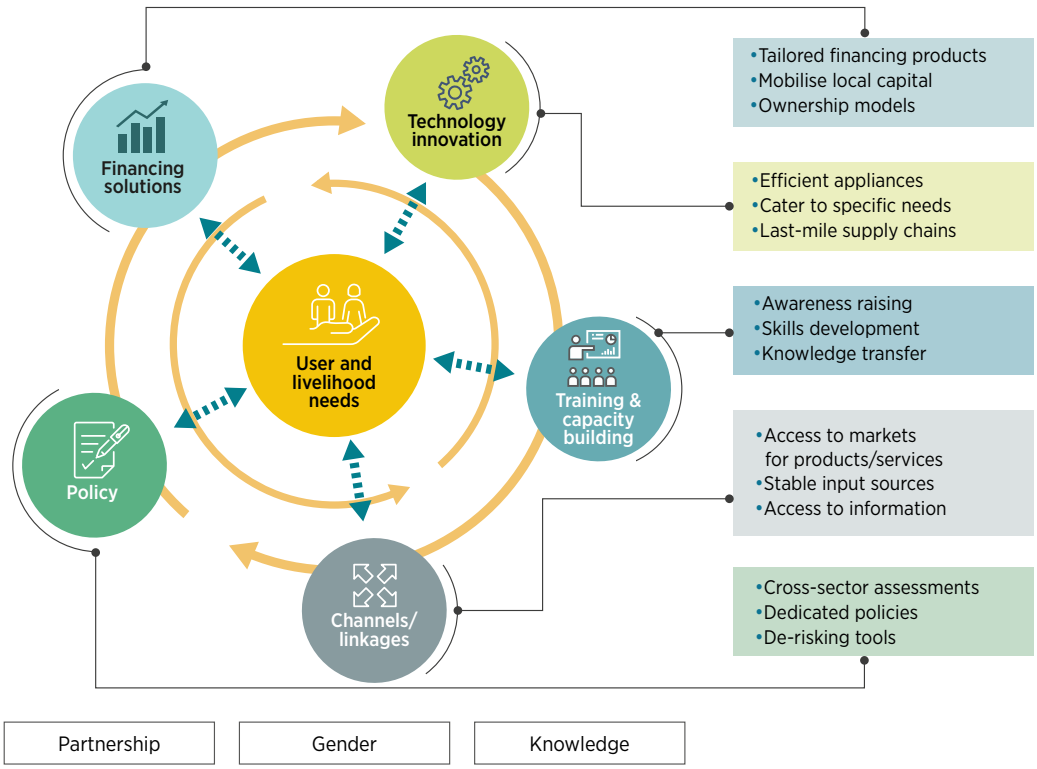
3.1. OVERVIEW OF THE ECOSYSTEM

Over the last decade, there has been a strong focus on the issue of energy access globally. A number of initiatives, programmes and philanthropic efforts have been launched to encourage the deployment of different types of electrification solutions, including stand-alone systems, mini-grids and grid-interactive systems. There is growing recognition that providing electricity connections alone would not enable many households to emerge out of poverty permanently. This is likely to be the case only for a small fraction of the population: one that has access to basic safety nets, children's education and steady income-generating avenues that can be strengthened with access to energy.

For the majority, the pathway out of poverty is gainful employment (i.e. income-generating activities/productive uses) complemented by long-term human capital development (*e.g.* through access to education, healthcare). There is a clear-cut case that access to reliable energy can pave the way for such opportunities, provided that many pieces of an enabling ecosystem are put in place. An enabling ecosystem to address grassroot-level poverty through decentralised renewable energy solutions centres on end users' needs rather than technological solutions. As illustrated in Figure 4, the ecosystem's critical components are as follows.

- **Technology**: reliable energy source, availability and accessibility of efficient appliances, supply chains via manufacturers and energy enterprises that deliver solutions, operation and maintenance services at the doorsteps of end users.
- **Financing**: cash-flow-based financial products, financiers who understand decentralised renewable energy solutions, targeted subsidies for end-users and enterprises, appropriate delivery models for financing, technical assistance funds for market development.
- **Backward and forward linkages** (market access): stable supply chains of inputs/raw materials, various channels to disburse increased outputs of goods, increased awareness to generate demand for these goods, transportation, business models and ownership.
- **Training and capacity building**: business and skills development, training modules on technology use and operation and maintenance, demonstration labs, mentorship and increased awareness among end-users on technology and financing.
- **Policies**: cross-sector co-operation, standards, promotion of enterprise development, financing targets, incentives for manufacturers to develop energy-efficient machinery and delivery channels to rural areas.

Figure 4. Ecosystem needs for livelihood-centric approach



The absence of any one of the above parts of the ecosystem compromises the sustainability of the whole. There are also strong interconnections between the parts. The efficiency of technology, for instance, influences the overall energy needs and viability of solutions, which in turn affect the appropriate ownership models and suitable cash-flow-based financial products. Delivering on such an ecosystem in a given area requires co-ordinated efforts across stakeholders (Box 6).

Each part of the ecosystem will be discussed in-depth in the following subsections, highlighting the pre-requisites, lessons from projects and programmes implemented to date, and the varied roles of stakeholders in different regions.

BOX 6. STAKEHOLDERS INVOLVED IN BUILDING THE ECOSYSTEM FOR DECENTRALISED RENEWABLES AND LIVELIHOODS

- **Technology:** vendors, suppliers of equipment, research and development labs, last-mile enterprises and distributors.
- **Financing:** financial institutions like co-operatives, agriculture development banks, rural banks, microfinance, intermediaries in pay-as-you-go systems, banking correspondents; regulatory bodies that oversee and mandate financial policies; government ministries.
- **Backward and forward linkages:** suppliers of raw materials/inputs, e-commerce platforms, aggregators, formal/informal groups for local-level aggregation, private value addition and access to bulk market, various distribution channels via non-governmental organisations, direct to customer, etc.
- **Appropriate training and capacity building:** district-level training institutes, agriculture training centres, skill building non-governmental organisations, grassroot incubators offering mentorship and advice.
- **Conducive policies:** state- or national-level government bodies, apex regulatory bodies, district-level authorities, ministries, etc.
- **End-users:** individuals, enterprises and community organisations.

BOX 7. DESIGNING TECHNOLOGY SOLUTIONS TAILORED TO LOCAL RESOURCES: THE CASE OF VIET NAM

The National Biogas Programme in Viet Nam, founded in 2003, utilises feedstock from the animal husbandry sector including waste from pig farming. Since its inception, the programme has facilitated the construction of nearly 250 000 domestic biogas digesters improving access to clean, renewable and reliable energy while also tackling the challenge of livestock waste management.

Biogas is used for cooking (for households and for livestock feed) and as a fuel for electricity production for lighting and powering other income-generating activities such as egg hatching, and rice wine and tofu production. The bioslurry, as a fertiliser, results in increased yields of crops that attract higher prices. The most popular digester model is a brick-made fixed-dome system, since it requires relatively little maintenance and can be built with local materials and masons. The programme also uses composite biodigesters that offer several advantages, including quicker installation time, reduced skilled labour needs and the ability to cope with areas having high water levels.

Source: IRENA, 2018c.

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3.1.1. Technology

Technology solutions represent an important pillar of the ecosystem for linking decentralised energy supply with livelihoods. Such solutions encompass the choice of energy technology (*e.g.* solar, biomass), efficient appliances for end uses (*e.g.* pumps, sewing machines, pottery wheels) and the appropriate combination and integration of the two. With end-user and livelihood needs at the centre, the ecosystem should revolve around delivering tailored solutions depending on the local context and conditions (see Box 7 for the case of Viet Nam's National Biogas Programme).

Across the range of productive uses, some needed appliances are unavailable, while others are highly inefficient. With the majority of rural populations working in the informal sector, there is a severe lack of documentation of technology-related problems and, as a result, a dearth of problem-solving and needs-based solutions for ubiquitous issues. For example, blacksmiths still rely on archaic methods which often involve intensive labour under unhealthy conditions. Similarly, rice mills are designed without consideration for the efficiency of the motors being used, and on the assumption that grid supply is infinite.

Technology intervention(s) supporting better-quality livelihoods for the poor could involve the following:

- Development of new technology solutions based on need; for example, energy-efficient solar-powered rice mills or new ultrasonic monkey repellers powered by solar.
- Modification of an existing technology (*e.g.* sewing machines, milking machine motors) to make it more efficient and affordable.
- Repurposing of a technology for uses other than its original intention, such as midwives' headlamps being used by agricultural workers for night-time flower or tea plucking, or efficient CPU fans being used for blacksmith blowers.
- Direct application of an existing technology; for example, implementation of existing energy-efficient vaccine refrigerators in the livestock sector and lighting for poultry.

BOX 8. IMPROVING THE ENERGY EFFICIENCY OF MILLET-GRADING MACHINES

Millet processing involves a number of stages, including de-stoning, de-husking, grading, sorting and pulverising. A typical millet grader consumes a minimum of 23 horsepower (HP) and much more in actual consumption. This translates into high processing costs for farmers and intermediaries. Coupling a traditional grading machine with decentralised energy supply will require large systems, adding substantially to the capital costs and affecting affordability.

A local technology developer (Millet Machines and Tools) in India collaborated with SELCO Foundation to improve the energy efficiency of a grading machine. A high-efficiency millet grader was imported and reverse engineered to bring down the power rating to 180 watts. This improvement in energy efficiency enabled the solar energy system to be reduced by over 60-70%, bringing down the costs, making it much more suitable at a decentralised level for last-mile farmers and more affordable. The scaled-down version could be run with a lower threshold requirement (in terms of throughput), making it a viable alternative to large, centralised mills.

Source: SELCO Foundation.

People-centred innovation for productive uses. Modification or repurposing is the most popular category of technology development and is a continuous process to address the dynamism in the needs of end-users with time. Generally, it occurs either when the product is available but is not efficient or when it needs technical and/or design modifications to suit sustainable energy inputs and uses (in terms of capacity and functionality).

Energy efficiency is key to improving the coverage and affordability of productive use applications. The efficiency of appliances used for subsistence livelihoods has rarely been a focus area amid the centralised and subsidised nature of existing energy grids and fuels. However, improving the efficiency of, for example, lathe machines and post-harvest processing machines, can reduce the costs of powering these appliances on renewable energy (Box 8). A typical milking machine used by dairy farmers is designed with oversized motors ranging from 0.5 - 2 HP while an efficient DC version could reduce costs by 50% utilising motors with capacity less than 180 W. Similarly, a blacksmith's heat-modulated blower typically uses standard 0.5 HP motor available from the market which is oversized and run at high-speed, but a blower that consumes between 15 watts and 60 watts is enough to keep the furnaces ignited (SELCO Foundation, 2019).

Moreover, when decentralised energy systems are designed and optimised on a need basis, their affordability for all types of end-use cases significantly differs. Powering appliances from sources such as solar, with a reliability of 4 - 8 hours, can cost 40% to 80% less than traditional solutions (SELCO Foundation, 2019).

It is important to encourage and incentivise local technology developers, private sector and R&D institutes to innovate, source components and manufacture machines. This will not only stimulate local supply chains but also make it easier to reach end users when tied up with last-mile energy enterprises. In addition, it enables enterprises to customise business models, delivery and after-sales service channels.

3.1.2. Finance

Financing needs vary for various stakeholders involved in the decentralised renewable energy and livelihoods landscape.

Technology providers and appliance distributors require high-risk capital for innovation and R&D to adapt products to end-user needs, as well as equity and working capital to scale up distribution and provide consumer financing. The financing must account for the high costs and risks of delivering energy solutions in rural and peri-urban areas. The capital mix must include public funding and philanthropic support for innovations, R&D and pilots; and debt and equity for grassroot enterprises that usually have longer gestation periods to deliver sustainable energy solutions and services. Grant funding from government and philanthropic sources will continue to play a crucial

role as a key enabler of not only initial infrastructure access but also as a source of 'ecosystem' building for the infrastructure to be effective.

Several governments have sought to encourage the flow of flexible capital for local start-ups and small and medium enterprises through risk-guarantee mechanisms to unlock local capital and support co-investments, easier registration processes, physical space and mentorship. However, cumbersome processes often make it difficult to access this critical support.

Meanwhile, adapted consumer finance products and innovative mechanisms are needed to bridge the affordability gap and enable end-users to access decentralised renewable energy solutions for productive uses. Even with business model innovation (*e.g.* pay-as-you-go) and falling technology costs, the deployment of productive use technologies will require consumer financing alongside long-term concessionary debt and risk capital for innovators and enterprises (Smith and Tsan, 2020).

The nature of consumer financing and its design depends on the cash-flows of consumers, ownership structures and the business models for the various applications (Box 9). Productive use applications are mostly owned and run by individual entrepreneurs, self-help or joint liability groups, producer groups/companies or co-operatives. Such machinery, be it small, medium or large capacity, is either fully owned or rented on a pay-as-you-go basis. For example, a farmer producer group or an individual entrepreneur engaged in millet processing may invest in an efficient solar-powered post-harvest machine.

BOX 9. TAILORED FINANCING FOR SOLAR MILKING MACHINE AND MILLET GRADERS IN INDIA

For small-holder dairy farmers, milking machines do away with manual labour and thus generate savings of around USD 290 (INR 21 500) annually. The system cost is USD 870 (INR 64 000).* With bank loans at the interest rate of 15%, monthly instalments come to USD 50 (INR 3 103) with a payment tenure of 36 months. With such a financial arrangement, a small-holder dairy farmer in India can break even in 41 months. The State Bank of India offers dairy input loans of up to 60 months with a moratorium period of 6 months. Such financial products, with a staggered payment tenure, ease the interest burden by keeping in mind customers' typical cash-flow patterns.

In another case, solar-powered millet graders in India have become a viable proposition for farmer co-operatives or a micro enterprise to own and operate for group use or to run as a service-based model in local markets. But loan instalments must be based on seasonal cash flow. The terms could be between 3 to 7 years with interest rates between 3% and 12%.

Source: SELCO Foundation, 2019.

**USD 1 = INR 73.56 in 2019*

Generally, investments such as these require a loan for a period of 5 - 7 years with the instalments tailored to seasonal changes in incomes depending on crop production and harvesting. Such financing is usually beyond the reach of many existing financing institutions, including Savings and Credit Co-operatives, thereby necessitating dedicated funding lines to service the sector.

Appliances such as sewing machines, blacksmith blowers, pottery wheels, sprayers and water pumps, are often individually owned. On the other hand, large cold storage for integrated agriculture processing or vaccines for animal husbandry in remote areas need to be developed with services offered on a pay-as-you-go basis (Box 10). The type of financing required for such infrastructure is usually long term (10 to 20 years). Thus, financing models need to be developed for different types of end users across various ownership or business models. A number of pay-as-you-go companies have expanded their offerings to include consumer financing for appliances such as televisions and refrigerators (Waldron and Hacker, 2020).

A key reason why many financial products for the poor are expensive is because they are designed as consumptive and not asset-building loans.[7] The seasonality and variance, and the lack of understanding, of income streams makes it seemingly more complex for local financial institutions to offer customised financial products which in the present form could be either unaffordable for the poor or not match their cash flow situation well. Gender also influences the capacity of end-users to access financing products, particularly when collateral is demanded.

Building and tapping into grassroots financing channels, including well-capitalised micro finance institutions, savings and credit co-operative societies and community banks, backed by appropriate policies will make the needed types of capital accessible to end-users and enterprises in a manner that is inclusive, flexible and encourages innovation (IIED, 2020).

BOX 10. SOLAR-POWERED COLD STORAGE: EXAMPLE OF PAY-AS-YOU-STORE MODEL IN NIGERIA

In developing countries, 45% of food waste is mainly due to lack of cold storage, leading to direct loss of income for hundreds of millions of small-holder farmers. Cooling of fresh fruits, vegetables and other perishable produce increases freshness from 2 days to about 21 days. In Nigeria, ColdHubs has deployed modular solar-powered cold storage for the storage and preservation of perishable foods. Each unit has a capacity to store up to 2 tonnes of perishable food. The infrastructure is most often used intermittently based on harvest cycles and storage needs. Farmers are offered a flexible pay-as-you-store subscription model based on a daily flat fee for each crate of food they store. The fee is approximately NGN 100 (or USD 0.27) per crate per day.

Over 54 units across 22 states in Nigeria are now installed, with more than 5,250 smallholder farmers, retailers, and wholesalers utilising the cold rooms. In 2020, over 40 000 tonnes of food was stored, contributing to reduced waste and increased farmers' profits.

Source: ColdHubs, n.d.; Energypedia, n.d; Cairns, 2021.

Financial institutions such as rural development banks, national banks, co-operative banks, micro-finance agencies, and lease-/credit-based enterprises need innovative and adaptive financial and ownership products to meet the needs of their clients. Tested innovations in financing include guarantee mechanisms, down-payment refinancing, and group lending (see the case of Cambodia in the agri-food sector in Box 11). Donors and public funding from governments will continue to play a crucial role in ensuring access of productive end-use appliances to the lowest-income end-users unable to be serviced by existing mechanisms.

[7] *Consumptive loans are short-term, while asset loans encourage the ability to secure income-generating hardware over a longer loan term and lower interest rate thus complementing cash flows and ultimately encouraging ownership.*

BOX 11. CLEAN ENERGY REVOLVING FUND FOR CAMBODIAN AGRI-FOOD SECTOR

The Clean Energy Revolving Fund (CERF) was established in 2016 with a view to mobilise affordable financing for small and medium agri-businesses and farmers to adopt renewable energy technologies in Cambodia. The traditional financing available for small and medium agri-businesses and farmers was expensive and fully collateralised (usually with land titles). To address this, CERF offered flexible financial terms whereby both loan tenors and repayment schedules were structured to fit agricultural cycles. The renewable energy technology was used as collateral, and low financing fees were charged.

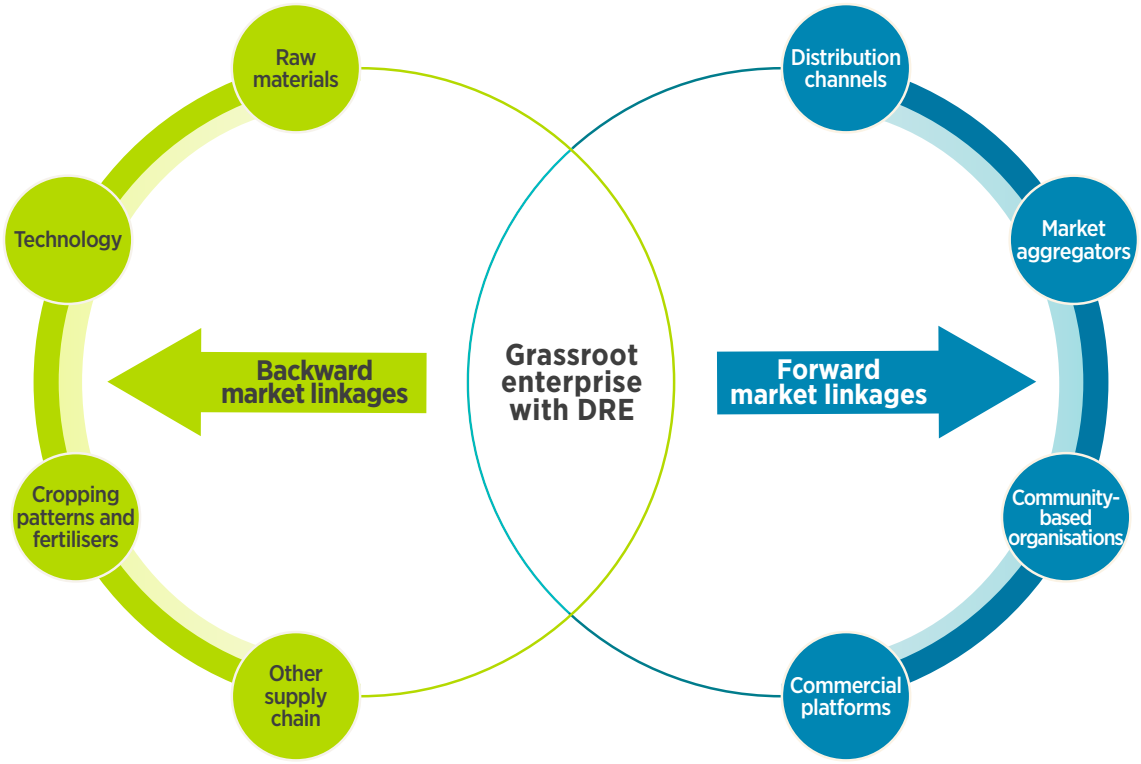
The loans were provided for 85% to 90% of total technology costs with most loan sizes varying from USD 10 000 to USD 15 000. The length of the typical loan agreement was three to five years, with an annual interest rate of 8%. The total project funding through the CERF stood at over USD 261 000 across fifteen projects over a three-year period. A key objective of the CERF was to create an ecosystem for local financing institutions to design dedicated products for renewable energy in the agriculture sector. Donor agencies should further incentivise local financial institutions through guarantee mechanisms to mitigate the risk of investments, to cover potential losses for a period and to reduce collateral requirements.

Source: Long and Louie, 2019.

3.1.3. Forward and backward linkages

Securing stable backward linkages and forward linkages is critical to the financial and business models of any enterprise. Forward linkages refer to commercial platforms, community-based organisations, market aggregators and distribution channels, while backward linkages refer to aspects related to the supply of all inputs, including raw material, labour, credit, technology, ownership models and cropping patterns, among others (Figure 5).

Figure 5. Forward and backward market linkages



Note: DRE = decentralised renewable energy.

Decentralised renewable energy solutions allow enterprises to diversify their products/services and capture greater value by undertaking a larger number of value chain activities locally i.e. closer to where the raw material is produced. The agro-processing of pulses, millet, cereals, spices and fruits by one entity can result in value addition (in terms of increased sales price) of up to 90% (SELCO Foundation, 2019). However, income levels, cash flows and ownership models, as well as the overall resilience of an enterprise, depend on strong and reliable forward and backward linkages. Literature has shown that additional income generation potential is modest at best in the face of market access limitations in rural areas (Ministry of Foreign Affairs of the Netherlands, 2013).

In Kenya, it is estimated that farmers who irrigate sell over 70% of their crops in local markets. Accessing markets farther away is difficult for small farmers. Enterprises working to deploy solar irrigation solutions that lead to substantial improvements in yields and productivity are, therefore, now working to facilitate access to markets for surplus produce. SunCulture (a private entity deploying solar irrigation solutions in Kenya), for instance, arranges contracts between farmers and large distributors to ensure offtake of the products and the realisation of additional income (REEEP, 2018).

In another example, a rising number of entrepreneurs using solar-powered bread-making machines in a region in India led several to establish new market channels and linkages (SELCO Foundation, 2018). The entrepreneurs responded to competition by tapping into new markets beyond domestic households such as hostels, hotels, local events, shops, exports and online sales, thus ensuring diversification to spread risk across multiple revenue channels. Forward market linkages can also involve selling products and services to other enterprises. For instance, sawmills utilising decentralised energy can provide semi-furnished goods, such as wide boards and wooden beams, to local carpenters who would otherwise have either imported or hand-sawed them (GIZ, 2013).

Measures to improve market linkages. To stimulate and stabilise linkages there is a need to tap into government or donor-funded livelihood support programmes, agri/dairy/other under-served business incubators or accelerators, e-commerce platforms, aggregators, etc. Key roadblocks to market access include large numbers of small-scale suppliers, limited aggregation, inadequate storage and transportation infrastructure, and large distances between rural areas and market centres. To address these, a cluster-based approach is often needed, with networked infrastructure to facilitate the transport of

BOX 12. ESTABLISHING FORWARD MARKET LINKAGES FOR PROCESSED PRODUCTS

Millet grading offers several value-added benefits. For farmers selling processed produce, it raises incomes. For a micro service-based enterprise, it reduces transaction costs, and for producer groups, it enables decentralised processing with significant savings.

Markets for graded/processed millet are a mix of local, domestic, global, public and private, depending on the type of region and enterprise. In one example from India, government policy ensured that all processed millet procured for public distribution to schools and hospitals would be sourced from rural producer groups only. In another, the producer group was able to merge the grader with other processing units and create export markets for the value-added product. These types of market linkages, coupled with incentives for millet as a crop where feasible, make a strong case for bringing solar-powered efficient millet graders to scale.

In another instance, a rural entrepreneur engaged in roti (bread)-making was able to access an urban market by developing relationships with a local travel operator. It thus opened up a distant market by leveraging a local resource. Devising such a creative mode of operations depends on the entrepreneur and local resources.

Source: SELCO Foundation.

processed goods and services from producer to various markets with limited losses (Box 12) (Lighting Global, 2019). There is also potential for linking multiple value chains (specially in agriculture) where one may act as a backward linkage to the other and vice versa. Making use of these linkages can greatly improve profitability of enterprises, cross-subsidise technologies and lead to a larger impact in local areas. Finally, trust must be developed between producers and buyers for effective aggregation, as well as to communicate expectations on quality control and supply.

3.1.4. Training and capacity building

In an ecosystem linking decentralised renewables with livelihood applications, each stakeholder must fulfil unique roles and responsibilities for the ecosystem to effectively function. This requires capacity building and training, including strengthening the technical or managerial capacity of private and public firms, financing institutions, and educating villagers and communities about productive energy use (Sovacool, 2013).

Last-mile clean energy enterprises – those involved in distribution, installation and maintenance of sustainable energy solutions – may cover a few villages or even entire regions. Some of the key areas that can be strengthened or incubated for such enterprises are business plan development, financial know-how, and human resources and skill development, among many others. Incubation centres have been established in different geographies to train grassroots enterprises in business planning, inventory management, needs assessment, financial and team management, and the setting up of after-sales networks. Anza (United Republic of Tanzania), Entrepreneur Associates (India), SELCO Foundation (India) and Kenya Climate Innovation Centre, for instance, have all developed incubation programmes focused on nurturing and growing local energy entrepreneurs – some with a focus on gender. At a regional level, the Economic Community of West African States (ECOWAS) set up the Regional Renewable Energy Entrepreneurship Support Facility in West Africa while the Southern African Development Community (SADC) set up the Renewable Energy Entrepreneurship Support Facility in southern Africa implemented by SADC Centre for Renewable Energy and Energy Efficiency (SACREEE).

The stakeholders in the **financial inclusion ecosystem** (Power for All, 2017), such as collection agents, banking correspondents and financing institutions (like micro-finance, co-operatives, national or rural regional banks) need training, as well as internal leadership, to innovate, experiment and facilitate the inclusion of renewable-energy-oriented products in their financing offerings to individuals and enterprises. Efforts are being made through banker training institutes run at a national or subnational level.

Technology developers/manufacturers (Pan, 2014) play a crucial role in the development of livelihood-focused appliances that can be linked with decentralised renewable energy solutions. Such developers range from small, local entities supplying solutions, such as agro-processing equipment, weaving and milking machines, to large conglomerates manufacturing sewing machines or medical appliances. The incubation support required includes mentorship by experts and partner organisations with grassroots experience in user needs, support in identifying appropriate testing sites and related user research, and capacity building in core product quality, warranty arrangements, among others.

At the **end-user** level, most efficient appliances designed for productive uses require training and capacity building for their optimal utilisation (Chandramouli, 2020). An appliance like a sewing machine or grinding machine requires only an initial 510 minutes of training and can be easily operated to expert levels while on the job. Machines like bread making or milking machines require 13 months of periodic training to ensure optimum utilisation, while poultry egg incubators or driers often need hand holding over six months to one year.

Local NGOs can play a critical role in intermediary financing, skills training and mobilisation of local government, among others. Their proximity to communities and their knowledge of local practices and mindsets assists in securing trust and providing additional support in delivering solutions over the last mile. For example, NGOs in India are the primary promotion agencies for Farmer Producer Organisations which are in many ways a base to the enterprise creation movement and an important avenue for technology and energy system deployment. Similarly, in international contexts as well, NGOs play a vital role in bringing forth such activities through training programmes in the conventional sense – but also a deeper, business thinking philosophy that needs to be integrated into both the NGOs and the end-users.

An ecosystem for livelihood creation requires a plethora of human resources, with occupations ranging from technicians to managers to innovators. Local vocational schools and incubators should be strengthened to support this need (Box 13).

BOX 13. AWARENESS RAISING AND TRAINING FOR TECHNOLOGY DIFFUSION AND ADOPTION

To support the diffusion and adoption of new technology it is important to raise the awareness of potential end users. This can be done by grassroots partners that understand the socio-economic context of a community. For example, in India, the SELCO Foundation engages with the District Agriculture Training Centre, a state government body which organises two-day farmer awareness programmes and demonstrates efficient and appropriate agri-machineries.

Community-based organisations that regularly hold training programmes with self-help groups, social enterprises and financial officers can provide specific training in sustainable livelihood solutions.

To strengthen last-mile supply chains, skill centres with capacities to upgrade technicians' skills in solar technologies are needed. Partnerships with local industrial training institutes engaged in various trades can integrate solar technical modules as an elective to their main electrical courses. These cadre of solar technicians will bolster the confidence of end users. The Alternative Energy Promotion Centre, a government agency in Nepal, partners with the Council of Technical Education and Vocational Training in training solar technicians for last-mile connections. In Sierra Leone, the EU-Funded Promoting Renewable Energy Services for Social Development programme trained lecturers around the country and designed a Solar Technician curriculum that is now offered at three government institutes across the country.

Source: SELCO Foundation, 2018.

BOX 14. CROSS-SECTOR PARTNERSHIPS TO DEPLOY DECENTRALISED SOLUTIONS FOR LIVELIHOODS

In Jharkhand, a state in east India characterised by high levels of rural poverty, a partnership between the government agency, the Jharkhand State Livelihood Promotion Society, a local community-building organisation, a local self-help group (SHG) and a technical partner was forged to combine expertise in designing technical and financial models, infrastructure for financing, community mobilisation and market linkages. The SHG is involved in the procurement of paddy (jeera phul rice) and the creation of market linkages for small and marginalised farmers in the village of Mahuadnar (near the town of Latehar).

In order to improve local processing and thus value addition, the Jharkhand State Livelihood Promotion Society along with its local partners provided seed capital to set up a Rural Service Centre for the processing of paddy. Initiated in 2019, the Rural Service Centre is managed by the SHG. The selling price of 1 kilogramme of rice is INR45-50 (depending on the market). After hulling, the percentage of husk out of paddy is almost 25-30%. The husk also has a market value and is sold as fodder at INR 2 per kg. The cost of paddy procurement is INR 23-24 per kg.

The Rural Service Centre aims to provide hulling and polishing services, as well as market linkages to about 130 SHGs and 1 030 women farmers in the area. An annual hulling target of 40 tonnes was set for the first year. In the first three months of implementation, the Rural Service Centre had successfully stored 30 tonnes of paddy and hulled 6 to 7 quintals. The estimated revenue from 40 tonnes would be INR 1 520 000 annually in the first year and the cost of procurement of paddy is INR 960 000 as per the target, resulting in a profit of INR 560 000. This is a successful example of a model wherein a government agency integrates a sustainable energy solution in order to catalyse livelihoods at the community level.

3.1.5. Policies and programme design

Governments have a crucial role to play in supporting the development of an ecosystem for productive uses of decentralised solutions. An important first step is to encourage these end uses in national energy access planning and strategies. In the absence of a targeted effort otherwise, energy access programmes often focus on expanding supply with limited investments in facilitating productive end uses (RMI, 2018). Governments must also facilitate the flow of experiences and innovations between the policy makers and organisations promoting decentralised renewable energy solutions and productive end-uses. Policy implications also cut across many other parts of the ecosystem – technology, finance, linkages and capacity building.

Targets and holistic planning. Introducing targets and incentives for expanding the coverage of productive uses is the first step towards improving the sustainability of energy access initiatives and maximising socio-economic development outcomes. Their multi-sectoral linkages mean that decentralised renewable energy solutions require policies and programmes that engage a wide range of institutions and stakeholders from the different sectors to support livelihoods. Such partnerships are crucial for accurately determining energy needs, identifying tailor-made technological solutions and scaling up adoption. In the Philippines, for example, the Department of Energy and Department of Agriculture in 2021 announced the Renewable Energy Program for the Agri-Fishery Sector in 2021 to promote renewable energy technologies in agri-fisheries through measures to boost research and development, standards development and enforcement, human resource development, and assistance to local manufacturers, fabricators and suppliers (Philippines Department of Agriculture, 2021).

In India, the Jharkhand State Livelihood Promotion Society[8] promotes self-help groups and other local village organisations to improve livelihoods by reducing drudgery, filling energy gaps and enhancing incomes (Box 14). The

[8] *The society was established by the Rural Development Department of the Government of Jharkhand as a nodal agency supporting the effective implementation of livelihood promotion in the state. It also oversees the implementation of the National Rural Livelihood Mission in Jharkhand. The mission has an ambitious mandate to reach nearly 70 million rural households across the country, and link them to sustainable livelihood opportunities.*

BOX 15. POLICY MEASURES TO FACILITATE ACCESS TO FINANCING

Regular interactions at different levels and evidence-based advocacy served to raise a regional rural bank's awareness of the link between renewable energy and sustainable livelihoods. The Karnataka Vikas Grameena Bank, a prominent rural bank in Karnataka, has more than 600 branches across the state. In an internal policy memo, the bank set a target of loaning 1 000 sustainable energy- driven livelihoods within a time period of 12 months.

Another form of policy facilitation is the inclusion of a bankers' training programme that reduces transaction costs and improves the viability of energy solutions. The Indian Institute of Bank Management, an autonomous institute sponsored by the Reserve Bank of India, the National Bank for Agriculture and Rural Development and five other commercial banks, is actively engaged in capacity building, research and consultancy in the banking system. It has mainstreamed a programme on financial solar projects within the existing gamut of the training and capacity-building curriculum. This serves to sensitise bank/government officials about the imperatives of lending in solar projects and modalities of credit management in the life cycle of sustainable livelihoods projects.

role of data and decision-making tools cannot be understated. Access to local data related to demand, willingness to pay, as well as infrastructure access (*e.g.* processing centres) can support policy and investment decisions.

Technology. Setting technology-efficiency benchmarks can stimulate the industry to innovate decentralised energy solutions and productive appliances. Supply chains for efficient packaged solutions that utilise sustainable energy can be strengthened through fiscal incentives. Other enabling policy measures include introducing quality and standards, and tailoring government procurement policies to local manufacturers and last-mile enterprises. The right balance between standardising protocols and fostering innovation needs to be maintained. For instance, the Ministry of New and Renewable Energy in India provides financial support for solar pumps that align with standard specifications and has recently issued guidelines to support the testing of pumps that use innovative solutions to reduce costs and improve efficiency. New solutions with demonstrated improvements shall inform the ministry's updates of technological specifications (MNRE, 2020). Dedicated centres of excellence can also catalyse technology innovation. The Africa Centre of Excellence for Sustainable Cooling and Cold Chain (ACES), for instance, has been established by the governments of Rwanda and the United Kingdom of Great Britain and Northern Ireland and other partners to develop and accelerate the uptake of sustainable cold chain solutions in the agriculture and health sectors (REMA, 2020).

Finance. Policies can also facilitate access to financing. Examples include establishing dedicated financing schemes for enterprises to adopt renewable energy solutions and setting targets for lending for productive use applications (Box 15). The Reserve Bank of India has devised priority sector lending targets to channel credit to key economic sectors such as agriculture, micro and small enterprises, education, housing, social infrastructure and renewable energy. In the case of Nigeria's National Electrification Project, a component dedicated to the adoption of productive end-use solutions has been formulated. It aims to support 20 000 micro, small and medium enterprises in the use of productive appliances and equipment by 2023, backed by performance-based grants for decentralised energy enterprises (AfDB, 2018).

Some countries have also experimented with innovative financing for rural electrification programme "aggregators" (such as the Infrastructure Development Company Limited in Bangladesh, or the Alternative Energy Promotion Centre in Nepal) to facilitate affordable finance to consumers so as to enable them to purchase equipment and appliances, while bulk purchasing can lower costs, particularly for public facilities (SEforALL, 2019). Such aggregators are also known to strengthen opportunities to provide technical assistance beyond financing, including quality control, capacity building and policy design (IIED, 2019).

Capacity building. Banker and end-user training programmes at the local level can help reduce transaction costs and boost the viability of sustainable energy solutions. The ECOWAS Certification of Sustainable Energy Skills (ECSES) is a regional certification scheme launched by the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) to promote professional competency and address quality assurance gaps in the renewable energy and energy efficiency value chain. The ECSES scheme, presently covering off-grid solar photovoltaic systems, is based on a job-task analysis developed by all ECOWAS member states with inputs from stakeholders and industry experts. ECREEE aligns all certification systems to the requirements of ISO/IEC 17024:2012 "conformity assessment general requirements for bodies performing certification of persons". This facilitates the recognition of sustainable energy professionals' credentials internationally and regionally (ECREEE, 2019). In fact, the EU-funded PRESSD Sierra Leone program utilised the job-task analyses developed under the ECSES scheme as a foundation and adapted them for the local context. The curriculum is now offered at three government institutes across the country.

3.2. CROSS-CUTTING ELEMENTS

Certain cross-cutting elements must be in place for an ecosystem to have optimal and inclusive outcomes. This section discusses three such elements: inclusive partnerships, a gender lens (to ensure that opportunities and benefits are equitably accessible and distributed) and knowledge sharing across communities and regions.

Inclusive partnerships

With livelihood applications cutting across sectors involving multiple stakeholders, partnerships become crucial success factors as all actors have a different but complementary role to play in ensuring that the ecosystem's components function

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effectively and are strengthened (Box 16). As described in the preceding sections, governments, financial institutions and technology partners are well positioned to engage other key stakeholders at the local level.

In particular, inclusive partnerships with co-operatives, community-based organisations, farmer producer organisations and other market actors are vital to establish market access for local enterprises to derive the right value from the goods and services delivered. Solar irrigation pump provider SunCulture in Kenya, for instance, partners with food distribution platforms (Twiga) to improve market access for farmers (Joe, 2018). In India, a farmer produce organisation (comprising 527 members), with support from the National Bank for Agriculture and Rural Development, launched its own market access initiative to offer better processing services to local villagers, enhance agricultural production via solar-powered millet machines and improve incomes by cutting out middlemen (Menasinakai, 2020). In Nepal, a solar irrigation solutions provider, SunFarmer, partnered with local co-operatives to provide affordable rent-to-own financing to farmers. SunFarmer financed, installed, monitored and maintained the systems, while the co-operatives identified the farms, collected monthly repayments and retained a fee for collection (Mukherji *et al.*, 2017). SunFarmer also created market links, including opportunities for exporting produce, and established a lab to support farmers with advice related to farming practices such as soil issues.

BOX 16. HOLISTIC APPROACH ADOPTED TO ELECTRIFY SUMBA ISLAND, INDONESIA

Sumba is one of the four largest islands in the Nusa Tenggara Timur province in eastern Indonesia. The majority of its 700 000 residents are concentrated in the fertile western part of the island. Most are subsistence farmers, and poverty is widespread. Until recently, only two small grids powered by diesel generators irregularly supply about a quarter of the population with electricity. Recognising the potential of renewables and income-generating activities on the island, Hivos developed it as a showcase for a 100% renewable energy island in Indonesia, through its Sumba Iconic Island Initiative. The project was implemented through a collaborative partnership between the Ministry of Energy and Mineral Resources, Hivos, Winrock International, IBEKA, PLN and Yayasan Rumah Energi. The organisations set up technical and business systems in the early stages of the project, including building the capacity of the private enterprise (a renewable energy service company) deploying and operating the system.

Following extensive local support and thorough studies that validated the potential for a 100% renewables goal, a renewable energy blueprint and roadmap were developed together by all stakeholders (district, provincial and national governments; the state-owned electricity corporation, PT Perusahaan Listrik Negara (PLN); local NGOs and corporate social responsibility departments of many companies).

A mix of technological solutions have been deployed to meet diverse energy needs in Sumba Island. This includes solar PV systems (primarily covering schools, community micro-grids, solar home systems and solar water pumping), charging lanterns, hydro systems (12 were installed, totaling 3.5 MW of installed capacity) and biomass gasification units. A total 9.3 MW of renewable systems were installed from 2011 to 2019. Over 1 000 domestic biodigester units have been installed with capacities ranging from 4 m^3 to 12 m^3. The biodigesters use organic matter, such as livestock and human manure, with the biogas used for cooking and electricity generation. Bioslurry as the by-product of the digester is used as an organic fertiliser and animal feed. The introduction of improved agricultural practices that are climate resilient, including the use of bioslurry, increases yields and farming incomes, and also contributes to sustainable land use by preventing soil depletion and promoting the efficient use of scarce water resources.

Source: IRENA, 2021; IRENA, 2018b; Hivos, 2021.

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Local technology providers (*e.g.* suppliers of agro-processing equipment) with strong networks among their consumers often have the needed technical know-how and understanding of local demand. They can be important partners in efforts to improve efficiency and adapt solutions to decentralised renewable energy solutions. In the state of Karnataka in India, for instance, a local enterprise (Ksheera Enterprises) that was founded by a family of dairy farmers, specialises in the manufacturing of milking machines. Even though the enterprise uses motorised milking machines, unscheduled power cuts in rural areas meant that farmers were unable to use these machines when needed. Running on diesel generators is expensive. Upon integrating mechanised solutions with solar-based systems, reliability was improved and costs reduced.

For training and capacity building, partnerships are necessary at different scales. For example, the ECSES discussed earlier allows standardisation of skills related to off-grid solar at a regional level. The ECSES is a partnership between ECREEE, GIZ, IRENA, as well as academic training centres such as the Brew-Hammond Energy Centre in Ghana. At the local level, a wide range of skills development initiatives are needed across sectors. Even with access to decentralised renewables, without appropriate skills, local enterprises may be unable to fully utilise energy to produce diverse goods and deliver services. In Bangladesh, the Chittagong Hill Tract Development Board partners with a private sector entity, Ashika Bamboo furniture, to train locals to make bamboo handicrafts. In Myanmar, the Small-Scale Industries Department trains rural farmers to make bamboo products and assists the tourism board in creating an international market for the products.

Multi-stakeholder and cross-sector partnerships will vary from context to context, but in all cases constitute a fundamental pillar, securing the ecosystem's success.

Gender

Women entrepreneurs and employees also face different challenges than men when it comes to using and deriving benefits from electricity access. This is mainly because women and men engage in different types of productive activities, at different locations, and have different degrees of access to enablers such as assets, finance, markets, infrastructure and skills. Gender perceptions also continue to influence women's role in productive end-uses.

In the absence of targeted gender interventions, male-led enterprises are more likely to benefit from the promotion of productive uses of electricity (Pueyo, Carreras and Ngoo, 2020; Pueyo, 2019). With the lack of modern energy access disproportionately affecting women, it is important to ensure that the benefits of access are equitably distributed and that women-led enterprises can both deploy and utilise decentralised renewable energy solutions.

A survey conducted by IRENA in 2018 found that over two-thirds (66%) of respondents stated their belief that women working or seeking work in efforts to expand access through renewable energy faced barriers. These barriers particularly relate to cultural and social perceptions, and a lack of gender-sensitive policies, training opportunities and asset ownership (IRENA, 2019b). Gender aspects must be integrated across each component of the ecosystem outlined above for inclusive outcomes.

Gender-specific policies. Gender mainstreaming needs to occur at different levels, beginning with regional and national policy making and planning, through to the design of programmes and delivery models, and continuing during project implementation and monitoring (IRENA, 2019b). Some of the approaches that can be adopted are:

- Ensuring that women's roles cut across the energy value chain in financing, community development, innovation and entrepreneurship – including as workforce trainers and policy influencers – and not as an afterthought or as a targeted quota of all beneficiaries. This can be done through various measures: actively supporting women-led clean-energy enterprises, promoting them in decision-making roles in enterprises, encouraging women trainers in different aspects of businesses and ensuring women's representation in policy making and innovation.
- Showcasing women-led enterprises as role models to encourage other women and stand as counterpoints to gender stereotypes.
- Encouraging asset ownership among the poor, particularly women, such that safety nets are created to tide them over future shocks. Promoting ownership through tailored financing instruments that overcome traditional barriers, such as lack of collaterals, will allow women to get involved in the design, finance and deployment of solutions for household and enterprise use.
- Build evidence into policy advocacy efforts that women's increased participation in various parts of the energy and economic value chains leads to more inclusive and sustainable local economies.

Though there has been some progress in mainstreaming gender in the electricity policies of countries, the attempts are not well structured, and often not applied at the national scale (IRENA, 2018a; Govindan *et al.*, 2019). Only a third of 192 national energy frameworks reviewed by one study included any reference to women and/or gender (IUCN, 2017). However, there is a positive trend, as energy policies increasingly acknowledge the need to enhance women's participation in policy making and decision making in the sector. In 2019, Kenya's Ministry of Energy was the first in Africa to launch a gender policy that provides a framework for state and non-state actors to mainstream gender in policies, programmes and projects in the energy sector. The policy is expected to promote gender-sensitive energy institutions, enhance inclusivity and ensure that women do not just participate as beneficiaries but play an active role in the entire energy value chain (Ministry of Energy, Government of Kenya, 2019; Energia, 2019a).

Financing solutions. Women-owned enterprises tend to face higher challenges to access credit, finance and capital compared to male counterparts. This impacts their capacity to invest in productive end-use appliances and technologies. Designing gender-sensitive financing incentives and products could help improve accessibility. In Nepal, for instance, special incentives were given for women farmers who are offered a 10% additional capital subsidy for solar irrigation solutions if the land is owned by the woman beneficiary (Mukherji *et al.*, 2017) (see Box 17).

Training and capacity building. The lack of access to training and skills development opportunities remains a key barrier facing women's participation in the decentralised renewables for access sector (IRENA, 2020). The ECSES certification programme (discussed earlier) offers financial support in the form of scholarships for female applicants through a Women's Technical Exchange Program. Support business owners to develop soft skills and gain exposure to role models who are overcoming occupational segregation (ENERGIA, 2019).

Technology innovation. Technology solutions for livelihood applications should be tailored with a view to unlocking new opportunities for women entrepreneurs and workers, particularly

BOX 17. DESIGNING A WOMEN-CENTRED POLICY AND IMPLEMENTATION PLAN IN NEPAL

The Renewable Energy Subsidy Policy (2016) and the Renewable Energy Subsidy Delivery Mechanism (2013) in Nepal seek to provide an opportunity for poor and socially excluded rural households to use renewable energy solutions and minimise regional disparity through concessional loans (*e.g.* Article 4.1.2, Rural Energy Policy, 2006) or additional subsidies (Renewable Energy Subsidy Delivery Mechanism, 2017). They offer an additional 10% subsidy for productive end-uses to traditionally excluded groups such as women-headed households, single women, the poor or marginalised.

The policy was effective to a certain extent. It is estimated that 45% of the solar home systems subsidised under the policy between 2012 and 2017 were owned by women. However, uptake among other marginalised groups was still limited despite the additional subsidy allocated.

Source: ADB, 2018; AEPC, 2017; IIED, 2020.

focused on sectors (*e.g.* milling, carpentry) that have been traditionally male dominated due to the physical nature of the work (Energy Future, 2020; Energia, 2019b). This entails integrating gender-sensitive end-user feedback into the technology innovation process, as well as offering financing support that is equally accessible for women-led enterprises. In some cases, women's empowerment has specifically been targeted through financing design.

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Knowledge management

Another critical element of an ecosystem is the need to share lessons – both of failures and successes – across regions, countries and micro-level contexts. These need to be:

- **Actionable** which implies a shift from static to practical. It is important to condense information in ways that enable its consumption and processing. Innovative tools to this end include bilingual reports, manuals, podcasts and webinars. It is important that lessons feature on-the-ground perspectives.
- **Collaborative**, in a move away from silos towards alignment with common goals and solutions between sectors. South-south co-operation platforms can play a key role in strengthening collaboration across countries and stakeholders. The Hydro Empowerment Network – a micro-hydro practitioner network in South and Southeast Asia – conducts stakeholder workshops for developers, financing institutions and government agencies to share practical lessons on tackling key aspects related to micro-hydro development and operation, including productive end-use development.
- **End-user centric**, with in-depth understanding of consumers' needs being integral to the messaging.

In order to dispel misconceptions but still motivate learning across different contexts, the nature of storytelling, capturing data and disseminating information needs to change. Furthermore, with a significant number of programmes and initiatives operating globally to scale-up decentralised renewable energy solutions for productive end-use applications, a key focus on knowledge gathering and sharing is important to support replication and impact at scale.

4 Creating the ecosystem for supporting sustainable livelihoods with decentralised renewables

Access to modern energy solutions is often cited as one of the pre-requisites for socio-economic development. Yet, over 750 million people continued to live without electricity access in 2019 and many more had to contend with unreliable supply. The consequent economic and social cost is significant and a key argument for mobilising urgent action and investments to reach universal access in a timely manner. An integral part of building back better from the COVID 19 pandemic will be steps to catalyse rural economies, create local jobs and ensure resilient public infrastructure. Access to modern energy will be a central pillar of such a recovery and of building a more inclusive and just energy system in the long-term.

Linking decentralised renewable energy supply with livelihoods is an important step. It offers the opportunity to translate investments in electricity connections and kilowatt hours into higher incomes for communities and enterprises, local livelihood opportunities and well-being for large populations in rural and peri-urban areas, although it is not the only pre-requisite. Achieving this transformative change requires greater efforts than simply deploying decentralised systems or delivering units of electricity. As noted in this brief, it requires investing in an ecosystem that can foster technology solutions tailored to livelihood needs and deliver the financing, capacity and skills, market access and policy support to realise the full benefits of decentralised renewable energy.

Developing such an ecosystem requires the involvement of a variety of stakeholder groups. These include different levels of government (from local to national) with mandates cutting across various sectors; finance institutions ranging from international donors to intermediaries and local banks; enterprises in energy and other livelihood sectors as well as non-governmental entities (i.e. fulfilling various enabling functions such as incubation support, advocacy, etc.).

This chapter discusses five key action areas for building this ecosystem, based on lessons learnt from ongoing initiatives across the developing world. It offers a blueprint for existing and upcoming energy access programmes and initiatives – public and private – to strengthen impacts on productive uses for greater socio-economic benefits. The chapter concludes with an overview of the relevant stakeholders that would ideally be responsible for each action area.

4.1. CONSIDER PRODUCTIVE END USES IN ENERGY ACCESS PLANS AND STRATEGIES

Experience suggests that the provision of electricity alone is not sufficient to maximise socio-economic development impacts. Targeted efforts are usually needed to integrate electricity supply with existing and new livelihood applications to strengthen social and economic outcomes in rural areas (see Box 19). Appropriate technology design, financing, policies, market linkages and capacity building are all required. High-risk innovation support is also needed, so that new and needs-based processes and models can be developed and institutionalised. Steps towards creating the requisite ecosystem are as follows.

- Ensure that electrification plans and strategies explicitly target local enterprise development in addition to household-level and public service access.
- Assess existing and new livelihood opportunities across sectors that stand to gain from improved access to modern energy services. Integrate energy into cross-sector policy objectives and institutional mandates for effective implementation (see Box 18). Working across sectors could also provide crucial productive loads for justifying investments in electrification initiatives. Accordingly, there is a need to involve energy and non-energy ministries and public bodies.
- Gather data on energy use across value chains of various goods and services, along with key across and identifying gaps and energy needs to be filled for further development. Link findings from needs assessments with high-risk financing for local enterprises and technology providers to test new end-user applications, business models and partnerships, and improve efficiency of appliances.

BOX 18. SUPPORTING POLICIES AND APPROACHES FOR CROSS-SECTORAL LINKAGES BETWEEN ENERGY AND LIVELIHOODS

Ethiopia has put electrification at the heart of its agricultural and rural transformation strategy. The Climate Resilient Green Economy strategy, launched in 2011, sets sector-specific plans for transitioning to a green economy. These include expanding electricity generation from renewables and leapfrogging to energy-efficient technologies in the agriculture sector. Furthermore, through dedicated programmatic interventions, the government has integrated electricity supply with other services to enhance productive capacity and has leveraged various energy sources to broaden overall access.

Similarly, Zambia has taken a cluster-based approach to agricultural electrification through "farm blocks" that are equipped with basic infrastructure and complemented by industrial cluster zones for agricultural processing. To meet increased energy demand and connect rural areas to electricity, a government strategy seeks to expand electrification using a combination of grid extension and off-grid solutions. The government also draws on different tailored financing tools for power supply and farm equipment, such as rent-to-own schemes and funds that de-risk companies' costs of operating and expanding. Zambia has a commitment in place to strengthen and diversify its energy supply through fiscal incentives, including reduced import duties.

Source: Malabo Montpellier Panel, 2018.

- Map stakeholders across livelihood value chains and establish partnerships to support the integration of decentralised renewables and enable access to markets, new skills and capacity to maximise benefits for local enterprises.
- Increase ecosystem actors' awareness of the productive end-use applications, economics and benefits of renewable energy technologies across value chains.

4.2. MOBILISE ACCESSIBLE, AFFORDABLE FINANCING FOR END USERS AND ENTERPRISES

Access to affordable and tailored financing for end users and enterprises is a critical part of the ecosystem for deploying decentralised renewables linked to livelihood applications. Both public and private capital provision will enable high-risk innovation for the development of scalable solutions that (over the long term) strengthen the local financial ecosystem. Grassroots financing institutions and intermediaries play a particularly crucial role in channelling funds and ensuring accessibility of tailored products for end users and enterprises.

- Establish grassroot channels (such as micro-financing and self-help groups) to make affordable and flexible capital accessible to all, including local enterprises and small technology developers. Local financing institutions also need to be adequately capitalised to enable long-term lending products.
- High-risk innovation capital and affordable financing for working capital and equity for enterprises working in the sector are critical to ensure the development of tailored technology solutions and development of supply chains to reach end-users.
- Earmark and mandate lending portfolios of local- and national-level financial institutions specifically to deliver financing at lower interest rates and longer payment periods for end users of livelihood products. These should be treated as assets and not as consumptive loans.
- Allocate special incentives and financial resources to motivate small and medium technology manufacturers to create and supply a range of products that enable the link between decentralised renewable energy and livelihoods.
- Mobilise development financing from government, multi-lateral, bilateral and international philanthropic institutions to building ecosystems (*e.g.* raising awareness, improving data and information access) that have a long-term impact for sustainability.
- Strengthen the capacity of financing institutions and enterprises to evaluate investment opportunities in decentralised renewable energy applications in livelihood sectors, align incentives/motivations for lending, prepare bankable proposals and design/access suitable financing products.

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4.3. SUPPORT TECHNOLOGY INNOVATION AND ADAPTATION PROCESSES

Technology innovation and adaptation processes are crucial for linking renewable energy solutions and energy-efficient productive appliances with local end-user and value chain needs. Targeted measures are needed to facilitate a participatory technology innovation and adaptation process, as well as end-of-life management.

- Position end-user and livelihood needs at the centre of innovation efforts to deliver tailored solutions that leverages, to the extent possible, locally available solutions.
- Encourage local technology developers and R&D institutes (and academia) to innovate, source easily available components and manufacture energy-efficient equipment that reaches end users via customised business models, delivery and after-sales-service channels.
- Support local and regional technology suppliers in experimentation and innovation, including through partnerships with technical institutions, access to early-stage, high-risk financing and platforms for experience and knowledge sharing.
- Strike the right balance between introducing technology and quality standards, and fostering innovation in system design (*e.g.* efficiency) and operation.
- Facilitate south-south knowledge sharing between regional stakeholders focused on renewable energy applications and complementary technologies such as appliances and metering devices (Box 19).

BOX 19. FACILITATING SOUTH-SOUTH KNOWLEDGE SHARING: THE CASE OF HYDROPOWER EMPOWERMENT NETWORK

The Hydropower Empowerment Network (HPNET) was established in 2013 as a collective of over 50 practitioner entities from South and Southeast Asia working to advance sustainable small-scale hydropower for community empowerment. HPNET provides an effective south-south knowledge exchange platform related to technology development and innovation, policy design and cultivation of local experts and productive uses. To strengthen local technology innovation processes, HPNET organises technical trainings related to pico-hydro design and fabrication, electronic load controller and canary chic Load indicator design, and grid interconnection. The platform has facilitated exchange of technical know-how among practitioner organisations and led to localisation of large segments of the micro-hydro value chain, thereby improving sustainability and local benefits.

Source: HPNET, n.d.

4.4. EXPAND INCUBATION SUPPORT AND SKILLS DEVELOPMENT

Adequate capacity needs to be built across the ecosystem to ensure sustainable and rapid scale-up of decentralised renewable energy solutions linked to livelihood applications. Local enterprises, including those delivering energy solutions and those benefiting from adoption, can be strengthened through tailored incubation efforts. The barriers they often face include limited access to working capital and innovation money; poor access to end-user capital and to custom-designed rural credit; geographical and supply chain constraints; lack of a trained workforce and in turn of after-sales service; lack of understanding of customers' requirements; lack of available, quality products; inadequate rural energy policies; and language barriers. Tailored incubation support and skills development initiatives can help address a number of these challenges and improve overall capacity.

- Increase spending on upgrading vocational training centres, especially in the rural areas, to become centres of innovation and entrepreneurship that encourage new advances and enterprises in the field of sustainable livelihoods. For instance, The Energy Change Lab in Tanzania partnered with a mini-grid developer and the Vocational Educational Training Authority to train community productive end-use champions to overcome local skills gap. The initiative offered 'training of trainers' sessions, video tutorials and appliance demonstrations, enabling entrepreneurs to invest in equipment such as wood lathes. Long-term partnerships with training entities, tailoring training modules for off-grid applications and innovation in distance learning platforms are important to strengthen local skills (IIED, n.d.). Provide incubation and human resources development support to local enterprises to build capacity, provide mentorship, create partnerships and enable the enterprises to successfully incorporate

BOX 20. HOLISTIC INCUBATION SUPPORT FROM THE KENYA CLIMATE INNOVATION CENTER AND SELCO FOUNDATION

The Kenya Climate Innovation Center (KCIC) provides holistic, country-driven support to accelerate the development, deployment and transfer of locally relevant climate and clean energy technologies. KCIC provides incubation, capacity-building services and financing to Kenyan entrepreneurs and new ventures that are developing innovative solutions in energy, water and agri-businesses to address climate change.

KCIC runs a 12-month incubator programme targeted at start-ups and early-stage enterprises that have, as a minimum, a prototype. The programme runs from March of every year to February of the following year. With the aim of strengthening market linkages, a six-month accelerator programme is targeted at graduates from the KCIC incubator programme, most of which have products in the market.

In its first five years of operation, KCIC supported over 170 innovations. Over 80 business have been commercialised, generating sales revenues of USD 11 million and attracting public and private investments worth over USD 6.7 million. Participating businesses have contributed to the creation of over 1600 jobs.

SELCO Foundation incubates grassroot enterprises and institutions across the sustainable energy value chain with hands-on mentorship to develop tailored business model and processes. The Clean Energy Enterprise Incubation Program began in 2015 focusing on sustainable energy enterprises looking to deliver need-based solutions to communities. In 2019-20, the programme supported 32 enterprises covering five states in India.

In 2019, the incubation programme was expanded to include enterprises that are involved in innovating and manufacturing energy efficient technologies which represent a key part of the sustainable energy ecosystem. The Technology Incubation Programme primarily focuses on application-based technologies developed for, or in partnership with, low-income populations, and technologies that are futuristic and can enable transformative changes that have climate or social sustainability benefits. In 2019, 10 enterprises were mentored through the programme.

Source: KCIC, 2020; 2018; SELCO Foundation, 2021.

sustainable energy-based livelihood solutions as part of their offerings. The incubation centres should be able to train grassroots enterprises in business planning, inventory management, needs assessment, financial and team management and the setting up of an after-sales network (Box 20).

- Provide incubation support for small-scale technology suppliers to develop livelihood-focused highly efficient appliances compatible with decentralised renewable energy solutions. Incubation could involve access to field-based technology mentors, support in identifying testing sites, end-user feedback gathering, marketing and building channels for scale, among others.
- Provide incubation support for NGOs, think tanks and other enablers typically involving sustainable energy orientation and utilising grassroots-level understanding to bridge gaps in the ecosystem (*e.g.* financing, awareness raising, community mobilisation).
- Establish infrastructure and mechanisms to deliver technical skills training, such as in installation, maintenance and repair of system components, to ensure the long-term sustainability of renewable energy solutions in remote mountain contexts. Partnerships with technical research institutions will be instrumental.

4.5. MAINSTREAM GENDER ACROSS THE ECOSYSTEM

Women and men engage in different income-generating activities and face varying challenges to secure decentralised renewable energy solutions for livelihood applications. Traditional roles informed by cultural and social norms, as well as limited access to skills, financing and self-perception challenges continue to influence women's ability to fully utilise the opportunity modern energy access offers for livelihood development. To ensure equity and inclusivity, encouraging productive end uses through decentralised renewable energy supply implies carefully considering the accessibility of technologies and other support services (*e.g.* training, financing) for women-led enterprises.

- Adopt a gender lens in the development of each component of the ecosystem to ensure that traditional gender-related challenges to accessing financing, skills and mentorship do not hinder equitable access to renewable energy opportunities.
- Establish dedicated funding channels, or earmark quotas within existing funds, offering tailored financing products to encourage the adoption of decentralised renewable energy solutions for livelihood applications among women-led households and enterprises.
- Mainstream gender in energy access policy and programme design ensuring women's perspectives are integrated from inception and design stage through to implementation. Effective gender-disaggregated monitoring systems need to be set-up to enable tracking of impacts.
- Facilitate access to training and skills development programmes for women-led enterprises through dedicated facilities, peer-to-peer learning and mentorship programmes, and funding support in the form of scholarships. Showcase women-led enterprises as role models to encourage other women and challenge gender stereotypes.

4.6. FACILITATE STAKEHOLDERS TO BUILD THE ECOSYSTEM

Delivering on the ecosystem will require close co-ordination between stakeholders across sectors. Table 1 (overleaf) maps the key actions to build an ecosystem for decentralised renewable energy solutions for livelihoods with the stakeholders involved.

Realising the full benefits of energy access for meeting multiple SDGs will require a focus beyond connections and towards end-uses, including for income generation and public service delivery. Investing in an ecosytem laid out in this report must be a priority for governments and development partners for long-term socio-economic dividends that are underpinned by sustainable livelihoods.

Table 1. Overview of key actions and stakeholders involved

ACTION AREA	ACTIONS	RELEVANT STAKEHOLDERS
Mobilise accessible, affordable financing for end users and enterprises	Establish grassroot channels (such as micro-financing and self-help groups) to make affordable and flexible capital accessible to all, including local enterprises and small technology developers. Local financing institutions also need to be adequately capitalised to enable long-term lending products.	G F D N
	High-risk innovation capital and affordable financing for working capital and equity for enterprises working in the sector are critical to ensure the development of tailored technology solutions and development of supply chains to reach end-users.	G D N
	Earmark and mandate lending portfolios of local- and national-level financial institutions specifically to deliver financing at lower interest rates and longer payment periods for end users of livelihood products. These should be treated as assets and not as consumptive loans.	G F
	Allocate special incentives and financial resources to motivate small and medium technology manufacturers to create and supply a range of products that enable the link between decentralised renewable energy and livelihoods.	G F
	Mobilise development financing from government, multi-lateral, bilateral and international philanthropic institutions to building ecosystems (e.g. raising awareness, improving data and information access) that have a long-term impact for sustainability.	G D N
	Strengthen the capacity of financing institutions and enterprises to evaluate investment opportunities in decentralised renewable energy applications in livelihood sectors, align incentives/ motivations for lending, prepare bankable proposals and design/ access suitable financing products.	G E N

G Local and national governments
E Enterprises (clean energy and livelihood)
F Financing institutions
N Non-governmental organisations
D Bilaterals/ development partners
A Academia

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ACTION AREA	ACTIONS	RELEVANT STAKEHOLDERS
Consider productive end uses in energy access plans and strategies	Ensure that electrification plans and strategies explicitly target local enterprise development in addition to household-level and public service access.	G E
	Assess existing and new livelihood opportunities across sectors that stand to gain from improved access to modern energy services. Integrate energy into cross-sector policy objectives and institutional mandates for effective implementation. Working across sectors could also provide crucial productive loads for justifying investments in electrification initiatives.	G D N
	Map stakeholders across livelihood value chains and establish partnerships to support the integration of decentralised renewables and enable access to markets, new skills and capacity to maximise benefits for local enterprises.	G N
	Gather data on energy use across value chains of various goods and services, along with key across and identifying gaps and energy needs to be filled for further development. Link findings from needs assessments with high-risk financing for local enterprises and technology providers to test new end-user applications, business models and partnerships, and improve efficiency of appliances.	G A D N
	Increase ecosystem actors' awareness of the productive end-use applications, economics and benefits of renewable energy technologies across value chains.	G D N
Support technology innovation and adaptation processes	Position end-user and livelihood needs at the centre of innovation efforts to deliver tailored solutions that leverages, to the extent possible, locally available solutions.	A N
	Encourage local technology developers and R&D institutes (and academia) to innovate, source easily available components and manufacture energy-efficient equipment that reaches end users via customised business models, delivery and after-sales-service channels.	A G
	Support local and regional technology suppliers in experimentation and innovation, including through partnerships with technical institutions, access to early-stage, high-risk financing and platforms for experience and knowledge sharing.	G A F D
	Strike the right balance between introducing technology and quality standards, and fostering innovation in system design (e.g. efficiency) and operation.	A G
	Facilitate south-south knowledge sharing between regional stakeholders focused on renewable energy applications and complementary technologies such as appliances and metering devices.	D A G

ACTION AREA	ACTIONS	RELEVANT STAKEHOLDERS
Expand incubation support and skills development	Increase spending on upgrading vocational training centres, especially in the rural areas, to become centres of innovation and entrepreneurship that encourage new advances and enterprises in the field of sustainable livelihoods.	G D
	Provide incubation and human resources development support to local enterprises to build capacity, provide mentorship, create partnerships and enable the enterprises to successfully incorporate sustainable energy-based livelihood solutions as part of their offerings. The incubation centres should be able to train grassroots enterprises in business planning, inventory management, needs assessment, financial and team management and the setting up of an after-sales network.	G D A
	Provide incubation support for small-scale technology suppliers to develop livelihood-focused, efficient appliances compatible with decentralised renewable energy solutions. Incubation could involve access to field-based technology mentors, support in identifying testing sites, end-user feedback gathering, marketing and building channels for scale, among others.	G A
	Provide incubation support for small-scale technology suppliers to develop livelihood-focused highly efficient appliances compatible with decentralised renewable energy solutions. Incubation could involve access to field-based technology mentors, support in identifying testing sites, end-user feedback gathering, marketing and building channels for scale, among others.	G A
	Establish infrastructure and mechanisms to deliver technical skills training, such as in installation, maintenance and repair of system components, to ensure the long-term sustainability of renewable energy solutions in remote mountain contexts. Partnerships with technical research institutions will be instrumental.	G A D
Mainstream a focus on gender across the ecosystem	Adopt a gender lens in the development of each component of the ecosystem to ensure that traditional gender-related challenges to accessing financing, skills and mentorship do not hinder equitable access to renewable energy opportunities.	G N F E D
	Establish dedicated funding channels, or earmark quotas within existing funds, offering tailored financing products dedicated to encouraging the adoption of decentralised renewable energy solutions for livelihood applications among women-led households and enterprises.	G A D
	Mainstream gender in energy access policy and programme design ensuring women's perspectives are integrated from inception and design stage through to implementation. Effective gender-disaggregated monitoring systems need to be set-up to enable tracking of impacts.	G D
	Facilitate access to training and skills development programmes for women-led enterprises through dedicated facilities, peer-to-peer learning and mentorship programmes, and funding support in the form of scholarships. Showcase women-led enterprises as role models to encourage other women and challenge gender stereotypes.	G A D

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