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The Quest for Scalable Business Models for Mini-Grids in Africa: Implementing the Keymaker Model in Tanzania

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Summary

Achieving universal electrification in sub-Saharan Africa requires creative solutions. Renewable mini-grids[1] are a promising technology to electrify remote communities with a substantial productive demand, mainly from agro-processing. Mini-grids have experienced fast growth and there are now around 2,200 systems in the sub-Saharan Africa region. However, their economic case in the sub-continent is unclear. Most mini-grids are struggling not only to obtain a profit but also to recover costs. This Research Report describes the case of a private company in Tanzania implementing a business model for mini-grids that promotes productive uses of energy to achieve financial sustainability (the 'Keymaker model'). A group of researchers worked jointly with the mini-grid developer to procure equipment for fish processing activities, support local entrepreneurs to use electricity productively, and to document and learn from the process. Although the business model was ultimately unsuccessful – facing high regulatory risks, high initial tariffs required to recover costs, and complex management of agro-processing activities – the project offers useful lessons and considerations for future efforts to promote mini-grids, and how public–private partnerships can help improve affordability and reduce regulatory risks.

Keywords

energy access; off-grid electrification; mini-grids; productive uses of energy; business models; Keymaker model; gender; Tanzania; sub-Saharan Africa.

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1 Mini-grids are decentralised electric power generation and distribution systems that provide reliable energy to off-grid communities.

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Executive summary

Mini-grids business models

Decentralised electrification is expected to play an important role in electrifying sub-Saharan Africa, where 51 per cent of the population remain without access. Mini-grids are a popular approach to reach remote populations in the sub-continent and have received increased attention from donors and the private sector. Most mini-grid developers are small companies or start-ups, but large international corporations have recently entered the market. Financing relies mostly on public funds, such as grants or concessional loans from development finance institutions or donor agencies (Bloomberg New Energy Finance 2020).

The term 'business model' has been used in the mini-grid literature to describe how mini-grids create and deliver value for investors and customers. Some elements to define a mini-grid business model include: ownership and operation management approaches; revenue-generation strategies; customer focus; and implementation strategies. Several combinations of these elements have been tested. For example, private ownership and management directed to productive consumers, seeking to recover costs and obtain a profit, or public ownership and management, with a focus on residential customers and relying on subsidies for financial viability. Some evidence points to hybrid ownership, partially subsidised, focused on anchor customers, as the most promising model.

To date, no mini-grid business model has proved broadly successful and scalable in sub-Saharan Africa. Balancing affordable service provision with acceptable cost recovery remains a challenge (Bhattacharyya *et al*. 2019; Moner-Girona *et al*. 2018; Pueyo and DeMartino 2018). Success is highly context-specific, depending on regulatory and socioeconomic variables (Franz *et al*. 2014; Safdar 2017).

Implementation of the Keymaker model in Tanzania

The Tanzanian mini-grid developer JUMEME Rural Supply Ltd was established in 2016 as a private joint venture, mainly financed through a European Union (EU) grant. From the start of its activities it had been seeking a business model that would enable it to achieve financial sustainability of its mini-grids while also being affordable for end consumers. To achieve this, productive users, using electricity to generate an income, are essential. However, the remote populations targeted by their mini-grids often lacked sufficient productive demand. Through a trial-and-error process, JUMEME developed

an original approach, which they called the 'Keymaker model'. Under this model, the mini-grid company develops productive activities relying on natural resources and supply chains already available in the community, in partnership with local workers and entrepreneurs. Accordingly, revenue not only accrues from the sale of electricity but also from the sale of agricultural products such as fish or maize. The availability of reliable electricity and management competences provided by the mini-grid developer unlocks local opportunities that have previously been underutilised.

Researchers from the Institute of Development Studies (IDS) and the Tanzania Gender and Sustainable Energy Network (TANGSEN) worked with JUMEME to implement and test the viability of the Keymaker model in the Lake Victoria island of Maisome. In 2019, JUMEME built a 60 kilowatt (kW) mini-grid on the island, serving approximately 600 customers, most of them residential, but with 21 intensive productive users and around 50 commercial users. The mini-grids initially charged cost-recovery tariffs that could cover operational and replacement costs, the share of investment costs not covered by grants, and deliver a profit for private investors. These tariffs were significantly higher than those charged by the national utility, Tanzania Electric Supply Company Limited (TANESCO).

To expand and diversify revenue sources, JUMEME started two commercial activities in parallel to the mini-grid: the commercialisation of Tilapia (freshwater fish), enabled by the availability of deep freezers powered by the mini-grid; and aquaculture, where fish grow in floating cages in the lake, and electricity is used in water pumps, freezers and milling machines for fish food pellets. JUMEME had also planned to control the fish food supply value chain by partnering with a local entrepreneur who would process grain with mills and extruders to produce pellets to feed the fish. Besides, the research team supported some male and female entrepreneurs, such as millers, tailors and fish traders, with electrical equipment and training to improve the productivity of their businesses or create new ones.

The Tanzanian government mandated a reduction of mini-grid electricity tariffs in 2020, to match those of TANESCO. As a result, JUMEME's revenues decreased by over 90 per cent and it became no longer financially sustainable to operate the mini-grid. As a result, availability and reliability of electricity declined, and there was a halt to new connections. JUMEME had to limit electricity use for existing consumers to a maximum of 2 kilowatt hours (kWh) per consumer per week for residential and commercial users. The decline in the quality and availability of electricity raised discontent among Maisome's customers, even though affordability improved dramatically. The Keymaker model activities of fish trading and aquaculture faced cash-flow problems and management deficits, and were discontinued.

Appraisal of the Keymaker model in Tanzania, and lessons learned

An appropriate tariff design is at the heart of the commercial and financial viability of a mini-grid business model. JUMEME followed a private ownership model, which required a tariff that could recover most costs, except for a capital investment grant, and generate an attractive profit for investors. However, this tariff was considered unaffordable or unjust by many customers, who would compare it to the low national tariff applied by TANESCO for the same service. Although the mini-grid was clearly creating positive externalities for the community, a sense of grievance prevailed. When there is a gap between affordability and financial sustainability, guaranteed and stable subsidies should be part of the revenue-generation strategy.

The design of the Keymaker model complemented electricity revenues with fishing and aquaculture revenues that would also add a productive load to the mini-grid. However, this element of the business model did not take off due to the lack of working capital, skills and motivation.

Even the best-designed business model is not immune to context-specific external and organisational risks. The most significant risks faced by the Keymaker model in Maisome were regulatory. The sudden tariff reduction mandated by the government without previous consultation sparked a corporate management crisis. On the other hand, the resulting decline in quality of electricity supply led to discontent among the community, and the prospect of people losing their jobs due to JUMEME's economic woes reduced staff motivation and increased cases of internal fraud.

It is hard to say if the Keymaker model would have been viable and scalable had the initial tariffs remained. But some lessons can be learned about the different mitigation strategies required for different risks. First, private mini-grids will be harder to implement and scale up in countries with heavily subsidised national tariffs, as these will be taken as a benchmark by customers. Stable and secure consumption subsidies should be considered as part of the revenue-generation strategy in such contexts. Meaningful partnerships with local businesses, and continuous engagement with political representatives and the community, are clear risk-mitigation strategies. Having a robust management system and keeping costs to a minimum while providing good quality of supply are also key to scalability.

Policy recommendations

Drawing from the experience of the implementation of the Keymaker mini-grid business model in Maisome, we outline four key recommendations for policymakers and developers:

- **Set affordable tariffs for your customers**. Affordability of electricity is defined in three main ways: ability to pay; willingness to pay (WTP); and cost compared to other electricity supply alternatives, primarily the national grid. A preliminary survey to determine ability and willingness to pay can support tariff design, but developers should be wary of the dynamic character of WTP. When the service is not yet available, or at the start of operations, customers are typically willing to pay a high price for a high-quality electricity service they did not have before. But WTP decreases as they take the new energy services for granted and compare the price they pay to the grid tariff (IED 2013). To account for this, developers should plan for a downward review of tariffs to get closer to the grid tariff after a few years of operation.
- **Stay close to the political pulse of the country**. Undertake a political economy analysis to identify powerful actors and the interests they protect. Align with those actors supporting the universal and sustainable provision of high-quality electricity supply to rural areas. Engage with policymakers at the local, regional and national levels.
- **Do not underestimate the complexity of agro-processing activities**. Partner with local companies with a strong track record to mitigate this risk.
- **Ensure a stable source of consumption subsidies** if required to bridge the gap between financial sustainability and affordability.

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Acronyms

ABC	Anchor-Business-Community
AfDB	African Development Bank
ARE	Alliance for Rural Electrification
CAPEX	capital expenditure
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEP	Energy and Environment Partnership
ESMAP	Energy Sector Management Assistance Program
EWURA	Energy and Water Utilities Regulatory Authority
FCDO	Foreign, Commonwealth & Development Office
FGD	focus group discussion
IED	Innovation Energie Développement
IPP	independent power producer
IRENA	International Renewable Energy Agency
IRR	internal rate of return
KII	key informant interviews
KPI	key performance indicator
kW	kilowatt
kWh	kilowatt hour
kWp	kilowatt peak – refers to PV systems
LCOE	levelised cost of electricity
MoEM	Ministry of Energy and Minerals of Tanzania
MP	member of parliament

MW	megawatt
NGO	non-governmental organisation
OPEX	operation expenditure
PPP	public–private partnership
PREO	Powering Renewable Energy Opportunities
PUE	productive uses of energy
PV	solar photovoltaic
REA	Rural Energy Agency
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SHS	solar home system
SIDO	Small Industries Development Organization
SPP	small power producers
SSA	sub-Saharan Africa
TANESCO	Tanzania Electric Supply Company Limited
TANGSEN	Tanzania Gender and Sustainable Energy Network
TSh	Tanzanian shilling
UN	United Nations
VPC	Village Power Committee
WTP	willingness to pay

1. Introduction

More than 770 million people live without access to electricity globally (International Energy Agency 2021). Most of them are in sub-Saharan Africa, where a combination of geographical challenges, low incomes and poor governance have delayed the electrification process. Recognising the importance of electricity for sustainable development, the international community set Sustainable Development Goal (SDG) 7, to achieve universal electrification by 2030. The bulk of electrification processes has happened through a centralised national grid extension. However, decentralised options, like mini-grids and stand-alone systems, will play an essential role in the sub-Saharan Africa region, where national utilities are too financially stretched for the expensive effort to extend the grid to remote and dispersed populations.

Mini-grids[2] are expected to be a key piece of the universal electrification puzzle. They could provide least-cost access to at least 30 per cent of the unelectrified population in Africa (International Energy Agency 2019) and are particularly suitable for remote communities that the main grid struggles to reach. To be competitive with stand-alone systems, however, mini-grids require a productive demand and a population concentrated in a centre that can be connected through a distribution system.

Mini-grids have evolved from a niche solution into a widely deployed technology, reaching 19,000 systems, with 47 million consumers in 2019, mainly in Asia (ESMAP 2019). Most mini-grid developers are small companies or start-ups, but large international corporations have recently entered the market. Financing relies mostly on public funds, such as grants or concessional loans from development finance institutions or donor agencies (Bloomberg New Energy Finance 2020). Donors and developers are both calling for even further acceleration in the deployment of funds. The Energy Sector Management Assistance Program (ESMAP), for example, calls for 490 million people to be connected to mini-grids globally by 2030, estimating that this would require US$220bn in investment (ESMAP 2019). Furthermore, the mini-grid private sector envisages that half of

2 Mini-grids are decentralised electric power generation and distribution systems that provide reliable energy supply to off-grid communities in a remote settlement or a small, localised group of customers (AfDB 2016; ECREEE 2016; ESMAP 2019). They typically consist of energy from solar photovoltaic (PV), biomass gasification, wind or diesel, battery storage, and a distribution system (Chambon *et al*. 2020). A mini-grid can be stand-alone, operating independently of the national grid, or grid-connected, feeding some of its power into the national distribution network. Although the term 'mini-grid' is collectively used to refer to systems involving small-scale electricity generation up to 10 megawatts (MW), some definitions distinguish based on the power capacity. Thus, mini-grids are typically divided into three size categories: 1–10 MW (Type 1), 100kW–1MW (Type 2), and less than 100kW (Type 3) (AfDB 2016).

the unelectrified communities in Africa will be reached by these systems, and requests further public funding, programmes to increase demand for electricity, and the reduction of red tape (ECA and AMDA 2020).

However, the economic case for mini-grids in sub-Saharan Africa remains inconclusive. To date, no business model has proved broadly successful and scalable. Mini-grids in the sub-continent are struggling not only to obtain a profit but also to recover costs (AfDB 2016; IRENA 2016; Ogeya, Muhoza and Johnson 2021; Peterschmidt 2019). A sizeable and stable demand (or anchor load) remains a stumbling block for mini-grids to become an economically viable alternative. In rural sub-Saharan Africa, household electricity demand is low and irregular due to seasonal income-generation activities and low incomes. Integrating productive users[3] into the load is essential for the mini-grid's financial sustainability, which explains the interest of private developers and development partners in supporting productive uses alongside mini-grids.

In 2020, the United Kingdom (UK) government launched the Powering Renewable Energy Opportunities (PREO) programme, co-funded by the IKEA Foundation, aiming to enable African businesses to harness clean energy to improve incomes, build climate resilience and reduce reliance on fossil fuels. PREO supports productive uses of energy (PUE) projects and collaborative partnerships designed to meet the specific needs of local communities. This report documents the process, outcomes and lessons learned from one of the awardees of grant funding, the action-research project, Promoting Inclusive Productive Uses of Energy from Solar Mini-Grids in Lake Victoria, Tanzania: A Gendered Approach to the Keymaker Model ('the project'). The project was led by IDS, in partnership with mini-grid developer JUMEME and Tanzanian research and advocacy organisation TANGSEN. The project's three broad goals were: to test the viability of the Keymaker business model; to promote women's economic empowerment through the productive use of energy; and to promote economic development in the community by creating new jobs and businesses.

The mini-grid developer JUMEME devised the Keymaker business model to simultaneously increase the financial viability and economic impact of its mini-grids in Tanzania. The model consists of the dual development of mini-grids and electricity-consuming productive activities. The mini-grid would unlock productive opportunities, such as fish processing, using natural resources that had previously been underutilised or undervalued in the community due to poor energy access. Through this project, JUMEME tested the Keymaker model on the island of Maisome, with support from IDS and TANGSEN for research, awareness and capacity-building

3 Productive users are people who use electricity to generate an income.

activities. The project provided financial resources to purchase equipment for productive uses, mainly related to the fishing sector – the mainstay of the island. Besides equipment, the project funded capacity-building, awareness-raising and research activities. The project aimed to increase the gender inclusivity of the model, specifically targeting women, because previous research has shown that men typically benefit more than women from productive uses of electricity. This is because men tend to own more and bigger enterprises, operate in the more electricity-intensive sectors such as milling, metalworking and woodworking, and control the key economic activity of a community (Pueyo and Maestre 2019; Pueyo, Bawakyillenuo and Carreras 2020a; Pueyo, Carreras and Ngoo 2020b).

The project started promisingly, with a baseline analysis highlighting the potential to use electricity productively along the fishing value chain and in other sectors. During baseline data collection, our team gathered a lot of interest from potential entrepreneurs, after several meetings during which they explained the potential to improve people's business or start a new one using electricity. JUMEME procured equipment for a new aquaculture business as part of the Keymaker model and engaged a consultant to get it started and train their staff. A business development workshop delivered several feasible productive uses that would be supported with electricity connections and partial financing of electrical equipment. However, a series of events derailed the project from mid-2020. The Tanzanian government revoked the right of mini-grid developers to charge cost-recovery tariffs and imposed the national tariff instead.[4] Although the new tariff was very affordable for the community, JUMEME´s revenue decreased by over 90 per cent. Electricity consumption rationing and a halt to new connections followed suit. Consequently, the new promising productive activities to be connected were put on hold. Financial constraints led to drastic staff downsizing, a breakdown in employee motivation, and fast employee turnover in JUMEME.

The case of JUMEME in Maisome shows that a successful business model relies on a favourable regulatory environment. This report outlines the successes, challenges and potential for future replication of the Keymaker model in Tanzania, drawing on lessons learned from the project to provide future recommendations tailored to an African context. The report will examine the impact the model has had on the local community, the techno-economic performance of the mini-grid and the economic empowerment of women.

4 The national regulations allowed very small power producers to apply cost-recovery tariffs, but considered the potential for these to be reviewed if customers complain.

The report starts with a review of the literature on mini-grid business models and enabling environments (Section 2). Section 3 provides some background about Tanzania's energy system, particularly the mini-grid sector. Section 4 describes JUMEME's solar mini-grid activities in Tanzania, particularly on the island of Maisome. Section 5 describes the activities carried out by the project. Section 6 presents the data collection methodology and the framework used to analyse the performance of the Keymaker model. Our analysis in Section 7 looks at the Keymaker business model, the internal and external risks at play, and the final outcomes and impacts achieved. The discussion evaluates the model according to the analytical framework described previously. Finally, the conclusions draw some lessons for development actors and the private sector looking to invest in mini-grids in sub-Saharan Africa.

2. Literature review: mini-grid business models and risks

This section reviews the key literature on mini-grids business models, providing insights on what has worked and what has not in the sub-Saharan Africa context. We also review the literature about enabling factors for mini-grids, which influence their success in the communities where they are implemented. The aim of the review is to extract an analytical framework to structure the evidence gathered about the Keymaker model in Maisome. This analytical framework is presented in Section 6, which presents our methodology.

2.1 Mini-grids business models

The term 'business model' has gained incredible popularity over the past decade as one of the critical ways of approaching business innovation and strategy. A standard definition of the term is the approach taken by a business to create and deliver value to its customers. Therefore, a business model is a practical tool for describing business activities and value creation, as it is an analytical tool for comparing them (Ogeya *et al*. 2021). The literature on mini-grids does not always focus on value creation. Models of ownership and operations management are the most predominant in the mini-grids literature (AfDB 2016; Franz *et al*. 2014; Korkovelos *et al*. 2020; Peters, Sievert and Toman 2019; Safdar 2017), followed by revenue-generation models (Schnitzer *et al*. 2014) and customer focus (Knuckles 2016; Ramchandran, Pai and Parihar 2016), and implementation models (ARE 2014; Weston *et al*. 2018). We review each of these approaches to define mini-grid business models, explaining the advantages and disadvantages of each model.

2.1.1 Ownership models

First, mini-grid ownership models vary according to who invests, holds and operates the mini-grid assets, including generation and distribution. There are four main ownership models: public utility, private sector, community and hybrid models. The choice of ownership model may depend on two variables: access to finance (where the funding comes from) (Bloomberg New Energy Finance 2020); and the management approach (who runs the operation and maintenance?) (Safdar 2017). In sub-Saharan Africa, the literature suggests that none of the established ownership models has worked

exceptionally well. However, hybrid models and particularly public–private partnerships (PPPs) show the greatest potential for scale-up (AfDB 2016).

Under the **public utility model**, the national or regional utility owns and operates the mini-grid, and so it is responsible for installing, managing and maintaining it. In addition, the utility likely provides the initial financing, often with support from development funds (AfDB 2016; IED 2013; Safdar 2017). The ability to adapt the regulation to the mini-grid necessities, the government's capacity to borrow capital at lower rates, and the cross-subsidisation of tariffs are the main advantages of this business model (ARE 2014; Duran and Sahinyazan 2021). However, mini-grids developed by utilities are often more expensive and inefficient than in any other ownership model. For political reasons, the national utility typically applies tariffs well below cost recovery, equivalent to those of the main grid. As a result, utilities already under financial stress become more cost-constrained and fail to provide, maintain and operate the mini-grid at a high-quality standard. Besides, public utilities often prioritise increasing connection rates in areas already served by the grid rather than implementing mini-grids (AfDB 2016; ARE 2014).

The **private model** leaves the ownership, development and operation of the mini-grid in the hands of a private company. The funding can come from multiple sources, including private equity, commercial loans, and public and/or development finance grants, results-based financing, or concessional loans (AfDB 2016; ARE 2014; Franz *et al*. 2014; Safdar 2017). The literature highlights the private sector's efficiencies and expertise in developing mini-grids as the main advantage. However, some disadvantages include high regulatory risks, which increase the cost of finance, and unaffordable prices that limit supply. Therefore, subsidies are often key to achieving financial sustainability, and a 100 per cent private-financed model is unlikely to succeed.

The local community owns and operates the mini-grid in a **community model**. The community might receive the mini-grid assets from a government programme, a non-profit, or a development institution, and contribute some co-funding (Bloomberg New Energy Finance 2020). This model is more frequent in isolated rural areas that do not attract private sector or utility interest (ARE 2014; ECREEE 2016). The main advantages of this model are the community's involvement in the development of the project and the low costs achieved, which would contribute to high acceptance among users (AfDB 2016; Butchers *et al*. 2020). Frequent disadvantages include donor dependence and poor management and maintenance due to a lack of local skills or insufficient revenue generation. Most community models focus on the social impact rather than long-term operations and viability.

The **hybrid model** combines the features of the aforementioned business models, with different parties building, owning and operating the distribution and generation assets of the mini-grid. The PPP model combines the benefits of the private sector's entrepreneurial skills with the public partners' ability to reduce legal and regulatory risks and obtain lower-cost finance. There are different PPP models according to the degree of involvement of the private and public partners. As the involvement of the private partner increases, the level of grant funding decreases, leading to higher tariffs (AfDB 2016). The literature indicates that PPP models are attractive financially and operationally, as the risk allocation is more efficient than in other structures (Gershenson *et al*. 2015). This approach allocates project risks between the public and private sectors and combines their financing sources. Yet, experiences in sub-Saharan Africa show the importance of having a legal framework that enables the PPP model while limiting tariffs, long licensing processes, and funding delays that discourage private participation (AfDB 2016; Peters *et al*. 2019).

2.1.2 Cost-recovery models

The second definition of mini-grid business models classifies them according to their approach to cost recovery. There are three different cost-recovery models: for-profit, partially subsidised, and fully subsidised (Schnitzer *et al*. 2014). These may also be defined as commercial (for-profit) and non-commercial (subsidised) mini-grids. The trade-off between profits and subsidisation lies in the affordability for the end consumer. The higher the subsidies, the more affordable the service for consumers, but the less profitable for public or private investors. Complete dependence on subsidies, on the other hand, damages the commercial viability and scalability of mini-grids. Therefore, the literature indicates that partially subsidised models, where the initial investment is partially or fully subsidised, but tariffs cover operation and maintenance costs, provide a good balance between financial viability and affordability (Schnitzer *et al*. 2014).

The **for-profit model** requires tariffs high enough to recover the initial investment, replacement, operation and maintenance costs. This model is only appropriate for customers with high purchasing power, particularly commercial clients. Evidence of the scalability of the for-profit business model is weak in the literature (Knuckles 2016; Schnitzer *et al*. 2014).

The **partially subsidised model** relies on large subsidies for initial investment costs. However, it depends on tariff-based cost recovery to cover operations, maintenance and replacement costs. It represents a balance between affordability/inclusivity and financial viability. Nevertheless, this model still requires loyal customers who

can pay for the operational costs, and to achieve this it is necessary to provide a reliable energy service (Schnitzer *et al*. 2014).

The **fully subsidised model** covers capital costs and part of the operational costs with subsidies. Tariffs are set well below cost recovery, at a level affordable for most of the population, and can only partially cover operational costs. This model requires a reliable source of subsidy finance and makes the mini-grid operation fully dependent on a sponsor (Schnitzer *et al*. 2014).

2.1.3 Revenue-generation strategies

The revenue-generation strategy first requires targeting clients for the electricity supplied by the mini-grid. The mini-grid could focus on households, a combination of households and commercial demand, or a single anchor customer, which would guarantee demand at a sufficient price for a large share of the generation output at an appropriate price. Focusing on household demand reduces the financial viability of rural mini-grids in sub-Saharan Africa, where there is a limited ability to pay, dependent on seasonal productive activities (Peters *et al*. 2019). Hence, the literature recommends the inclusion of productive users to improve load demand and thus the revenue streams (AfDB 2016; Bahaj and James 2019; Sharma and Palit 2020; Uamusse *et al*. 2020).

The literature is strong and consistent in proposing the **Anchor-Business-Community (ABC) model** as the most promising approach to achieving financial sustainability of mini-grids (AfDB 2016; Beath *et al*. 2021; Knuckles 2016; Safdar 2017). In the ABC model, a customer with a high and stable load, such as an agro-processing factory, a telecom tower or a hospital, acts as an anchor client. An anchor client can stabilise mini-grid revenues and reduce the risk of connecting small and variable residential users. In addition, by consuming electricity during residential low-peak periods, anchor consumers can also reduce the overall price of electricity.

While the ABC model is the most promising revenue-generation strategy, anchor customers in rural sub-Saharan Africa are scarce, which could limit its scalability and neglect many promising communities (AfDB 2016; Energy and Environment Partnership 2015). The Keymaker model, proposed by mini-grid developers INENSUS and JUMEME in Tanzania, could present a solution to this pitfall. Under the **Keymaker model**, the mini-grid investor would expand its revenue-generation sources from only the sale of electricity to the sale of locally processed natural resources from the community. The resource processing requires reliable electricity, capital and management capabilities to be profitably exploited. Consequently, the mini-grid operator would increase the electricity demand and diversify its business

to create additional revenue for the community and its own business. In addition, the synergies between the electricity and agro-processing businesses can reduce costs. Some examples of natural resources that could be more productively exploited with reliable electricity are fish, good soil, low-cost water for irrigation, or minerals (Peterschmidt 2019).

2.1.4 Implementation models

Finally, business models can differ in their implementation strategies to scale up and reduce costs. Bundling models, such as franchises, clustering and portfolio diversification, can reduce risks and optimise costs through economies of scale and scope. Still, the evidence from the literature on these different approaches is weak and inconsistent.

A **clustering** approach bundles under a single operational management structure a group of mini-grids that are geographically close to each other, thus reducing overheads (Franz *et al*. 2014; Safdar 2017). Evidence shows that this approach leads to lower capital and operational costs (Moner-Girona *et al*. 2018).

Development finance institutions are increasingly encouraging operators with a proven track record to implement this model to reduce costs and accelerate scalability (Franz *et al*. 2014). In any case, the management of clustered mini-grids requires high levels of management skills and regulatory support from the government (Safdar 2017; Sharma and Palit 2020).

Operational bundling refers to aggregating mini-grids that share similarities along the value chain to reduce development and operating costs and spread the risk. For example, in sub-Saharan Africa, there are six categories of operational bundling: design and engineering; installation; operations and maintenance; customer service; standardised productive-use offering; and monitoring and reporting (Weston *et al*. 2018). This approach can complement the clustering model, as these bundling activities help ensure better demand estimation, reduce operational costs, improve performance, and promote interest from investors. However, evidence of success is still limited.

In a **franchise approach**, the franchiser is responsible for most of the management costs, minimising this burden for the franchisee. Furthermore, as the number of franchisees increases, the marginal cost of managing an additional one decreases (Franz *et al*. 2014; Safdar 2017). Therefore, this approach could improve market efficiencies and promote scalability. However, the model requires franchisers with experience in providing a standardised business model and the managerial capacity to develop a brand (Safdar 2017). The model has not yet been tested at a significant scale.

Financial bundling aggregates diverse projects into a portfolio to reduce risk and encourage private investment. Investors in pooled funds of bundled mini-grid projects can benefit from economies of scale, lower transaction costs, risk diversification, and more professional management. Gershenson *et al*. (2015) identify the potential to increase returns for investors by centralising some fixed expenses and transactional costs. Moreover, Malhotra *et al*. (2017) find the de-risking benefits of investing in portfolios of projects across different geographical jurisdictions and markets. However, complexity can lead to a poor understanding of the magnitude and correlation of risk, reduced management capacity, and an inability to accurately assess portfolios for bankability (Gershenson *et al*. 2015). Evidence of the success of this model is not yet available in the literature.

2.1.5 Which business model works? Evidence from sub-Saharan Africa

The literature on mini-grids does not provide a single definition of a business model; instead, it refers to four components: ownership, cost recovery, revenue generation and implementation. The evidence from successful case studies is still limited, but the literature points to hybrid ownership, partially subsidised, ABC-focused, and portfolio diversification as the most promising models. Experiences with mini-grids across the region suggest that balancing affordable service provision with acceptable cost recovery remains a challenge (Bhattacharyya *et al*. 2019; Moner-Girona *et al*. 2018; Pueyo and DeMartino 2018). Therefore, there is currently no proven business model for mini-grid development that is entirely replicable and sustainable. In sub-Saharan Africa, many models have been tried, but none has been a complete success (AfDB 2016; Weston *et al*. 2018). Success is highly context-specific, depending on regulatory and socioeconomic variables (Franz *et al*. 2014; Safdar 2017). Table 2.1 summarises the evidence of different business model components in the region. (A descriptive summary of the evidence is provided in Annexe 1.)

Table 2.1 Evidence of success of business model components in sub-Saharan Africa

		Strong evidence	Lack of evidence
Ownership models	Public utility	Need for the government to guarantee a clear regulatory framework	The lack of enough successful and scalable examples in sub-Saharan Africa (SSA)
	Private	The private sector is vital for achieving rural electrification	Lack of initiatives that have attained financial sustainability. Low ability to pay for cost-recovery tariffs in rural areas
	Community	Community acceptance and engagement are necessary	No proof that the model is sustainable and scalable. Significant dependency on donor funding
	Hybrid	It can overcome the government's budgetary constraints, diversify the project risk, and optimise the expertise of the private sector	Lack of clear regulatory framework for these models
Cost-recovery models	For-profit	Need to implement cost-recovery tariffs	Low ability to pay for cost-recovery tariffs in rural area
	Partially subsidised	Mini-grids need subsidies to guarantee competitive tariffs – for instance, results-based subsidies	The lack of enough successful examples in SSA
	Fully subsidised	Mini-grids need subsidies to guarantee competitive tariffs	Dependency on donor's funding diminishes its sustainability
Revenue-generation strategies	ABC model	An anchor client can stablilise the revenue and improve the viability	Lack of availability of large businesses in rural areas
	Households and small businesses	Integrating productive users into the load improves viability	Lack of households' willingness to pay and irregular income
	Keymaker model (KMM)	KMM expands the revenue-generation sources	No proof that the model is viable and scalable
Implementation models	Clustering approach	Opportunities for economies of scale	Lack of strong managerial and operational skills to succeed
	Operational bundling	Opportunities for economies of scale	Lack of successful examples in SSA
	Franchise approach		Lack of successful examples in SSA
	Portfolio diversification	Potential to improve mini-grids' access to finance	Lack of successful examples in SSA

Source: Authors' own.

2.2 Risks

The review of the literature on mini-grid business models indicates that their success is highly context-specific. It depends on internal and external pressures, where the former includes organisational aspects that the mini-grid developer can control, and the latter are out of its control – including, for example, the political or macroeconomic risk.

The most frequently mentioned risks in the literature relate to the uncertainty of the regulatory framework, limited demand, and the threat of expansion of the national grid, which would provide access at a much lower, heavily subsidised rate. Other risks, such as macroeconomic instability, social and reputational risks, internal governance, or non-payment risk are considered secondary. Constraints and enablers that can frustrate or propel a business model are briefly reviewed in the remainder of this section.

Firstly, developers and investors perceive **inconsistent and unclear regulation** as the most important challenge to the sustainability and scalability of mini-grids (AfDB 2016). Many countries in the sub-Saharan Africa region lack specific policies for mini-grids in their national electrification plans, or they have such policies but do not implement them (Energy and Environment Partnership 2015; Bloomberg New Energy Finance 2020). The most favourable policies involve streamlining permitting procedures, allowing cost-recovery tariffs, and establishing a clear process to reduce the risk of expansion of the national grid to a community with a mini-grid (AfDB 2016; Bloomberg New Energy Finance 2020; Weston *et al*. 2018). The primary regulatory risk is the volatility of tariff policies in response to political pressures (Gershenson *et al*. 2015). Some of the actions to mitigate regulatory risks include: nurturing relationships with the government to guarantee that cost-reflective tariffs will be allowed and maintained; developing small mini-grids below the threshold for regulatory approval, usually below 100kW; and finally, developing mini-grids at sites unlikely to be reached by the centralised grid, such as on islands or in remote mountain ranges (ECA and AMDA 2020; AfDB 2016; ARE 2014; and Bhattacharyya and Palit 2016). However, these remote areas may have less economic activity to support a mini-grid.

The lack of sufficient local demand or unreliability of demand data is the second most frequent risk identified in the literature (Peters *et al*. 2019). It is hard to accurately project future electricity demand before electrification. The load profile based on a needs assessment will certainly not reflect the reality of electricity consumption when the system and tariffs are in operation (Bahaj and James 2019; ECA and AMDA 2020; Hartvigsson *et al*. 2021). There is, therefore, a high risk of designing oversized or undersized mini-grids. An oversized mini-grid has high upfront costs and unnecessarily high tariffs, which decrease demand even further. On the other hand,

an undersized mini-grid suffers from reliability issues, which damages customer satisfaction and hence, willingness to pay (Hartvigsson *et al*. 2021). Thus, incorrect sizing leads to a cost-recovery problem for the mini-grid developer. The literature strongly suggests starting with a smaller size to assess demand before increasing capacity in a modular way (AfDB 2016; Aziz and Chowdhury 2021). Another approach to avoid oversizing involves encouraging productive uses of electricity (ECA and AMDA 2020).

Macroeconomic instability causing currency depreciation can damage the ability to recover investment in foreign currency (ESMAP 2019; Odarno *et al*. 2017). Although international hedging tools are available, it would increase financing costs. Avoiding currency risks requires the availability of credit in local currency, which is limited in the sub-Saharan Africa region.

Rural mini-grid operators sell to customers with little income and limited ability to pay and are exposed to **non-payment risks** (Bloomberg New Energy Finance 2020). Furthermore, they face multiple challenges in payment collection, although new cashless, mobile-based, pay-as-you-go approaches are reducing these risks (Pueyo 2013). The mini-grid developer needs to adapt payment collection methods to the specificities of the demand. In sub-Saharan Africa, there is still the challenge of breaking the culture of 'donation' and replacing it with one of 'paying for a service' (Bahaj and James 2019). To that extent, innovation in metering and payment collection is necessary.

Governance risk relates to the transparency and effectiveness of the mini-grid's management procedures. The developer's expertise contributes to reducing the governance risk. The developer's track record is indeed a key requirement to access finance (AfDB 2016; ARE 2014). Besides, development funders typically require frequent reporting of the mini-grid performance and its impact on the community, as well as external audits.

The lack of a skilled workforce and the cost and availability of spare parts are important **technology challenges** (Azimoh *et al*. 2017; Bhattacharyya and Palit 2016). Community-led mini-grids are more exposed to these risks by relying on donors' funding and capacity building. Some risk-mitigation strategies include: selecting the optimal technology; investing in operations and management capacity building; and ensuring the supply of spare parts in the medium and long term, financially and operationally (Duran and Sahinyazan 2021; Sharma and Palit 2020).

Social and reputational risks include lack of community engagement and rejection of the technology. A mini-grid can be rejected by the community when the tariffs are higher than those of the main grid. The grid tariff differential could be perceived as unjust, which may generate social and

political tensions (Peters *et al*. 2019). Social and reputational risks can also emerge if the quality of service is below consumer expectations. Unsatisfied users are more likely to miss payments (Lillo *et al*. 2015). Likewise, when customers struggle to track and manage the units or kilowatt hours (kWh) they consume, they distrust and disengage from the service (Ulsrud *et al*. 2011). Thus, to face the risks of non-acceptance and lack of engagement, the literature proposes continuous communication and engagement with the local communities before implementation and during the mini-grid operations. Identifying and working with local champions – individuals such as village leaders in the local community – helps to increase credibility and reduce reputational risks (Duran and Sahinyazan 2021).

3. Mini-grids regulatory framework in Tanzania

Following two decades of strong economic growth, Tanzania successfully achieved the status of lower-middle-income country (LMIC) in 2020 (World Bank 2022). Despite its commendable economic performance, Tanzania's income per capita, at US$1,076.5 in 2020, remains far below the world's average of US$10,916.1 (*ibid.*). Accordingly, the country experiences high levels of poverty. Over 49 per cent of the population survives with less than US$1.9 a day,[5] and people struggle to access basic services, including energy.

Although Tanzania has significantly improved energy access in the past 20 years, it remains one of the most energy-poor countries in the world. Over 62 per cent of the population has no access to electricity, and 95 per cent rely on traditional biomass for cooking (International Energy Agency 2021). Besides, the electricity consumption of those people who do have access is far below what is required to support increasing levels of welfare. Reducing energy poverty through the provision of universal access to affordable energy is the key priority for Tanzania's energy policy, as stated in the National Energy Policy, updated in 2015 (Government of Tanzania 2015) and the SEforALL Action Agenda (Ministry of Energy and Minerals 2015a). The government has strong ambitions to reach 75 per cent electricity coverage by 2030 while increasing the share of renewables to 50 per cent (*ibid.*).

Given the country's large size and low rural population density, extending the national grid to many isolated rural areas is not economically feasible in the short or even medium term. Therefore, in its Rural Electrification Investment Prospectus, Tanzania estimates that about half the rural population may be more cost-effectively served by decentralised options (Ministry of Energy and Minerals 2015b).

Tanzania became a regional leader in mini-grid development when, in 2008, it adopted a groundbreaking mini-grid policy and regulatory framework to encourage private investment in the sector: the Small Power Producers (SPP) Framework. It applies to generators with a capacity below 10MW, on- and off-grid. The framework includes feed-in tariffs and streamlined interconnection and licensing requirements. Generators below 1MW were allowed to set up their own tariffs, allowing cost recovery and a reasonable profit, after approval by the regulator EWURA (Energy and Water Utilities Regulatory Authority). Very small producers, below

5 US$1.9 per day is the international poverty line, the universal standard for measuring poverty set by the World Bank for comparison purposes.

100kW, did not require approval unless customers made a petition to the regulator. The SPP framework was considered a milestone for the development of mini-grids in Africa, and initially facilitated a boom of the sector. Since its approval, the number of mini-grids in the country has doubled. Over 50 mini-grids were commissioned between 2008 and 2016, and more than 67MW of new capacity was installed (Odarno *et al*. 2017).

The favourable environment started changing when the new administration, from 2015 to 2021, took a hard line against private capital and international companies, calling for a more state-led development process (Dye 2021). Furthermore, communities served by mini-grids had complained about the price differentials with the main grid. Accordingly, the Electricity Act Cap 131, under Development of Small Power Project Rules 2019, introduced new pressures to reduce tariffs closer to the heavily subsidised tariffs from the national grid. Thereafter, in July 2020, the government made an announcement requesting all mini-grids in the country to apply similar tariffs to those applied by the national utility TANESCO, well below their costs.

The new president, taking power in 2021, has shown willingness to restore tariffs to a more sustainable level for mini-grid developers. The new minister of energy has instructed a new tariff review, to improve cost recovery and the quality of the service, wary of rising customer discontent with a declining service. The national regulator EWURA is now in the final stage of completing this review. Once approved, the new tariffs will be published in the national gazette for enforcement.[6]

6 Interview with EWURA staff, 19 May 2022.

4. Background to JUMEME's mini-grid business in Tanzania

4.1 JUMEME Rural Power Supply[7] and the Keymaker model

JUMEME Rural Power Supply Ltd was established in 2016 as a joint venture between European companies INENSUS and Terraprojects, and Tanzania's St Augustine University, mainly financed through a European Union (EU) grant, but also raising equity and debt. JUMEME develops and manages solar PV hybrid mini-grids in Tanzania. Its mini-grid started operations in 2018 in Bwisya village, located in Ukara island, serving 200 customers. After this successful pilot, JUMEME began an expansion process with the arrival of a new international majority shareholder, RP Global, which provided a significant amount of equity. RP Global came from a background of independent power producer (IPP) investment in larger-scale renewables, and JUMEME was their first incursion into the African market. With the new capital injection, JUMEME started a fast growth path. By 2021 it had installed 23 mini-grids serving more than 10,000 customers, and two solar farms connected to the main grid. However, JUMEME stopped further expansion plans involving 15 additional mini-grids when the government announced the tariff reduction for small power producers in 2020.

From the start of its activities in Tanzania, JUMEME had been seeking a business model that would enable financial sustainability of its mini-grids while also being affordable for end consumers. Productive uses were essential to achieve this, but experience in the region showed that they did not emerge spontaneously when mini-grids arrived; they needed to be promoted in parallel to the electricity supply. With support from partners, JUMEME experimented with several models, from looking for anchor loads (without much success) to upgrading agro-processing or supporting small women-led enterprises. Through this trial-and-error process, JUMEME developed an original approach – the Keymaker model. Under the model, the mini-grid company develops productive activities relying on natural resources and supply chains already available in the community, in partnership with local workers and entrepreneurs. Accordingly, revenue not only accrues from the sale of electricity, but also from the sale of agricultural products such as fish or maize. The availability of reliable

7 This section draws from interviews with five employees and ex-employees of JUMEME or its shareholders, carried out in April and May 2022. The interviews are anonymised to maintain confidentiality.

electricity and management competences provided by the mini-grid developer unlocks local opportunities that were previously underutilised.

The decision to invest in Keymaker model opportunities is made after comparing the costs of producing, processing and transporting agricultural goods in rural areas with mini-grids to those in peri-urban areas typically connected to the main grid and better connected to trade hubs. The superiority of natural resources in the deep rural areas selected for the Keymaker model and local experiences of exploiting these resources are the most important foundations for the success of a Keymaker model opportunity. Another consideration is the potential to reduce transport costs through pre-processing natural resources with electricity, to reduce their volume and weight. Further opportunities can arise from the mini-grid's company management expertise (González Grandón and Peterschmidt 2019).

JUMEME trialled the Keymaker model in Ukara island, starting a fish trading business jointly with electricity supply from a solar hybrid mini-grid. JUMEME would purchase fresh Tilapia from local fishermen, freeze it on-site with electric freezers, and deliver it to large cities in the mainland, without breaking the cold chain. This represented an improvement for the local fishermen, who did not have much bargaining power against fish traders, as fish could not last fresh for long kept in ice provided by fish traders themselves. The Tilapia Keymaker model was very successful in Bwisya, providing employment for the community and exceeding the financial margin generated by the sale of electricity.

The next step, after the successful trial, was to improve the sustainability of the fishing business through fish farming in cages, rather than open fishing in the lake. Aquaculture was a new activity in Tanzania but was already well-tested in Kenya and Uganda. It presented a solution to the problem of overfishing in Lake Victoria and would deliver a more reliable business, allowing those involved to anticipate the expected size of the catch. Fish farming requires electricity for refrigeration and the production of fish food. A first trial of fish farming in Bwisya was relatively successful, and delivered some important lessons – mainly the importance of counting on experienced professionals to manage the cages, and the need to control the supply of fish food. Furthermore, producing fish food on-site would strengthen the local value chain, providing jobs to farmers and millers.

Building on the lessons learned in Ukara island, JUMEME decided to scale its Keymaker model approach. They would develop aquaculture in three sites: Bwisya and Bukiko (both in Ukara island), and Maisome island. They would also scale up the fish trading business, with different mini-grid sites becoming hubs for different regions of Lake Victoria. Maisome would be one

such hub, collecting fish from neighbouring islands, freezing and storing it on-site before delivering it to the market. At this stage, JUMEME received funding from the PREO programme and was able to invest in developing and growing the aquaculture and fish trading businesses in Maisome.

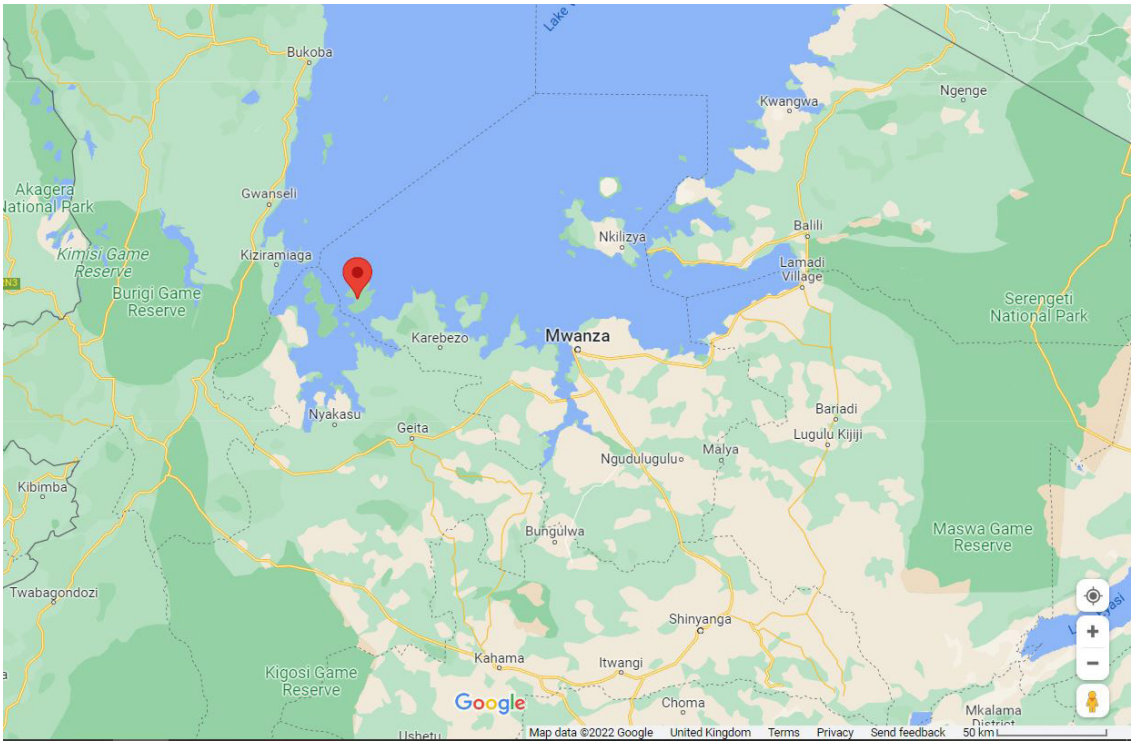
However, within six months of receiving the grant funding, the project faced severe financial challenges as a result of a government mandated electricity tariff review, which led to a 90 per cent drop in JUMEME's revenues. Despite support offered by JUMEME's shareholders, the deliverability of the project was further compromised by staffing issues. Adjusting to the new status quo required making redundancies, appointing a new management team, and giving up the productive activities outside the core business of generating and selling electricity.

At the time of writing this report, JUMEME had been meeting with the Tanzanian authorities to discuss the mini-grid tariffs review. Government officials had visited their sites and gathered financial data to recalculate tariffs. JUMEME is optimistic that the revised tariffs will lead to an uplift in cash flow, even if it does not extend to recovering all costs. However, this is balanced by reduced investment from JUMEME's majority stakeholder, which is currently looking to find potential buyers to take over their share in the company.

4.2 The case of Maisome island

The activities funded by the PREO programme to promote productive uses of energy from mini-grids were limited to the island of Maisome. Maisome is located on the southwest of Lake Victoria, falling within the Sengerema district in Mwanza region. It has an area of 122 square kilometres, more than half of which is protected forest (see map in Figure 4.1). According to the most recent national population census of 2012 (Tanzania National Bureau of Statistics 2012), the island has a total population of 16,489 (8,699 males, 7,790 females), but according to 2020 data provided by government representatives to the research team, the population had grown to 20,488 (11,739 females, 8,749 males). People live mainly in three villages: Kanoni, Kisaba and Busikimbi.

Figure 4.1 Location of Maisome island in Lake Victoria, Tanzania



Source: **Google Maps**

Several tribes live on the island, many of which have migrated from other regions, mainly for economic reasons. According to the ward executive officer, the most populous tribe is Zinza (from Ukerewe district), followed by Kara (mainly from Ukara island). Other tribes are Gita (from Musoma and Mara regions), Waha (from Kigoma) and others from neighbouring countries such as Burundi. Tribes were mixed early in the history of Tanzania by political order to prevent inter-tribe conflicts.

Figure 4.2 Dwellings on the island of Maisome

A typical dwelling on Maisome island.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

Fishing is the mainstay for Maisome residents, generating about 90 per cent of their income, and employing about 80 per cent of men. Women draw their livelihoods from more diverse, natural resource-based activities such as farming on small plots of about 2 hectares (ha) per household, growing food crops such as maize or cassava and cash crops such as coffee and banana, keeping livestock such as cows, goats and free-range chickens, and collecting wood. In addition, women grow woodlots for firewood, which they sell to textile industries in Mwanza. Women also run micro and small businesses, selling clothes, fruits and vegetables, baked and fried fish, sardines and cereals, and running restaurants and small shops (see Figure 4.3). Male-run businesses are less numerous than women's but relatively bigger in terms of investment, and are mostly involved with carpentry, retail, motorbike and bicycle maintenance shops, pharmaceutical shops, music and cinema halls, lubricants, fishing, fish trading, tree planting, fishing boat renting and milling machines.

Figure 4.3 Fishing is the mainstay of Maisome's economy

A woman cooks fish for local sale.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

JUMEME has operated a 60 kilowatt peak (kWp) solar-diesel hybrid mini-grid in Maisome since 2019. The generation and storage set-up includes 60kW peak solar, a 12kW back-up diesel generator, 57kW of batteries and 54kW of inverters. The mini-grid supplies electricity to around 600 consumers in Maisome's three main villages: Kanoni, Kisaba and Busikimbi (see Figure 4.4). The system was sized to supply electricity to energy-intensive productive uses, such as motors and pumps, as well as residential uses. The chairman of the Village Power Committee estimated, during our visit in April 2022, that 50 per cent of the households were connected to electricity. The connection would be free of charge where customers had their own indoor installation. Otherwise, an initial subsidised fee of 15,000 Tanzanian shillings (TSh) would cover indoor wiring and two bulbs.

In addition to supplying electricity, JUMEME started two commercial activities in Maisome: the commercialisation of Tilapia, enabled by the availability of deep freezers powered by the mini-grid; and aquaculture, where fish are raised in floating cages in the lake, and electricity is used in water pumps, freezers and milling machines for fish food pellets. The first activity involves the collection of Tilapia from local fishermen, which is then cleaned, deep-frozen and packed in cooler boxes, delivered by ferry to the mainland and onwards by road to wholesalers in Mwanza and Dar es Salaam. The second activity involves growing fish in cages in the lake, which after harvest would be commercialised as with the fish collected from fishermen. In addition, JUMEME had planned to control

the fish food supply value chain by partnering with a local entrepreneur who would process grain with mills and pallet extruders to produce pellets to feed the fish. All the equipment required for the aquaculture business was funded by the PREO programme (as described in the next section).

Figure 4.4 The mini-grid distribution system in Maisome

Maisome's mini-grid distribution system.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

JUMEME supported some male entrepreneurs in each village with loans to switch from diesel-powered milling machines to electrical milling machines to boost productive uses of electricity. However, electricity is still mainly used for lighting, mobile phones, television (TV) and music systems.

The reduction of electricity tariffs in Maisome, as mandated by the government in 2020, caused problems with the operation of the mini-grid. It was no longer affordable to use the diesel generator during peak hours, and the mini-grid had to rely solely on solar power and batteries, but these were insufficient. Furthermore, the low tariffs caused an increase in electricity demand. To cope with the shortage, JUMEME rationed electricity, allocating a maximum of 2kWh per consumer per week for residential and commercial users. Furthermore, it halted new connections,

and these have remained stable between 2019 and 2022. The project had planned to fund equipment and connections for several promising productive activities on the island, but JUMEME decided the grid would not be able to cope with these intensive consumers at the current fees. Since electricity consumption from the mini-grid was rationed, the community has increased the use of stand-alone solar systems and pico-solar lighting.

Due to the extent of the challenges to the project posed by reduced revenue and internal staff problems, the Keymaker model activities in Maisome were ultimately unsuccessful. The aquaculture business was hampered by shortcomings in management and discipline, along with insurmountable financial constraints. Despite an encouraging start, the fish trading activities were also unsuccessful. The loss of investment from the main shareholder was a further setback to the project. Looking ahead, JUMEME is open to the possibility of re-engaging in Keymaker model activities once the financial situation improves with reviewed tariffs in place. In the meantime, the freezers used for the fish trading business, as well as the milling and pelletising machines for the fish food production, have been transferred to local entrepreneurs for their operations.

5. The intervention: promoting inclusive productive uses of energy from solar mini-grids in Maisome

The PREO programme awarded a grant to IDS, and its partners JUMEME and TANGSEN, in January 2020. The action-research project aimed to demonstrate the viability and scalability of a gender-inclusive Keymaker model, and to benefit men and women in Maisome by upgrading the fishing sector and other productive activities with the use of electricity. The project's expected outcomes were:

- to upgrade Maisome's fishing economy with improved electricity supply and electrical equipment to allow people to sell to more lucrative markets;
- to improve the sustainability of the fishing sector thanks to the introduction of aquaculture;
- to increase welfare in the rural economy through fishing spillovers;
- to improve women's economic empowerment as they would participate in profitable activities in the Tilapia value chain typically reserved for men;
- to prove the viability of a gendered Keymaker business model for mini-grids that supports scaling-up of electrification of rural communities in Tanzania and beyond;
- to improve the profitability of JUMEME's mini-grid business.

To achieve these outcomes, IDS proposed a series of activities, including:

- awareness raising in the community about the opportunities for men and women to use electricity productively. There should be special emphasis on addressing the social norms that prevent women from getting involved in enterprises, particularly in the most lucrative activities;
- technical, economic and financial feasibility studies of activities related to the fishing value chain and other productive activities in the community;
- capacity-building activities, targeting women specifically;
- financial support: engagement with microfinance grants and loans for electric equipment, targeting women specifically;

- equipment supply: procurement of productive equipment for JUMEME's Keymaker model activities and other local entrepreneurs;
- marketing support: missions to target customers and engage in supply negotiations and market networks.

The project was designed flexibly, so that the final actions implemented were appropriate to the local circumstances, analysed through a baseline report that was submitted to PREO in February 2021, and updated in May 2021. The decision about which productive activities the project would support, and the type of support provided, was taken following a bottom-up approach, through continuous engagement with the community. The final activities implemented as part of the project are listed in Table 5.1, and further detailed in the subsequent sections of the report.

Table 5.1 Productive uses of energy support activities implemented by the project

Type of activity	Detail	Quantity
Procurement of productive equipment and supplies	Equipment and supplies for aquaculture	– 2 boats and boat engines – Fish cage construction and fingerlings – 2 tablets for cage attendants
	Equipment and supplies for fish trading	– Refrigerated container – 5 cool boxes
	Equipment for women entrepreneurs	– Electric sewing machines – 5 freezers for fish trading – 1 milling machine for fish food production – 1 extruder for fish food – Hut to house fish feeding machine

Cont'd.

Type of activity	Detail	Quantity
Awareness-raising and information campaigns	Meeting with the Kanoni government to introduce the project, November 2020	13 participants, of which 2 were women
	Meeting with women to raise awareness about opportunities for businesses using electricity, November 2020	8 women participants
	Meeting with men to raise awareness about opportunities for businesses using electricity, November 2020	8 men participants
Feasibility studies of productive uses	Review of business plan, and financial feasibility analysis of proposed activities	8 business plans and financial analyses prepared
Capacity building and mentoring	Technical training	Embroidery training for 7 women tailors in Mwanza, provided by the Small Industries Development Organization (SIDO)
	Business plan preparation workshop, March 2021	Mentoring and training to 8 women interested in developing a business plan, including: a bakery, 2 fish collectors, garments, frozen poultry, sardine fishing, milling, fish feed plant
	Market development: identification of raw material suppliers, March 2021	Identification of 10 women suppliers of grain and sardine for the fish food plant
	Aquaculture training and consultancy 2020	Contracting 2 suppliers to design and manage fish cages, and to train JUMEME staff on the aquaculture business
	Business development training for women benefiting from the productive use of electricity from Maisome's mini-grid, April 2022	14 participants (12 women, 2 men)
	Supporting women entrepreneurs to negotiate a fish supply agreement with JUMEME	– Support with drafting and negotiating the contract – Travel expenses and accommodation to meet JUMEME staff in Mwanza

Source: Authors' own.

5.1 Procurement of productive equipment

The project procured several pieces of equipment and infrastructure (see Table 5.2). Most equipment was financed using the grant, but some items were co-funded by JUMEME. Table 5.2 provides further detail about the equipment procured by the project for JUMEME's Keymaker model activities, aquaculture and fish trading.

Table 5.2 JUMEME's aquaculture and fish trading equipment procured as part of the PREO programme

Item	Description
2 boats and boat engines	2 wooden boats were procured from local carpenters, and engines sourced from Mwanza. Boats are required for the management of the fish farming cages, as well as to collect fish from fishing camps
Fish cage construction, consultation and fingerlings	JUMEME contracted consultants to build, install, and operate 30 cages in the lake shore by Maisome. The consultants also farmed fingerlings and fed them during the initial stages of the fish farming business
Refrigerated container	Refrigerated container procurement and cost of its transportation from Dar es Salaam to Maisome
Tablets	2 electronic tablets for cage attendants
Cool boxes	5 cool boxes for fish transport inside the island

Source: Authors' own.

JUMEME contracted several suppliers from Tanzania and Uganda for the design and construction of the fish cages, the formula for fish food, and the supply of consumables such as nets, drums, fingerlings and fish food. All these activities represented the biggest equipment expense for the project. The cages were floating in Lake Victoria at the start of 2021. Figure 5.1 shows the situation in 2021, when the Keymaker model activities were functioning. The cages were floating in the lake, and fingerlings were being released, while Tilapia purchased from fishermen were stored in freezers before being shipped to the mainland. Figure 5.2 shows one of the wooden boats purchased with the project's funds.

Figure 5.1 Fingerlings are released to feed farmed Tilapia in floating cages, Lake Victoria, Maisome

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

Figure 5.2 Wooden boat procured to manage the fish cages

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

The action-research project team encountered quality issues with some of the equipment and consumables for the aquaculture business, resulting in the need to replace items that were broken, lost or no longer usable after the first year of operation. In December 2021, the JUMEME board decided not to continue the aquaculture business. Figure 5.3 shows the poor condition of the cages.

Figure 5.3 Disused cages and drums in Maisome

Many of the cages are now disused and in poor condition.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

The fish trading activity required the procurement of several freezers and cool boxes. This activity has also been halted, and the unused equipment is currently in storage. Five freezers from JUMEME were transferred to women in the community who wanted to start businesses as fish traders. The women signed agreements committing

to start a business, rather than selling the equipment to make a profit. Figure 5.4 shows the equipment sitting in the warehouse.

Figure 5.4 Cool boxes and freezers sitting in JUMEME's storage shed, after Keymaker model activities cease

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

The project targeted women entrepreneurs specifically. Equipment included electric sewing machines for seven tailors, five freezers transferred from JUMEME, and equipment for the production of fish food, including one milling machine and one pelletiser. The project also funded construction of the building that would host the fish food production machines. Figure 5.5 shows one woman entrepreneur signing the transfer of a freezer from JUMEME. Figure 5.6 shows the milling machine and extruder transferred by JUMEME to the woman who would deal with fish food production. Both machines are connected to the mini-grid, but have not started operations since JUMEME, which would be the main customer, has abandoned the aquaculture business. Under the same caption, we can see the structure hosting the machines during the construction process.

Figure 5.5 Woman entrepreneur signing agreement to receive one of JUMEME's freezers

Woman entrepreneur signs an agreement to receive one of JUMEME's freezers and start operating as a fish trader.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

Figure 5.6 Transfer of JUMEME's milling machine and extruder for fish food production business, and structure hosting the machines during the construction process

Left-hand side photo: Woman entrepreneur takes possession of JUMEME milling machine and extruder.

Right-hand side photo: The structure hosting the machines during the construction process.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

5.2 Awareness-raising campaigns and focus group discussions

5.2.1 Meeting with the village government on 10 November 2020

The action-research team started activities in Maisome through an awareness-raising event with Kanoni's government, held on 10 November 2020, which included 13 participants, 2 of them women. The participants included JUMEME staff, the ward executive officer, the village chief, the village executive officer, members of the Village Energy Committee and village sub-committee leaders. Participants were particularly concerned about electricity supply restrictions, and JUMEME clarified that these would need to continue until they could charge cost-reflective tariffs allowing the use of the back-up diesel generator. Once these queries had been clarified, the TANGSEN team explained that the purpose of the project was to provide opportunities for men and women to use electricity productively. They also explained how energy could provide opportunities for income generation and pointed to the specific challenges women face in harnessing these opportunities. Finally, the team encouraged the village governing structures to think about potential business opportunities arising from the use of electricity and to discuss these with the community. After the discussion, the village chairman requested the committee members to cooperate and be good ambassadors to the villagers, sharing information about the activities of TANGSEN and JUMEME in the village.

5.2.2 Meeting with women to raise awareness about opportunities for businesses using electricity, November 2020

Eight women attended a meeting to raise ideas for businesses benefiting from electricity. Discussants were selected for their willingness to engage in business or for running a business already that either uses electricity or could be upgraded to use it. They included two tailors, two grain sellers and two restaurant owners, as well as a farmer and a retail seller. However, only half of the participants were already connected to electricity.

The facilitators from TANGSEN informed participants about the potential productive uses of electricity on the island, and the qualities and skills needed to be a successful entrepreneur. Participants reflected on their own strengths and weaknesses regarding these qualities and potential areas of improvement. The facilitator offered examples of new businesses using electricity on the island of Bwisya, where JUMEME implemented a mini-grid over four years ago. The group then brainstormed promising business ideas that could benefit from the electricity supply on the island. The facilitator

subsequently provided discussants with a form for them to document their business ideas (translated into Swahili language). Of the eight women discussants, three filled out the forms and resubmitted them as required.

5.2.3 Meeting with men to raise awareness about opportunities for businesses using electricity, November 2020

The meeting with men followed the same format as the meeting with women. It was attended by eight participants, including two carpenters, two millers, two retail shopkeepers, a cinema hall owner, and a businessman. Only the miller and the cinema hall owner were already connected to electricity. As in the women's group, men reflected on the required traits and skills of a successful entrepreneur, identified their gaps, and were guided through an exercise to identify business opportunities.

The two brainstorming sessions delivered a list of promising businesses in the community, alongside JUMEME's Keymaker model activities, including: weaving and embroidering; poultry farming; bakery; carpentry; fish storage; sardine drying; fish food production; and fish food raw material supply.

5.3 Techno-economic feasibility analysis of productive uses of electricity

The business plan preparation workshop, described in the following section, delivered eight business plans for our viability assessment. The feasibility assessment concluded that seven of those businesses were viable, delivering positive internal rates of return (IRR) and payback periods under two years. These included a bakery, poultry farming, tailoring, milling, fish trading, and fish food production. Only the poultry farming business did not have a clear marketing plan, as it aimed to sell in supermarkets on the mainland, but was not aware of the health and quality requirements to do so. The next step in the project would be to provide grants covering part of the cost of the equipment required. However, at that moment, JUMEME announced that due to the tariff reduction, their mini-grid could not cope with current demand and would not be connecting additional consumers, especially energy-intensive consumers like millers or bakeries. Therefore, the procurement process had to be halted, to the disappointment of the women entrepreneurs.

5.4 Capacity building

5.4.1 Embroidery technical training for women seamstresses, January 2020

A group of seven women attended the training on embroidery with electric sewing machines, provided by the Small Industries Development Organization (SIDO) of Tanzania. The training took place in Mwanza. Women learned how to operate sewing machines, as well as new embroidery techniques. The project provided the training fee and travel costs for participants. Furthermore, each participant received an electric sewing machine (see Figure 5.7), which they took back to Maisome to use in their businesses.

Figure 5.7 A seamstress with the electric machine received after she participated in SIDO embroidery training

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

5.4.2 Aquaculture training and consultancy, 2020

JUMEME engaged two aquaculture consultants to support the design and construction of the cages, the formula for fish food, the initial procurement of nets, fingerlings and fish food, the management of the cages, and the training of employees. Consultants were training JUMEME's staff on the job. However, JUMEME management was disappointed with the consultants, as they did not provide a good service or good equipment and did not deliver the harvest numbers they promised when they were contracted.

5.4.3 Business plan preparation workshop, March 2021

The awareness campaign run at the start of the project identified some potential entrepreneurs. These were invited a few months later to participate in a workshop to assess the feasibility of their business ideas through preparing a business plan. First, participants completed a business registration form stating their responsibilities. After that, TANGSEN delivered some training on developing a business plan. After the session, participants started practising filling out the template.

The invited participants were from different sectors like garments, bakery, fishing (sardine fishing and Tilapia collection), poultry selling and milling. Fifteen participants attended, and they agreed with the roles and committed to cooperating while implementing the project. Among these 15 potential entrepreneurs, 8 were interested in developing a business plan, including: a bakery; fish collectors; seamstresses; poultry farmers; sardine fishing; milling; and fish food production. In some cases, husbands took the lead in business decision-making and helped their wives write up their business plan. Figure 5.8 shows different moments of the workshop, including: explaining the contents of the business plan template; participants taking notes; and one participant completing the business plan template with support from her husband.

Figure 5.8 Business plan preparation workshop

Different stages of the business plan preparation workshop.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

5.4.4 Market development – identification of women suppliers for the fish food plant, March 2021

We surveyed potential suppliers of raw materials for the fish food production plant. The identification exercise started with visiting farmers' households as well as grain sellers and miller premises. We enquired about access and quantity. We shared the information with the woman entrepreneur who was willing to develop the fish food production plant. She became aware of the

raw materials available to the village and provided inputs on the required quantity and accessibility, while focusing on JUMEME's fish feed formula.

We identified ten women suppliers of grains and sardines who committed to supply throughout the year. Sardine suppliers were involved in fishing from Bwego and Chinga camps and sold sardines to different markets within and outside Maisome. After the exercise, the team held a meeting with the village chairman to verify suppliers' capacities to meet the expected demand. In the meeting, six people were selected as suppliers after fulfilling the required criteria.

Figure 5.9 Woman entrepreneur reads the selection criteria

Mrs Anastazia, a sardine supplier from Bwego fish camp, reads the project's entrepreneurship selection criteria.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

5.4.5 Business development training for women benefiting from the productive use of electricity from Maisome's mini-grid, April 2022

The training took place in Kanoni village and was attended by 14 entrepreneurs (12 women and 2 men). The aim was to enhance business skills, mainly for women who had received electric equipment as part of the project. The training covered content on:

- marketing, including how to identify customers, promote products and set prices;

- bookkeeping, introducing concepts such as costs, revenues, profits or debt, stressing the importance of keeping daily records;
- costing, and how to determine the key elements of cost, including the cost of their time, and how these have an effect on profits;
- customer services, identification of different types of customers, and how to build customer loyalty.

Figure 5.10 Introduction to the district government officials during the training session on business development

Participants in the business development training meet district government officials.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

Participants showed interest in creating a group of businesswomen who could support each other. The group was established, including seamstresses, fish traders owning freezers, and a fish food producer. The group could also jointly demand reliable electricity supply from JUMEME. In the process of forming the group, government officers from Buchosa municipality, who were on a mission at Maisome, entered the training room and were interested to see how women learned business skills. Government officers introduced their roles: community development officer, environment officer, and culture and sports officer. They informed participants of the availability of government funds to support women entrepreneurs, including credits and grants. The funds require women to be registered and submit quality business plans. The group would soon be registered in the district office, with the expectation of gaining support.

Figure 5.11 Participants and trainers in the business development training, joined by district officials

Participants, trainers and district government officials outside the training venue.

Photographer: © Gisela Ngoo/Editruda Daulinge/TANGSEN.

5.4.6 Supporting a woman entrepreneur to negotiate a fish supply agreement with JUMEME

We supported Ms Kalunde, the woman who would develop the fish food production business, to draft and negotiate a fish food supply contract with JUMEME. However, the contract was never signed, as JUMEME's board decided to abandon the aquaculture activity.

6. Research methodology

The action-research approach involved a combination of problem-solving actions that were situation-based and context-specific, and critical reflection, created at the point of application. Research supported actions at the planning, implementation and reflection stages. This section of the report describes the data collection process, using a combination of qualitative, quantitative and participatory tools, and the analytical framework used to interpret the data collected.

6.1 Data collection

Data collection took place throughout the whole process, using quantitative and qualitative research tools. Research activities are summarised in Table 6.1. Details of participants in semi-structured interviews are provided in Annexe 3, although the identity of JUMEME staff members is anonymised. Some detailed activities, including preparing the business census, semi-structured interviews and focus group discussions (FGDs), happened at key moments in the process: baseline, endline and, in the case of the census, also at midline. Other activities – mainly monitoring the performance of the mini-grid, and the implementation of project activities – happened continuously. A separate document – *Monitoring and Research Guidelines* – provides a detailed description of each research tool.

We describe baseline, midline and endline fieldwork activities in the remainder of this section.

6.1.1 Baseline data collection

The baseline field assessment was conducted in November 2020, two weeks after the national election. The country was politically stable, and all Covid-19 restrictions had been lifted since July 2020. Therefore, it was possible to gather and meet with people in groups and individually.

However, the study coincided with heavy and long rains causing rising water in Lake Victoria. The gates to the ferry to and from Maisome island were flooded, creating difficulties for passengers to get to the island. Flooding had also caused damage to houses and farms. Heavy rains were nonetheless very welcome for farming activities, providing plentiful yields of coffee, timber, maize, cassava, banana, beans and sweet potatoes.

Table 6.1 Research activities

Method	Research activity	Frequency	Data collection
Quantitative	Business census	Baseline census, midline, endline census	TANGSEN with support from JUMEME staff on-site
Quantitative	Mini-grid performance data	Monthly reporting	JUMEME
Quantitative	Keymaker business plan calculator	Baseline	JUMEME/IDS support
Quantitative/ Qualitative	Monitoring of project activities	Continuously	IDS with TANGSEN and JUMEME's data
Qualitative	Semi-structured one-on-one interviews with men and women entrepreneurs or workers in Maisome, JUMEME staff, and government officials	31 interviews at baseline (17 women, 14 men) 25 interviews at endline (11 women, 14 men)	TANGSEN and IDS
Qualitative	FGDs: FGD 1: Community map and constraints to access energy FGD 2: Female-only brainstorming business activities using electricity productively FGD 3: Male-only brainstorming business activities using electricity productively FGD 4 and 5: Gendered fishing and aquaculture value chains	4 FGDs held at baseline, with a total of 26 participants	TANGSEN

Source: Authors' own.

Fieldwork activities started on 8 November 2020 in Mwanza, with key informant interviews (KIIs). On the first day, the TANGSEN field team convened a meeting with JUMEME to get an overview of JUMEME's activities in Maisome and discuss the baseline mission. On the following day, the team met the director of the Environmental Management and Economic Development Organization (EMEDO), a non-governmental organisation (NGO) working in the region.

The research team travelled to Maisome on 10 November, where they stayed for eight days to conduct fieldwork. On their first day, they held a meeting with the government of Kanoni village to provide an overview of the

baseline study and to raise awareness about the project. Upon their return to Mwanza, they conducted additional interviews and held a feedback meeting with JUMEME. The collection of mini-grid performance data and the interview with JUMEME's director of projects were done remotely.

Baseline research involved a multi-methods approach, combining quantitative, qualitative and participatory methods. Table 6.1 presents the research activities, indicating the number of participants (or sample size) for each activity.

The business census covered the three villages in Maisome island reached by JUMEME's mini-grid: Busikimbi, Kanoni and Kisaba. The census included all businesses that were open during the fieldwork exercise and that agreed to be interviewed. The aim of the census was to gauge the number of businesses on the island and the types of activities they do, their energy-use status, and the gendered division of work. We would compare this data to that collected at endline. Most businesses were covered by the baseline census; however, some businesses refused to participate due to dissatisfaction with electricity provision, as JUMEME had already been forced to limit supply due to the tariff reduction mandated by the government before and after the general election.

The research team focused on the village of Kanoni for qualitative data collection, including interviews and focus group discussions. Kanoni was selected as it is the gateway to the island, where the ferry port is located, as well as the site for JUMEME's mini-grid powerhouse and Keymaker model activities (Tilapia collection and aquaculture). The other two villages reached by the mini-grid are more than 10km away.

Participants for the FGDs and interviews were purposefully selected as per the project's *Monitoring and Research Guidelines*. The selection criteria were communicated to the chairman of the Village Power Committee, who was involved in identifying and inviting the discussants and interviewees. The decision to use the chairman was recommended by JUMEME's manager in Maisome. (Details of interviewees and FGD participants are provided in Annexe 3.)

6.1.2 Midline data collection

The TANGSEN team conducted a second field visit to Maisome in March 2021. The team had a brief meeting with JUMEME staff in Mwanza. Then, they travelled to Nyehunge, a village on the mainland, close to the port, to take the ferry to Maisome. In Nyehunge, they met Ms Kalunge, a woman who had shown interest in starting a fish feed production plant at Maisome. They informed her of the project goal and her roles.

The second part of the field visit took place in Maisome, where the objective was to develop business plans for identified entrepreneurs and update the business census. The census revealed that new businesses had emerged in the village after the arrival of electricity, such as mobile phone charging, a café, and video show halls. They were all connected to JUMEME's mini-grid despite the challenge of power rationing resulting from the tariff reduction. Around 40 enterprises had requested to be connected as productive users, but JUMEME was restricting new connections, with no new connections made since September 2020. Most business people interviewed indicated discontent with the restrictions on electricity connection and consumption.

During the midline field visit, TANGSEN visited JUMEME's aquaculture activities. About ten cages were floating in the lake, with fingerlings of different ages in each cage. JUMEME was using a newly purchased boat to move around the cages to feed the fish. Fish food was imported from Mwanza.

6.1.3 Endline data collection

The final field visit took place in April 2022, during the rainy season. The team noted increased economic activity on the island. The entrance to the island by boat had changed from Kanoni village to Busikimbi, due to the flooding of the jetty. Several modern houses and three new guesthouses had been built. A team from the government telecommunications company was on the island to install new telephone towers to improve network connectivity and accessibility. The government team had discussed with JUMEME the possibility of getting electricity supply from the mini-grid. The field researchers also observed a wider prevalence of solar home systems in houses and businesses due to the restrictions on electricity supply. Many households were using their mini-grid connection to power businesses and had purchased solar home systems for their household needs. In general, businesses were unhappy with the low availability of electricity.

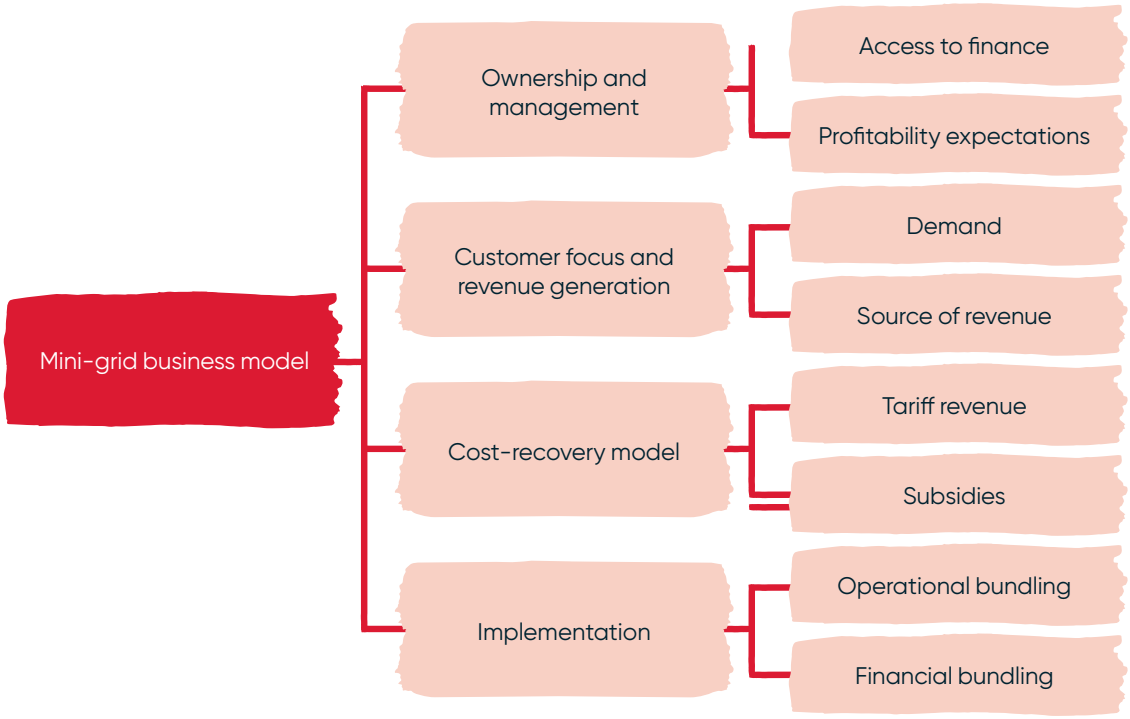
Research activities involved 20 interviews with locals in the three villages of Kanoni, Kisaba and Busikimbi. The informants were purposefully selected to include the owners of productive uses of energy electrical equipment purchased with funding from the PREO programme (including tailoring machines, freezers, and fish feed production machines). Interviewees are detailed in Annexe 3. The business census was conducted in all three villages and covered all businesses whether connected to the solar mini-grid or not.

6.2 Analytical framework

The analytical framework draws from the literature review in Section 2. It aims to systematise the evidence gathered about the design of the Keymaker business model, internal and external constraints, and outcomes and impacts for the community.

First, we characterise the Keymaker model using the business model categories presented in Figure 6.1.

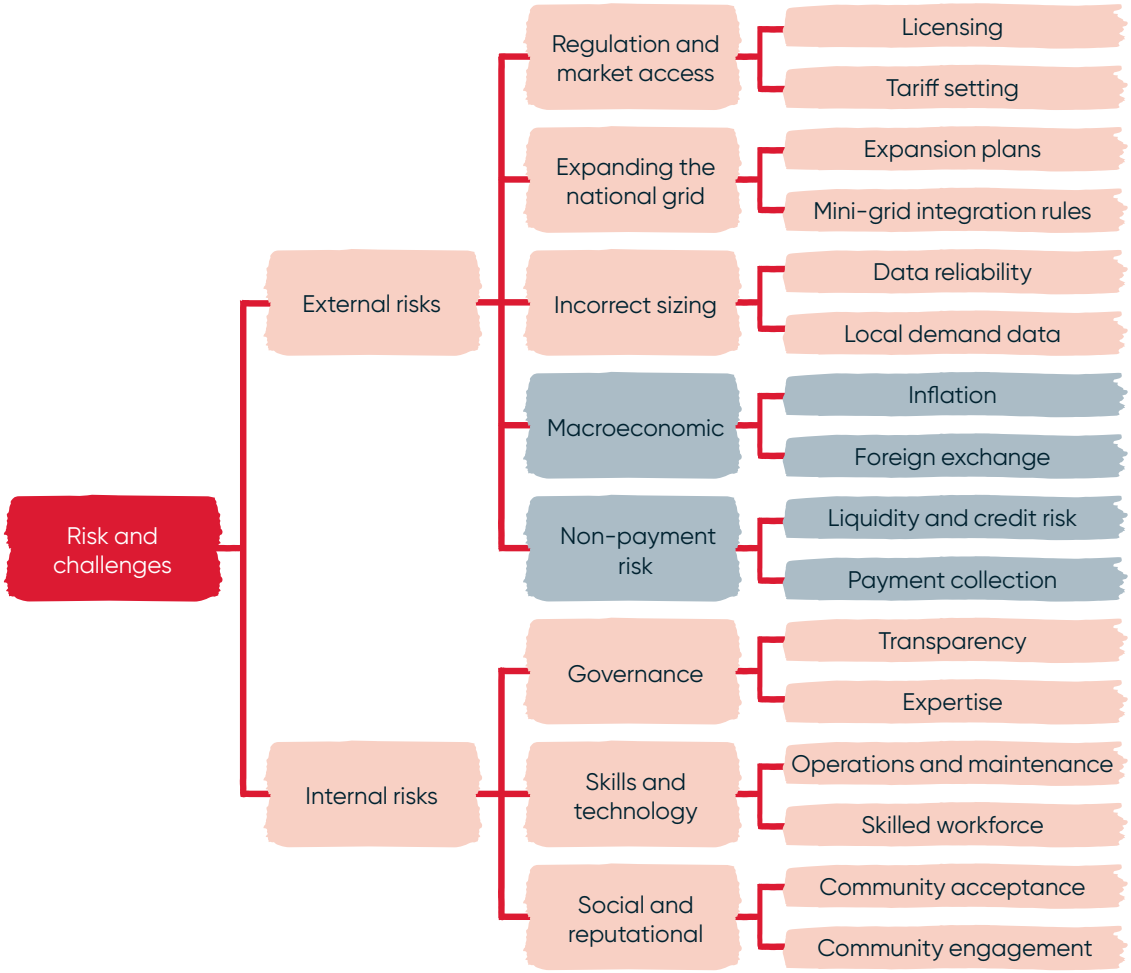
Figure 6.1 Mini-grid business model



Source: Authors' own.

Second, we analyse the internal and external pressures influencing the success of the business model according to the categories in Figure 6.2. We did not find in our case study enough evidence about macroeconomic or non-payment risks having caused a problem to JUMEME's business model. We shade these in grey in Figure 6.2, and they will not be included in the analysis. On the other hand, internal risks related to governance, skills and technology were interrelated, and we put them into a single category.

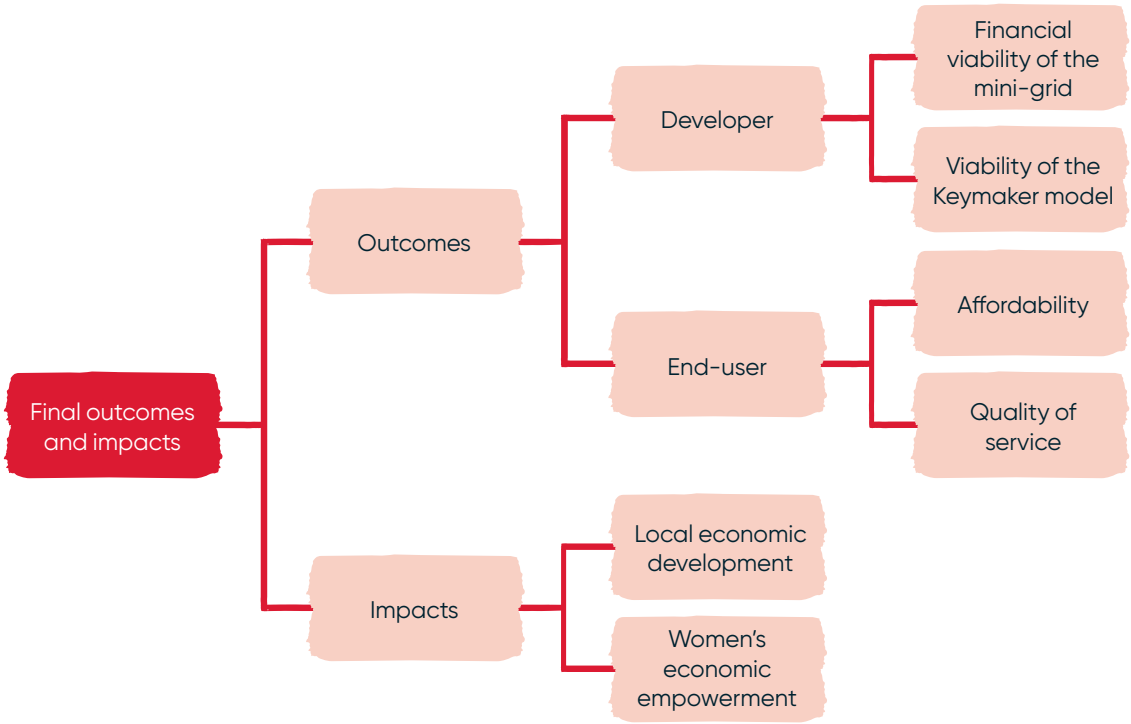
Figure 6.2 Risks and challenges



Source: Authors' own.

The third part of the analysis looks at the project's final outcomes and impacts, according to the categories in Figure 6.3. We analyse, on the one hand, the performance outcomes for the mini-grid, and on the other hand, the results for the community, focusing on economic development and women's economic empowerment.

Figure 6.3 Final outcomes and impacts



Source: Authors' own.

The project agreed on target goals for a number of key performance indicators (KPIs) in line with the categories above. The final results for these KPIs are presented in Annexe 2.

7. Analysis

7.1 JUMEME´s business model

The characterisation of JUMEME's business model draws from qualitative data retrieved through interviews with JUMEME's staff and members of the Maisome community.

7.1.1 Ownership and management

Key message: The private model introduced pressure to grow and make profits fast. The implementation of a scalable business model for mini-grids requires patient capital.

JUMEME is a private company with a majority shareholder, RP Global, and three minority stakeholders: INENSUS, Terraprojects and St Augustine University. The initial capital for the pilot stage in Ukara island was provided by an EU grant, as well as an Energy and Environment Partnership grant and equity from the founders. The expansion, however, was funded (mainly) privately by RP Global in combination with the EU grant (46 per cent). RP Global is a fast-growth IPP with experience in large-scale renewable power generation plants. The minority shareholders provided technological expertise and local knowledge.

Profitability is the main goal of private equity investors, and it needs to be higher and faster in high-risk environments with an uncertain regulatory framework, as in Tanzania. The required IRR of an investment in Tanzania is typically higher than 30 per cent, with a payback period of less than two years.[8] JUMEME's expectations were in line with these requirements, and the initial tariff had been set up to achieve close to a 30 per cent return, with the subsequent upward impact on tariffs.

After a successful pilot project on Ukara island, the entry of RP Global signalled that the company was ready for expansion. Ambitious plans involved building around 50 mini-grids, both on islands and on the mainland, as well as larger grid-connected solar power plants. Mini-grids would follow a Keymaker model approach to diversify revenue sources and improve profitability.

8 Interview with JD, 2020.

According to some of JUMEME's staff who were interviewed, the expectations of the majority stakeholder were unrealistic:

> *The expansion was quite hurried, the company was not properly oiled yet.*
> (Staff JR)

> *During the acquisition process, RP Global got the impression that all the systems were in place, that everything worked, but on the ground, the reality was very different. The two-year turnaround was highly unrealistic.*
> (Staff JR)

The requirement to get results fast prevented careful testing of the model, as the majority shareholders were discouraged by some initial drawbacks:

> *RP Global said: 'let's not try this anymore, you tried, and it did not work'. But we are sure we could have made the maize trading business profitable, only we had bad luck with the weather in the first year. We need patient capital that is willing to wait for a couple of years and see what happens.*
> (Staff JN)

Unfortunately, Tanzania's regulatory risk materialised with the government's unexpected tariff reduction. As a result, RP Global suffered heavy losses when it was forced to inject capital every month to keep JUMEME afloat. After this setback, and despite the promising outlook with the ongoing tariff review, RP Global has decided to divest in JUMEME. A potential option for exit would involve an asset deal, through which a fund would buy the mini-grid assets from JUMEME and create an asset payment contract, similar to a flexible lease agreement. JUMEME would then be solely the mini-grid operator, paying a fee for using these assets, which would no longer be on its balance sheet. This model is a new development in mini-grid financing, but requires reliable cash flows, which JUMEME cannot offer until the tariff issue is resolved.

7.1.2 Revenue-generation strategy

Key message: A Keymaker model, where revenue is generated both from electricity and commercial activities, is synergistic and can diversify risk. However, it requires cost-recovery electricity tariffs and tight control of the productive activities, with meaningful involvement of commercial partners.

JUMEME's Keymaker model in Maisome would have two sources of revenue: the sale of electricity to residential, commercial and productive consumers; and the sale of fish purchased from local fishermen and grown in cages.

The initial cost-recovery tariffs followed a staged model, where the more intensive productive consumers – using electricity mainly out of peak hours – would benefit from the lower tariff (750 TSh/kWh), and the least intensive, residential consumers – consuming only at peak hours[9] – would pay the highest tariff (3,500 TSh/kWh). Commercial consumers would pay lower tariffs than residential consumers (2,500 TSh/kWh), as they were expected to consume electricity during working hours. Productive users were key to the financial viability of the mini-grid, as they provided a large share of the total demand out of peak hours. The tariff model was designed accordingly to limit residential consumption while promoting productive consumption. As we know, the financial logic of JUMEME's model was broken when the government imposed a blanket ultra-low tariff across all mini-grids. Residential and commercial tariffs went down to 122 TSh/kWh, and productive use tariffs to 356 TSh/kWh. As a result, residential demand during peak hours soared, and JUMEME stopped new connections for productive users. The quality of supply deteriorated as there was not enough cash flow for maintenance or for the operation of the diesel generator during peak hours, and battery storage was not sufficient to cover the gap.

The second revenue source, the sale of fish, also delivered disappointing results. Fish trading started promisingly but stalled after the tariff review. As demand increased, due to high price elasticity, there was not enough electricity supply for the fish freezers, which started operating at all times. Demand for fish from local fishermen declined, and the delivery chain broke. Besides, JUMEME found instances of fraud, as some of their staff would start a parallel fish trading business for their own benefit, using JUMEME's assets. Aquaculture also failed due to a combination of lack of skills and poor management. These unfortunate outcomes discouraged the majority shareholder, RP Global, from continuing to invest in the Keymaker model. They argued that selling fish was not within their core business, so they could not innovate in that market, which was

9 The peak hours for electricity consumption on the island are the hour before dawn and one or two hours after sunset.

best left with the locals. Many current and previous members of JUMEME, however, believe in the value of the Keymaker model proposition:

> *Fish trading makes a lot of sense, as very low know-how is required, the supply chain is already set up, and it allows us to leverage our local presence. It generated positive cash flow until the tariff incident. Fish farming, however, requires more expertise that we do not have and cannot create easily. Our staff does not have the motivation to carry it through.*
> (Staff JN)

> *The Keymaker model actually works, but it must be under certain conditions. The productive activities and the mini-grid are co-dependent. The productive activities should be related to the main value chain of the area, which in this case was the fish. The fish would complement the incomes of the mini-grid, by strengthening the existing value chain. That is why fish farming makes a lot of sense because it creates the need for fish food, which then gives jobs to farmers and millers. But if the electricity supply fails, the productive activity fails, as you cannot keep the fish frozen or produce fish food.*
> (Staff JD)

> *The magnitude of the fish trading business is huge.*
> (Staff JA)

A new development during the research team's last visit to Maisome was the arrival of a new telecommunications tower, which could become another electricity consumer. However, JUMEME staff indicated that they may instead opt to use diesel generators that they can control.

7.1.3 Cost-recovery model

Key message: Tariffs should cover operational, maintenance and replacement costs as a minimum. Otherwise, one enters a vicious cycle of poor quality of supply–discontent–unwillingness to pay.

JUMEME is a privately owned mini-grid operating a for-profit model. Initial capital consisted of a combination of a public grant and private equity. The mini-grid installed in Maisome had a capital investment of €319,000 for a 60kWp installed capacity. The tariff level was designed to recover operation expenditure (OPEX), and the private portion of capital expenditure (CAPEX), while allowing a return of up to 30 per cent. The tariffs were set below the levelised cost of electricity[10] (LCOE) as they did not expect to cover grant-funded initial capital.

After the tariff review, the cost-recovery model was broken. Tariffs could not cover OPEX, replacement costs, or provide a profit, and regular capital injections from shareholders were required. Furthermore, the frequent cycling of batteries in the absence of the diesel generator for peaking reduced their life by approximately two years, increasing costs. Reliability has reduced from a 24x7 service to 12–16 hours of service per day. Poor reliability and maintenance are having an impact on the operations of local businesses.

The productive activities related to the fishing industry were competing with local value chains, but had very large overheads associated with being part of an international company where directors had European salaries and were flying from Europe, with a business too small to cover their costs.[11] As a result, large-scale restructuring has taken place recently to reduce costs.

10 The LCOE represents the average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant during an assumed financial life and duty cycle, and is calculated as the ratio between all the discounted costs over the lifetime of an electricity generating plant divided by a discounted sum of the actual energy amounts delivered. See **Wikipedia definition of LCOE**.

11 Interview with JA.

7.2 Internal risks

7.2.1 Corporate governance, skills and technology

Key messages:

- A strong management system needs to be in place before the mini-grid company scales up.
- The Keymaker model introduces significant complexity, and it is better implemented in partnership with local companies with a long track record in the sector.

The tariff reduction was the main cause of JUMEME's disappointing financial results, but not the only one. In addition, cash-flow problems revealed internal management inefficiencies that had contributed to poor service and a disappointing financial performance. Some of the internal problems described by current and previous JUMEME staff include demotivated staff, lack of appropriate skills, lack of clear management and reporting systems, and poor service quality. These are described in more detail below.

Demotivated staff. The staff did not trust that JUMEME would survive after the tariff reduction and started to look after their own interests, rather than JUMEME's. Besides, local staff did not feel protected or heard by the company. Directors were based in Europe, with little contact with operations on the ground, and national managers were out of touch, rarely visiting the mini-grid sites. Consequently, very simple tasks, such as feeding fish in cages or protecting the cages from theft or storms, were not being done, but the management was unaware of this.

> *When I left the company, many other people from my team were leaving, because they did not understand the business or what was expected of them.*
> (Staff JR)

> *The local staff were not trusting the management anymore. The trust was lost.*
> (Staff JR)

Two members of staff were arrested for charging high tariffs, but the company did not do anything to release them. Staff were scared from the locals' anger, or the government arresting them, but the managers were sitting in their offices far away in Europe.
(Staff JR)

There was a breakdown between management and staff more from a cultural perspective.
(Staff JA)

Lack of appropriate skills. Junior staff in JUMEME were not getting the support they needed. They had too much independence in some respects but were micro-managed in others. Regarding the aquaculture business, JUMEME did not have the appropriate skills internally and did not procure the right external consultants to support them.

When they were recruiting staff, the company did not understand the kind of people they needed and the support they needed to give to those people. They assumed that if someone had knowledge of Tanzania and Africa from a development perspective, they would know how to operate a business. Also, some of the staff were fresh out of school and needed a lot of guidance that they did not get.
(Staff JA)

The challenge for aquaculture was the management. We learned we cannot manage the cages ourselves and need to get either a professional or a consultant. We understood that the high costs came from feeding the fish.
(Staff JR)

The team did not have the know-how or the patience to learn about aquaculture. The consultant we engaged did not have the right knowledge for a fish farming business either. He provided us with substandard equipment that we cannot even sell now.
(Staff JA)

Lack of clear management and reporting systems. Some JUMEME staff argue that the company grew too fast before appropriate management, reporting and control systems were in place. The lack of a governance structure that would allow the prompt identification of any problems limited their ability to correct the ongoing issues. The views of some staff (current and ex-employees) are reflected in the following quotes:

> *The tariff was not the only reason for the poor performance. There were problems in the finances, and in implementing the nitty gritty of the productive uses.*
> (Staff JR)

> *There were problems of communication between the management and staff on the field. Managers were not understanding what was happening on the ground, and when the management eventually investigated, they saw everything was going very badly.*
> (Staff JD)

> *The reporting procedures did not allow the people in the field to provide the records, but these were provided by someone in the office who was giving fraudulent data. They should have relied on the people on the field, not on JUMEME's staff from the Head Office.*
> (Staff JL)

> *Supervision was poor. For example, sometimes the delivery notes for some supplies said 100 bags, but we only received 50 bags.*
> (Staff JL)

> *This is a company that grew really quickly and the structures, hierarchies and policies did not follow... We need to put systems in place, particularly financial systems and HR* [human resources] *systems. Staff need to have job descriptions, know their responsibilities and be made accountable for them.*
> (Staff JA)

> *The operations manager at the time had never been to any of the sites. She was doing everything remotely.*
> (Staff JA)

> *There were no strict controls, no paper trail for activities, there were no protocols for procurement or for staff management, no quality control of the materials and equipment we were purchasing, there was a lot of collusion with suppliers, there were staff carrying a lot of cash around, there was not a per diem system.*
> (Staff JA)

Quality of service. Some of the problems described by JUMEME staff include a defective billing system that did not record some transactions, creating a lot of customer dissatisfaction. Also, there was no automated customer support system. Instead, the phone number of the country manager was given for queries. She shared that on one occasion, she got more than 400 calls from disgruntled customers during the weekend.

JUMEME is currently resolving the internal risks described here. It has restructured its local operations and appointed a Tanzanian general manager who is developing a management system. They have fixed the problems with meters and customer service. The Keymaker model activities have been abandoned. The general manager believes that a local partner should have been engaged in the Keymaker model activities, and it would have become their anchor customer, as fishing was not the core business of the shareholders.

7.2.2 Social opposition

Key message: Lack of engagement with the community created distrust and discontent.

JUMEME's relationship with the Maisome community suffered from a lack of trust and misunderstandings. JUMEME's staff and management believe there is a negative perception of international investors in the country, which was in part encouraged by the previous president. The community believed JUMEME was taking advantage of people in poverty to make a profit, but on the other hand, JUMEME needed to recover its costs and provide a return to its investors to stay in business. According to some of our interviewees, the sudden tariff reduction mandated by the government would have been a populist turn to indicate that international investors deserved to be penalised. It sent a signal to the community that international investors were not respected and, after the tariff reduction, theft in the community and staff fraud proliferated. For example, fish nets in the cages were ripped, and fish were stolen, staff faked travel expenses, or pocketed fish sales revenues. As revenues went down, the quality of the electricity supply deteriorated, and discontent in the community grew.

Initially, JUMEME met with the community to explain that availability and reliability had declined as a consequence of the low tariffs. The community showed willingness to accept higher tariffs, but this was not communicated to local members of parliament (MPs), who could have lobbied the national government in their favour. At some point, the relationship between JUMEME and the local community broke down when several meetings did not deliver any results. To make things worse, the new managers did not feel confident enough to visit the sites and repair the relationship with the community. As customer complaints increased, the government became less receptive to allowing higher tariffs.

> *Customers were complaining directly to the commissioners, because our licence required them to provide a particular level of service.*
> (Staff JA)

> *The engagement of people is the massive driver for the success of a project. If you lose that, there is nothing you can do.*
> (Staff JD)

> *If people in the village are not happy, any other project that you try to implement will be sabotaged.*
> (Staff JR)

> *The trust relationship is easier to build with the involvement of a local partner. Although we had a local partner, they were never really involved, they remained silent.*
> (Staff JN)

Although people from the community acknowledged the difficulties that JUMEME was facing with the tariff reduction, they insisted that it fulfil the promise of providing reliable electricity. The perceptions from the community suggest that the lack of communication about JUMEME's action plan has left people on the island uncertain about the future of the project.

> *JUMEME have a justification because they need to do business, but because they have committed to electrifying this island, they have to find a solution.*
> (Eliudi Samweli Misana, chairman of Busikimbi village)

> *I am very thankful to JUMEME because before we didn't have this electricity but now we have it. Though now we have experienced several challenges and sometimes being perceived as corrupt people because we inquire a lot, but it is because we are not ready to see this service stopped.*
> (Zuberi Yahaya, Kisaba village leader)

Likewise, the community's disappointment has worsened as they have not seen an effort from JUMEME to establish communication channels with the villages. In particular, the company has shown little effort in contacting the end-user directly to hear their complaints, and villagers perceived the lack of management on the site as reckless.

> *They should as well collect views from their customers. They have never visited our village and instead they do invite leaders in the ward office, but they should hear from the villagers themselves.*
> (Resident, Busikimbi village)

> *JUMEME does not have a local office on this island. So if one has a problem we must communicate to their head office and it takes a lot of time to rectify.*
> (Resident, Kanoni village)

7.2.3 Oversizing or undersizing of the mini-grid

Key message: Large latent demand, but inability to pay for the initial tariff.

The mini-grid in Maisome is undersized at the current tariff, with a large latent demand. Weekly consumption is capped at 2kWh per week for residential and most commercial consumers, and at 50kWh per week for productive users. Furthermore, new connections have been capped. The main wish of most interviewees in the community is that these restrictions are lifted so that they can enjoy the benefits of more electricity consumption and their businesses can grow. Over 88 per cent of the existing businesses recorded by our census present the potential to use electricity productively. Many of them pinpointed the appliances they would like to purchase, such as electric sewing machines, electric ovens, blenders, dryers, fridges, kettles, welding machines or speakers. Furthermore, connections to prospective productive users have been denied until the tariff goes up. In response, many businesses were using their residential connection to the mini-grid and had purchased individual solar home systems for household consumption.

I have asked JUMEME to connect my tailoring shop but they said it will cost too much. They said I have to pay 198,000 TSh, which is unaffordable to me. So I decided to stay without electricity.
(Adelina Dioniz Petro, tailor)

Currently we don't get enough electricity. We are only able to purchase 2 units per week. We wish this electricity was more reliable and sufficient to enable income-generating activities.
(Zuberi Yahaya, Kisaba village leader)

Demand at the high initial tariff, however, was significantly lower among residential consumers, with many indicating that it was unaffordable. Residential consumers remain the most numerous, but have very low monthly consumption, at 5kWh/month. Commercial consumers include businesses with low electricity consumption, mainly related to service industries such as retail shops or hairdressers, with very few appliances. Their average monthly consumption is 15kWh/month. Very often, commercial users are connected to their household, so they appear as residential consumers. Intensive electricity consumers are referred to as 'productive' and include four millers, two welders, one fish freezing operator and the government dispensary. Their average monthly consumption was 171kWh/month as of December 2021.

Maisome has a stable population, with very low transit, as opposed to other islands with transient fishermen camps. This facilitates a stable demand for the mini-grid. Besides, there may be new demand from new telecom towers that are planned to be installed on the island.

7.3 External risks

7.3.1 Regulation and market access – licensing and tariff setting

Key message: The uncertain regulatory framework is the key weakness of JUMEME's business model.

Tanzania's uncertain regulatory framework is the key weakness of JUMEME's business model. The tariff was reduced to 3 per cent of its initial level without previous consultation or a predictable legal process.

The tariff was reduced nationally, affecting all the Tanzanian mini-grids. The reduction took place through a statement from the Ministry of Energy, rather than a decree or a law. On paper, the valid tariff was the one we were applying when we started operations, but on the ground, the community expected us to respect the minister's statement. We could not

have appointed a legal team to restore our tariff, as community opposition would have made it impossible anyway.
(Staff JD)

According to the discussion with a senior engineer at EWURA, the tariff imposition started in July 2020 for all off-grid companies in the country. The imposition was due to community complaints because many solar mini-grid companies were selling electricity at more than 5,000 TSh per kWh. The engineer mentioned that mini-grid companies with a capacity lower than 100kW were not regulated initially. This situation allowed off-grid companies to set their cost-reflective tariffs as they saw it possible to recover their investment. He acknowledged that the 100 TSh tariff had caused many complaints from the operators and the community. It was difficult for the operators to cover their costs. The community's main complaints were about the quality of the electricity, reliability and poor services. Some communities were ready for tariffs to be increased but to a level that was affordable for them.

The management capacity of JUMEME has, since then, been focused on lobbying the government to restore the tariff to a sustainable level, rather than on improving its service or providing access to more unelectrified consumers. The lobbying process has been long and frustrating, eventually wearing out the main shareholder, who has decided to divest.

Although the tariff reduction is the most flagrant regulatory problem, other issues include long delays in obtaining permits and disbursing grants where the Rural Energy Agency was a vehicle of international development partner grants. For example, mini-grids that should have been commissioned in 2016 could only be built after 2018, accumulating three-year delays. Despite these problems, according to one interviewee, Tanzania was one of the best countries in Africa to do business with until the change of government in 2015.

A stable regulatory framework is the condition number one for success.
(Staff JN)

Let's not forget that Tanzania had been open to the market, and one of the best places to do business for at least ten years, but when the new president came in, new challenges emerged. Magufuli did not change any of the existing policies. He just did not apply them. Policy was made with statements that were not agreed or written. The regulatory framework became totally unreliable.
(Staff JD)

> *Two of JUMEME's staff were detained without any charge. They even went on national TV as people who were not complying. Although they could not be accused of anything, this sent a message that the government did not support them and created a lot of insecurity in the company. The rule of law was not applied in Tanzania anymore.*
> (Staff JD)

The former president died in 2021, and Samia Suluhu Hassan became the constitutionally mandated successor. JUMEME is cautiously optimistic that the business environment is going to improve. A government team is reviewing the tariffs, and they expect a positive breakthrough soon.

7.3.2 Rule of law/corruption

Key message: The government's hostile environment towards private investors was correlated with an increase in corruption inside and outside the company.

JUMEME had experienced some cases of fraud and theft at a very small scale before the tariff reduction. However, after the government disregarded the interests of private mini-grid investors, corruption increased at all levels. JUMEME's staff members interviewed by the research team believe that private investors were presented as taking advantage of Tanzanians, which would justify rent-seeking to their detriment. On the other hand, the company did not have management systems in place to prevent fraud.

An important lesson learned is that private mini-grids require a strong regulatory framework and compliance with the rule of law. It is also necessary to engage closely with the government, through high-profile staff with experience in dealing with government officials.

7.4 Final outcomes and impacts

7.4.1 Financial viability

Key message: The mini-grid is currently financially unsustainable; it cannot recover operating costs, let alone replacement and capital costs.

JUMEME's business model in general, and the mini-grid in Maisome in particular, are not currently financially sustainable. Table 7.1 shows the key techno-economic indicators monitored for the first and last month on record. At the current electricity tariff, JUMEME cannot even recover its operational costs, let alone its capital costs. Monthly revenues are lower than monthly OPEX. In June 2020, before the tariff reduction, JUMEME was on a path to profitability. Monthly revenues were significantly higher than OPEX, allowing for some capital cost recovery and a profit for investors, who expected an IRR of close to 30 per cent. Tariffs were still set below the LCOE, not expecting to recover the part of capital expenses funded with a grant. Since September 2020, however, JUMEME has been making monthly losses and needs to inject cash to keep the business afloat. It cannot afford to purchase diesel for the back-up generator, which explains the reduction in operational costs. There is no available capital to replace batteries or other equipment. Electricity supply is limited to less than 18 hours a day and rationed to consumers.

Table 7.1 Techno-economic indicators of Maisome's mini-grid at baseline and endline

Indicator	June 2020	December 2021
Installed capacity (kWp)	60	60
Distribution system (km)	22	22
Total active connections	678	588
Residential connections	607	521
Commercial connections	51	38
Productive connections	3	8
Institutional connections	17	21
Electricity generation (kWh)	4,238	4,054

Cont'd.

Indicator	June 2020	December 2021
Electricity demand (kWh)	1,174	4,830
Household demand (kWh)	936	2,730
Commercial demand (kWh)	190	572
Productive demand (kWh)	-	1368
Institutional demand (kWh)	48	160
Revenues (TSh)	3,871,790	569,698
Capacity utilisation factor (%)[12]	10	9
Connection fee (TSh)	15,000	27,000
Tariffs		
Household (TSh/kWh)	3,500	122
Commercial (TSh/kWh)	2,500	122
Productive (TSh/kWh)	750	356
Availability of electricity (hours per day)	24	18
CAPEX (EUR)	319,000	
OPEX (TSh/month)	1,949,207	698,140
LCOE (TSh/kWh)	4340	
Expected IRR (%)	29.6	

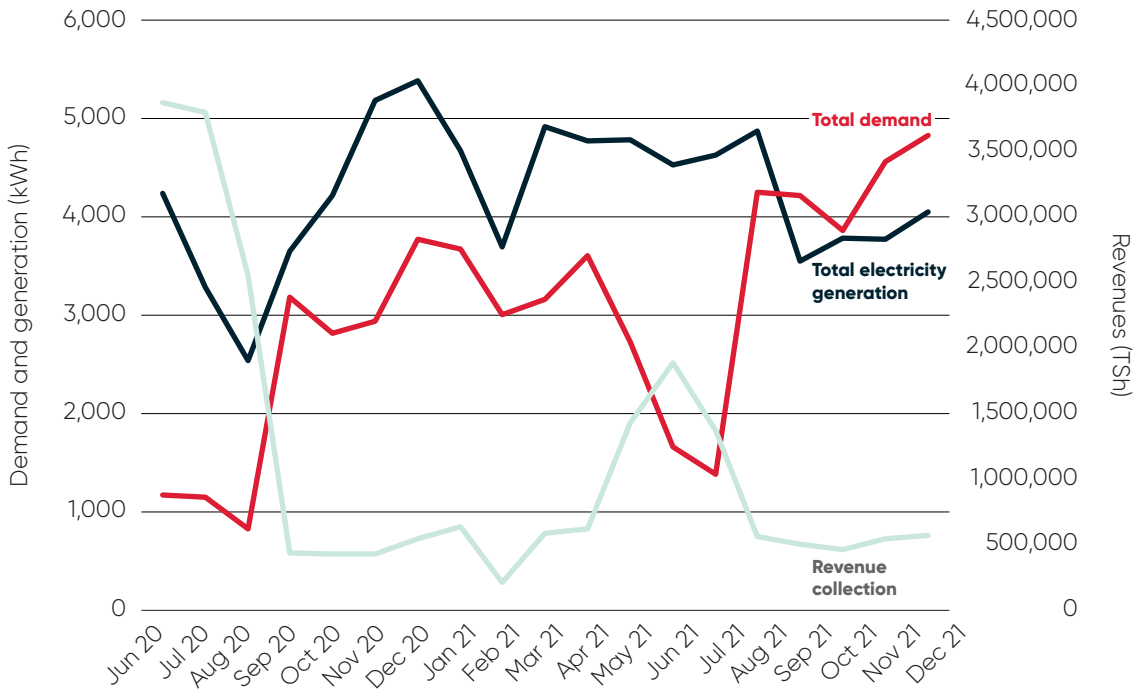
Source: Authors' own.

The performance of Maisome's mini-grid was tracked monthly as part of the action-research project's monitoring activities. Figure 7.1 illustrates the trends in demand, electricity generation and revenues from June 2020 to December 2021. The drastic tariff reduction from September 2020 caused a revenue fall, accompanied by a spike in demand. The tariff went down from 3,500 TSh/kWh to 122 TSh/kWh for residential consumers, putting mini-grids' viability in jeopardy. Another interesting spike happened between May and July 2021, when JUMEME raised the tariff to 2,000 TSh/kWh, after notifying EWURA, to try to recover some costs. Revenues increased during those

12 The capacity utilisation factor (CUF) is defined as the 'ratio of the actual output from a solar plant over the year to the maximum possible output from it for a year under ideal conditions' (**Capacity Utilization – an overview | ScienceDirect Topics**).

three months, even if demand decreased significantly. EWURA requested that JUMEME go back to the low tariff in August 2021, after some customers complained. Electricity consumption shows high price elasticity. Consumers tend to have a fixed budget for electricity; if prices go down, consumption goes as high as their budget can afford. Equally, when prices increase, demand goes down to accommodate a static budget. Figure 7.1 also shows that from September 2021, demand exceeded electricity supply. Customers purchased power that could not be provided due to lack of capacity. JUMEME manages supply shortages through load shedding and limits the weekly purchases of electricity. The main priorities for shareholders now are not to lose their investment and to reduce costs to the bare minimum. The company remains confident that it will regain financial sustainability soon.

Figure 7.1 Evolution of electricity generation, demand and revenues between June 2020 and December 2021



Source: Authors' own.

7.4.2 Affordability and willingness to pay

Key message: Electricity is very affordable now, but it was unaffordable at the initial tariff. Villagers are willing to pay more for better quality, but not as much as before. A middle ground is needed.

Electricity is very affordable at the currently reduced tariff. However, the service has deteriorated, and the electricity supply is not financially sustainable. According to JUMEME's staff on the ground and members of the Maisome community, they would be willing to pay higher tariffs, because they have experienced better service at a higher tariff, and they know that the service, and their businesses, would improve. However, the initial tariff was too expensive. In addition, mini-grid customers felt it was not fair that they had to pay much more for a similar service than the customers of the national utility TANESCO. As Kisaba's village leader said, 'JUMEME should charge the same rates as TANESCO because we are all Tanzanians'. That sense of injustice played an important role in the government's downward tariff review.

There are no studies of willingness and ability to pay for electricity in Maisome that can help set a viable yet affordable tariff. What is clear is that it should be set at somewhere between the initial high tariff and the current low tariff.

> *JUMEME is charging too low. Even the villagers feel so sorry for them.*
> (Staff JL)

> *If JUMEME raises the unit price of electricity to 1,000 TSh it will be ok to enable us to get electricity all the time. But if the price is raised to the previous level of 3,500 TSh we will have no alternative than paying.*
> (Grace Alex, ice cream and juice entrepreneur)

Several village entrepreneurs recognised the benefit that cheap access to electricity has had for their businesses. However, they also believe their businesses could not keep operating as they do with the initial high tariff but could absorb a moderate tariff increase.

> *Before, we were charged 750 TSh per unit. By then I was paying about 7,000 per week for electricity. Now the tariff is low and I am paying just 240 per week. My profits have improved with the low tariff. On average I can get 5,000 per day as net profit as compared to about 3,000 TSh when the tariff was high.*
> (Derick Sebastian, barber shop owner)

> *Now it is very affordable, though not reliable. Going back to the old price it will be very challenging to me, probably I will be forced to close some of the businesses.*
> (Gidion Jonas, workshop repairs entrepreneur)

It is affordable. But if the tariff is the same as the previous one, it will not be affordable at all. If it happens, then we will have to discuss and negotiate with JUMEME on the tariffs that can make us do the business.
(Lazaro Michael, milling machine owner)

7.4.3 Quality of service

Key message: The tariff reduction has led to a cash-flow problem. As a result, the quality of service has deteriorated.

The main complaint from customers is that supply is insufficient. Lack of reliability of the service restricts the regular use of electricity by households and productive users. Villagers complain based on having been initially told by JUMEME that the service would be available continuously without limitations. The community's disappointment has increased as they have seen their wish to use electricity restricted. The interrupted supply of electricity has affected the businesses in the village in particular.

There are a lot of complaints from JUMEME customers that they cannot use electricity as they wish. JUMEME should waive limitations and make electricity available all the time so that villagers can fully benefit from their services. When JUMEME came to introduce themselves on this island, they promised that electricity would be available all the time because it is from sunlight. We were not expecting any limitations. To me, this is disappointing.
(Eliudi Samweli Misana, chairman of Busikimbi village)

Some days we stay without electricity for the whole day.
(Zuberi Yahaya, Kisaba village leader)

Mini-grids cannot provide uninterrupted supply at the current tariff level. This presents challenges to businesses that depend on continuous supply, such as fish storage, where freezers need to operate continuously. Businesses like milling need to stop production when their allocated energy ends. Other businesses like bakeries or poultry farming, with an incubator, could not get their equipment connected.

> *I bought an incubator last year, but I cannot use it because of power rationing... If I plug in the incubator, then there is a power cut. So I can't use it.*
> (Mikaya Furaha, owner of chick incubator)

> *There was a time when we remained two days without electricity and about 60kg of fish were wasted. My husband helped me to look for ice and managed to rescue some, otherwise it could be a big loss.*
> (Domitila Crispin, freezer owner)

> *I don't get enough electricity. And this is my main challenge. Because I can buy 50 units only per week and sometimes it finishes in three days, so I have to stop milling.*
> (Lazaro Michael, milling machine owner)

Based on the complaints about JUMEME's service quality and the increasing electricity demand, people in the community have started looking for alternative solutions, such as stand-alone solar systems, to fulfil their electricity needs.

> *I have KUWA SOLAR. I have to pay for one year, and then I will own it. I use it for lighting only and when there is no power from JUMEME. This system is very reliable and I can use it the whole night so if there are customers I can extend working hours to midnight.*
> (Pamela Daniel, restaurant owner)

The recurrent community complaints add to a lack of communication from JUMEME management, increasing customers' frustration with the service. JUMEME does not have a permanent presence on the island that could communicate problems to the management, so these are directed to the village leaders or government commissioners to obtain answers. The lack of a local JUMEME presence is a consequence of the reduced OPEX and therefore reduced staff, due to the tariff cut.

7.4.4 Impact on local economic development

Key message: The number of businesses using electricity has increased, and there is an appetite to use more electricity productively, but there is low ability to pay cost-recovery tariffs.

The data collected as part of our baseline and endline census shows impressive growth in economic activity on the island. The number of businesses increased from 114 in November 2020 to 218 in April 2022. Most of this increase happened in the village of Kisaba, where the number of businesses increased from 37 at baseline to 120 at endline. However, without a robust impact evaluation with a valid counterfactual, we cannot attribute this growth to the arrival of the mini-grid or the tariff reduction. There could be many confounding factors, including seasonality factors such as the heavy rains that had battered the island right before the baseline survey. We did, though, observe increased levels of welfare in our second visit, with modern houses newly built and more services available, such as guesthouses or planned telecommunications towers.

Table 7.2 provides some key statistics on Maisome's businesses at endline and baseline. We observe that not only had the number of businesses increased, but also the share of those using electricity had increased, from 76 per cent to 86 per cent. Most of these are connected to the mini-grid, with a smaller share using individual solar home systems. In addition, the share of women-owned businesses has increased from 25 per cent to 31 per cent, and the share of home-based businesses – more prevalent among women – has also increased from 5 per cent to 16 per cent.

We asked business owners to estimate their income during the high and low seasons. While these estimates are likely inaccurate due to most businesses' lack of accounting records, they provide an idea of their size. Average incomes were higher at baseline than at endline, showing that even though the number of businesses has increased, the resulting income for the community has not increased to the same extent. Businesses are indeed very small, and most have no employees. The average monthly income in the high and low seasons is equivalent to US$338 and US$172 per month respectively at baseline and endline.

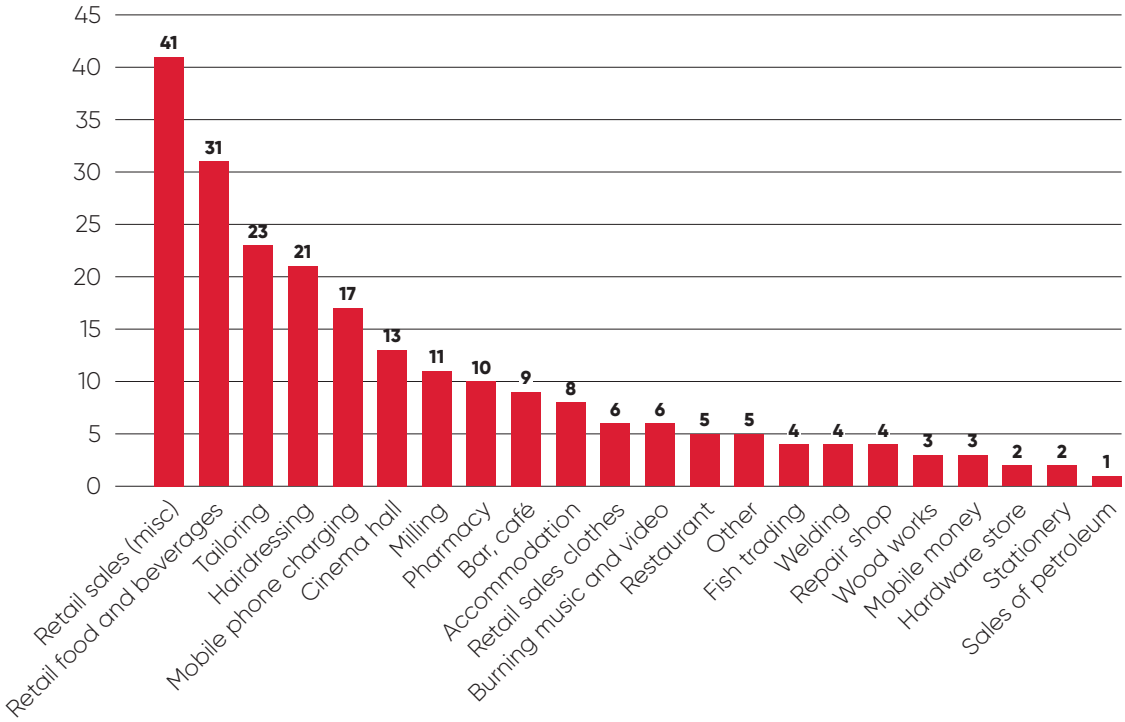
Table 7.2 Descriptive statistics of businesses in Maisome

Indicator	Baseline – November 2020	Endline – April 2022
Number of businesses	114	218
Share of businesses with electricity access	76%	86%
Share of businesses connected to the mini-grid	54%	72%
Share of businesses with solar home system	19%	16%
Share of female-owned businesses	25%	31%
Share of home-based businesses	5%	16%
Average revenue in high season (TSh)	1,006,382.3	787,385.8
5% trimmed mean high season (TSh)	671,710.24	629,843.5
Average revenue in low season (TSh)	416,470.6	400,680.2
5% trimmed mean low season (TSh)	380,332.24	311,346.3
Share of businesses with no permanent employees, apart from the owner	86.5%	75%
Share of businesses with no temporary employees, apart from the owner	85%	94%

Source: Authors' own.

Figure 7.2 shows the number of businesses on the island per type of activity. Retail shops are the most common type of business, but several new activities relying on electricity have emerged in large numbers, such as mobile phone charging, cinema halls, or establishments burning music and movies on compact discs (CDs) or pen drives.

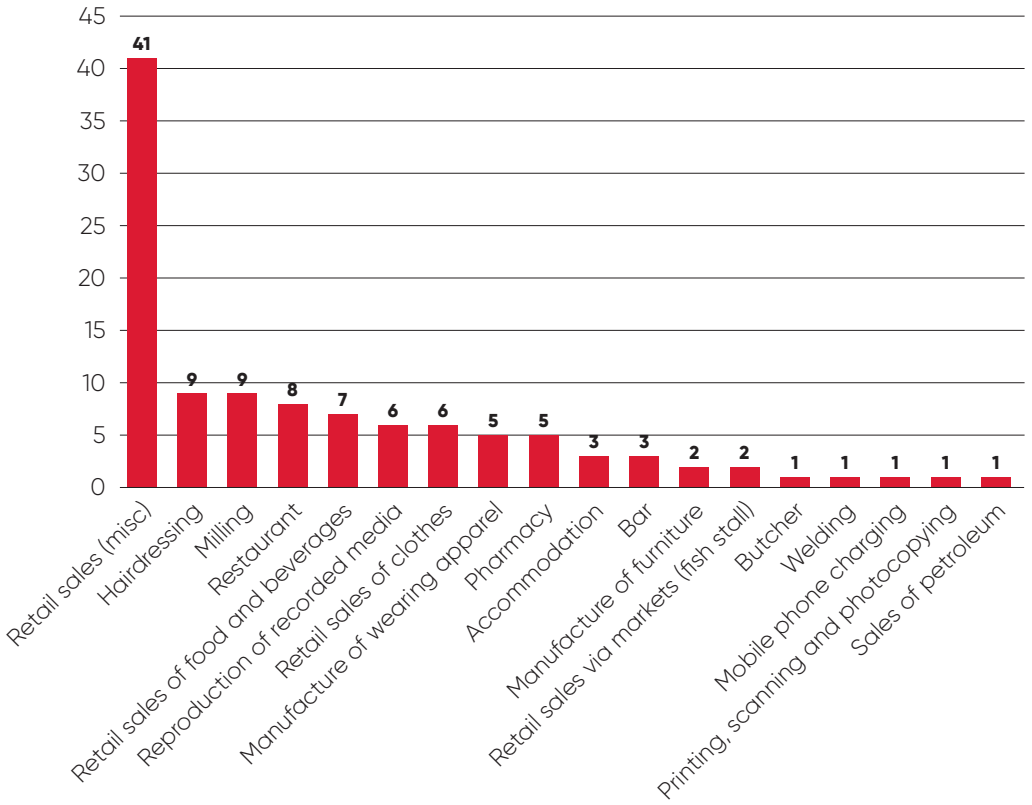
Figure 7.2 Number of businesses per type of activity at endline, April 2022



Source: Authors' own.

The number and types of businesses at baseline were more strongly dominated by retailing, as Figure 7.3 shows. The types of businesses that have increased their numbers most significantly since the baseline survey are: those selling food and beverages (in many cases, selling cold drinks using refrigerators); tailoring (from 5 to 23 tailors); mobile phone charging (from 1 establishment to 17); cinema halls (from 0 to 13); and music and video recording (from 0 to 6). All of them use electricity.

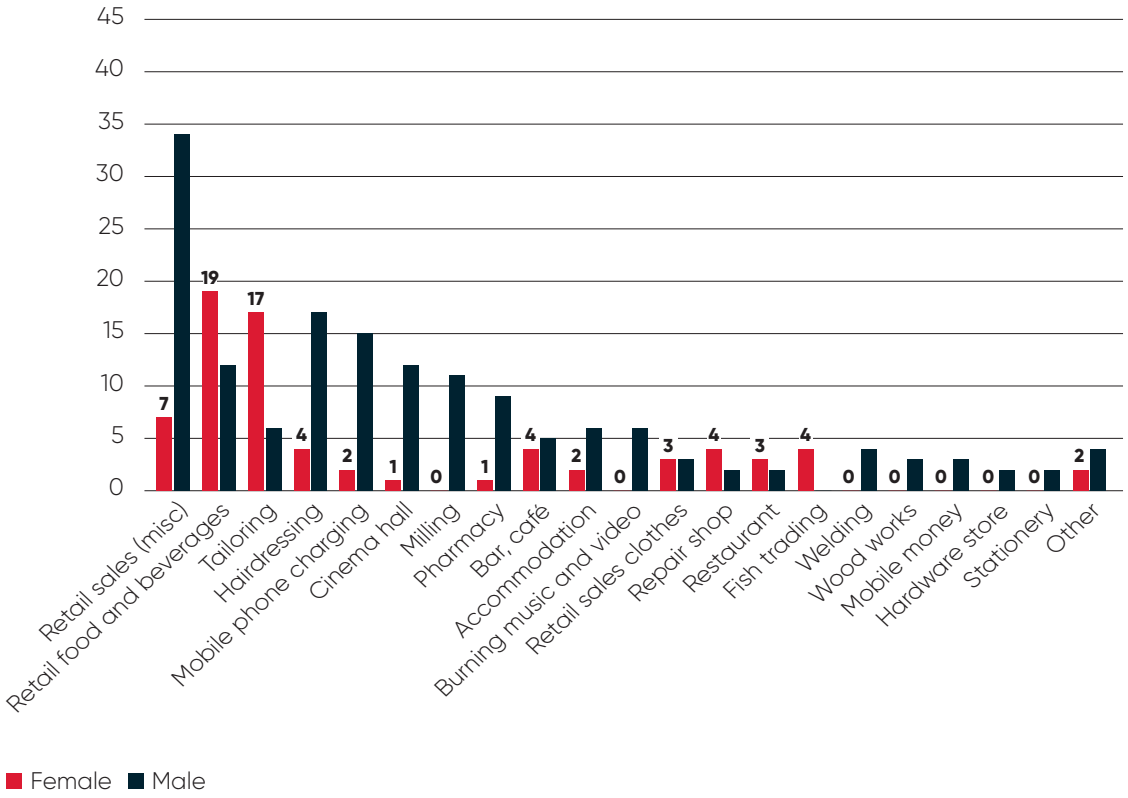
Figure 7.3 Number of businesses per type of activity at baseline, November 2020



Source: Authors' own.

Women's enterprise ownership had improved slightly by endline compared to the baseline. However, business activities are still dominated by men, who own 69 per cent of establishments, down from 75 per cent at baseline. We observe a clear gender division of activities (see Figure 7.4). Women's businesses span a narrower number of activities, mainly selling food and beverages, and tailoring. They are a majority, although in small numbers, in restaurants, fish trading and repair shops. Two activities actively supported by the PREO programme – tailoring and fish trading – have seen a significant increase in women entrepreneurs. The new activities emerging with the arrival of electricity – mobile phone charging, burning music and videos, and cinema halls – are all dominated by men. The most energy-intensive activities, such as milling, welding or carpentry, are also male-dominated. Nevertheless, the mean monthly revenues of male-owned and female-owned businesses are not statistically different.

Figure 7.4 Gender division of business activities at endline



Note: Data labels indicate the number of female-owned businesses only.

Source: Authors' own.

The number of electrical appliances in use by businesses is very small. The most prevalent appliances are TVs (16), radios (15), computers (10), shaving machines (9) and sewing machines (9). Since JUMEME transferred five freezers to women wanting to engage in fish trading, there are now eight freezers in operation on the island.

Villagers have also noticed an increase in electricity use for productive uses, indicating that access to electricity has brought development to the island. In general, the village has observed positive changes after the mini-grid arrival, from people acquiring electric appliances to improving services such as accommodation and health care. In addition, electricity has increased people's desire to improve housing conditions and wellbeing. They consider that JUMEME has helped them get electricity and move away from other energy sources.

I see there are several people using electricity for different activities like milling, or video shows, which is very good because it is a sign of development. I even see there are many new guesthouses, which I think is because there is electricity. In this village we are constructing a health-care centre near the JUMEME power house and we are assured of good health-care services because electricity is available.
(Eliudi Samweli Misana, chairman of Busikimbi village)

JUMEME electrification is a very good project in this village and all people are not ready for the project to be ceased, because there will be no development without electricity. Now I see a lot of development in this island, I see new buildings with as good standards as those in town because they have welded windows and doors, and there are a few businesses powered by electricity.
(Tyson Lwelenja, Kanoni village chairman)

The arrival of electricity has incentivised new businesses in the village. Also, existing entrepreneurs have seen positive outcomes since they have been able to use electricity. Before the mini-grid arrival, some entrepreneurs used stand-alone solar systems that they replaced for JUMEME's service to have more reliability and flexibility and add more appliances to their businesses.

My motivation for starting these businesses came from electrification and JUMEME promises that they will give me a big meter which can afford these uses. I paid 15,000 to be connected and bought a socket breaker. So I was assured that I will get enough electricity.
(Gidion Jonas, workshop repairs entrepreneur)

I added the haircut machines. Before I had only one but now I have three of them. I also purchased a radio for entertainment.
(Derick Sebastian, barber shop owner)

Now I open at 8am and close at 9pm because this is the time I can get electricity. When I was using SHS [solar home system] it was different because it depended on whether there was enough sunshine or not. On the cloudy days I was not working.
(Derick Sebastian, barber shop owner)

> *Now there are several youths who started to generate income by using electricity – for example, they have barber shops, welding, carpentry, they make beads but they face the challenge of not having electricity at all times.*
> (Zuberi Yahaya, Kisaba village leader)

Some villagers obtained better returns since having access to electricity. Likewise, people could diversify their income by opening side businesses.

> *Before electrification I was relying on my salary only. My average income was 100,000 per month. Now I can earn on average 200,000 per month when there is good tender repairing motorcycles. Other businesses can lead to 50,000 per month – that is, from welding and testing of malaria.*
> (Gidion Jonas, workshop repairs entrepreneur)

7.4.5 Impact on women's economic empowerment

Key message: Access to reliable electricity and appliances improves women's opportunities to create new businesses and upgrade existing ones, and women are eager to take up these opportunities.

Women's businesses remain a minority in Maisome, accounting for 31 per cent of the total number of businesses. Their business activities are narrower than those carried out by men, and the latter are typically in charge of the most energy-intensive activities, such as welding, milling and carpentry. We did observe, however, some progress in women taking on electricity-using activities as a result of the action-research project. Although gender norms typically determine the types of economic activities that men and women do, with the arrival of electricity, some activities can emerge that are not bound by these norms, or others can be upgraded and considered more appropriate for women. For example, fish trading, like every activity in the fishing value chain, was male-led at baseline, but has now been taken up by many women, who have received freezers to operate their businesses. The new fish food production business – essential for aquaculture – was meant to be run by a woman. She is still determined to make it work, even if its main potential customer, JUMEME, has abandoned aquaculture in Maisome.

Women participated eagerly in the business development workshops. They appreciated the learning and material outcomes, assembling prospective business ideas to improve their economy.

My training at SIDO helped me to know how to do embroidering, knitting curtains, bed sheets and other garments.
(Adelina Dioniz Petro, tailoring)

I have attended trainings which were organised by TANGSEN three times. The training was on how to prepare a business plan, marketing, business deployment. I also attended training at Tanzania Fisheries Research (TAFIRI) to learn about the current standards for fish feed production and government production protocols.
(Kalunde Joseph, fish feed owner)

The support from TANGSEN was very appealing to the community because I see now there are women who were given electrical tailoring machines, and freezers. If this could continue, women could be different as they just depend on their husband to provide all their needs.
(Tyson Lwelenja, Kanoni village chairman)

The training provided personal and professional skills that improved women's confidence and managerial abilities. Women in the community have implemented the tools learned within their businesses, seeing positive outcomes. Likewise, women have started building support groups to support their initiatives collectively.

Now I can trust myself and I am confident as compared to when I didn't have training. I know how to welcome my customers better than before, and that makes me so happy.
(Adelina Dioniz Petro, tailoring)

I am confident that the project will take off. I have also been able to establish new contacts even with the people in the government, which before was not the case.
(Kalunde Joseph, fish feed owner)

However, some beneficiaries have not been able to use electrical appliances as much as they would like due to supply restrictions. In some cases, power cuts have caused losses to the business.

Even those who have been given electrical machines cannot use them because they don't have electricity.
(Zuberi Yahaya, Kisaba village leader)

Access to capital is a key limitation for some women entrepreneurs.

> *My revenue has not changed because I don't have capital. Capital of about 300,000 will be adequate for me to buy garments and to electrify my tailoring business.*
> (Adelina Dioniz Petro, tailoring)

Access to electrical appliances through the project improved women's opportunities to create new businesses and increase their revenues. However, some of the recipients are still in the process of connecting the appliances to electricity and completing the initial capital. They expect to start running their businesses later this year.

> *The freezer I had before was small and could not store many fish. Sometimes in a good season I can collect about 200kg or even more, so I had to transport fish twice per day. Now I have got this big freezer, my challenge is gone.*
> (Domitila Crispin, freezer owner)

> *I haven't started production yet but there are three machines which will use electricity (milling, pelletiser and a mixer)... I am so happy to own the machines, which in a normal situation would not have been very easy.*
> (Kalunde Joseph, fish feed owner)

> *Since I have just received the freezer, I am planning to connect it to electricity and start collecting fish again. I will get some capital from the lending groups because I am a member of the two lending groups. I think I can get about 200,000 TSh. By May I will be able to start the business.*
> (Cecilia Francisco, freezer owner)

Other benefits of improved access to electricity include extending the duration of lighting hours at home, hence giving women more time to develop their economic activities.

> *My working hours have increased because before I was going to bed at 9pm but now I sleep at 10–11 pm.*
> (Cecilia Francisco, freezer owner)

> *Before I was opening from 4pm to 8pm. Now I open at 4pm and close at 10pm.*
> (Pamela Daniel, restaurant owner)

Women in the village have seen an improvement in revenues through two streams: lower expenditures on kerosene and increased business incomes.

> *My income increased due to reduced expenditure on kerosene.*
> (Cecilia Francisco, freezer owner)

> *I am happier than before the arrival of electricity to this island because now our family has a reliable income... On average the income has increased to about 200,000 as profit per week after removing all the costs.*
> (Domitila Crispin, freezer owner)

> *Now I have a radio, a big one for music. I bought it when I started this business... Before electricity, my income was on average 10,000 per day, but now is on average 20,000–40,000 per day. This is because people come here to dance and they like it.*
> (Pamela Daniel, restaurant owner)

8. Appraisal of the Keymaker model and lessons learned

The analysis of the Keymaker model highlights some of its strengths and weaknesses and provides some lessons for the future scalability of mini-grids in Africa. Furthermore, it shows that even the best-designed business model is not immune to context-specific external and organisational risks. In this section, we summarise the strengths and weaknesses of the Keymaker model and its context, and draw lessons for the future.

First, with regards to the design of the business model, Table 8.1 highlights the strengths and weaknesses of the Keymaker model design in Maisome, and points to lessons for the scalability of the model. An appropriate tariff design is at the heart of the commercial and financial viability of the business model. The private ownership model pushed for a tariff that could recover most costs except for a capital investment grant, and generate an attractive profit for investors. However, this tariff was considered unaffordable or unjust by many customers, who would compare it to the low national tariff applied by TANESCO for the same service. Although the mini-grid was clearly creating positive externalities for the community, a sense of grievance prevailed. When there is a gap between affordability and financial sustainability, guaranteed and stable subsidies should be part of the revenue-generation strategy. To ensure affordability and social acceptability, the tariff should be close to the national uniform tariff, and the rest should be subsidised.

The design of the Keymaker model complemented electricity revenues with fishing and aquaculture revenues that would also add a productive load to the mini-grid. However, this element of the business model did not take off due to the lack of working capital, skills and motivation.

Table 8.1 Lessons learned for the design of the Keymaker model

	Strengths	Weaknesses	Lessons learned
Ownership model	– Attracted private investment to scale up – International technical expertise – Capital grants allowed for lower tariffs – Was close to financial viability	– Lack of alignment between expectations of equity investors and financial outcomes – Pressure to grow fast – High return requirements, commensurate with risks, pushed tariffs up – High vulnerability to political risks	– Importance of patient capital until a business model has been tested at scale – High private returns required are not compatible with affordable tariffs – Important to align with political interests through lobbying, or PPPs
Revenue-generation strategy	– The combination of electricity and agro-processing activities is synergistic and should improve the financial viability of both – Cost-recovery tariffs ensure technical viability – Large demand for electricity in the village	– Agro-processing activities are complex and outside the core business of mini-grid developers – Cost-recovery tariffs are not affordable for the population – Poor reliability reduces willingness to pay	– Local partners with a long track record in the Keymaker model sector are required – Keymaker model activities should be simple. In our case, fish trading is more likely to succeed than fish farming – Tariffs need to be affordable to avoid a sense of injustice and disgruntled customers – Studies of willingness to pay and ability to pay can help set the tariff at the right level, but the national tariff will always be a benchmark of what customers consider to be 'just'
Cost-recovery model	– Tariffs were initially designed to recover most costs and allow a profit – Reliable service and capital replacement were feasible	– Cost-recovery tariffs were considered unaffordable and unjust – Keymaker activities required working capital, not available through the electricity business	– The gap between what is considered just and affordable, and what is financially viable, needs to be bridged with subsidies – Need to account for working capital needs for Keymaker model activities

Source: Authors' own.

Second, internal and external risks can jeopardise a well-designed business model, and risk-mitigation strategies need to be in place for scalability. Table 8.2 presents the evidence of these risks in our case study, and proposes risk-mitigation strategies.

The different internal and external risks are related. For example, regulatory risks, which were the key weakness of the Keymaker model, sparked a corporate management crisis. Besides, while regulatory risks and the ensuing undersizing of the mini-grid were unavoidable and abrupt, other risks – such as social opposition, technological risks and corporate governance – could be avoided with learning-by-doing, better communications, or further capacity building. It is hard to say if the model would have been viable and scalable had the initial tariffs remained. But some lessons can be learned about the different mitigation strategies required for different risks. First, private mini-grids will be harder to implement and scale up in countries with heavily subsidised national tariffs, as these will be taken as a benchmark by customers. Stable and secure consumption subsidies should be considered as part of the revenue-generation strategy in this context. Meaningful partnerships with local businesses, and continuous engagement with political representatives and the community, are clear risk-mitigation strategies. Having a robust management system and keeping costs to a minimum while providing good quality of supply are also key to scalability.

Table 8.2 Risks to mini-grid viability and risk-mitigation strategies

Type of risk	Evidence	Risk-mitigation strategies
Regulatory risk	– Unexpected tariff reduction in Tanzania, after a decade of favourable conditions for private investors and a regulatory framework considered as best practice in the region	– Cultivate relationships with local politicians that can defend the mini-grid in the interest of their constituents – Cultivate relationships with the local community to increase willingness to pay and reduce complaints to government – Fair and active local partnerships to increase trust in international investors – PPP, where the public sector has a stake in the mini-grid and needs to guarantee its survival

Cont'd.

Type of risk	Evidence	Risk-mitigation strategies
Corruption	– Increased cases of theft and fraud among staff and the community	– Operate in countries that respect the rule of law and protect private investment – Develop clear management procedures that limit opportunities for internal fraud – Cultivate trust with the community
Corporate governance	– Existing management systems were appropriate for the pilot stage, but not robust enough for scaling-up – Overheads were excessive, some of them arising from having international directors and members of staff – Staff were demotivated, not properly mentored and managed – Managers out of touch with the situation on the mini-grid sites – Opportunities for fraud due to lack of proper management systems	– Develop and test tight management systems so that all activities leave an audit trail – Reduce overheads and streamline costs – Have clear job descriptions, mentoring and appraisal systems for employees – Managers need to schedule frequent visits to the mini-grid sites and engage with customers
Skills and technology	– Lack of internal skills for complex agro-processing Keymaker model activities like aquaculture – Some problems with metering and billing technology – Junior members of staff lacked skills and required more mentoring by senior staff	– Agro-processing activities as part of the Keymaker model are best undertaken with a local partner with a long track record – Initially engage in simple agro-processing activities, such as fish trading, over fish farming – Staff development systems need to be in place
Social	– Disappointment and distrust in the community – Failure to deliver on initial promises – Absence of communication channels – Lack of presence of the management in the villages – Poor reliability and quality of the service	– Have a frequent (or permanent) local presence on the sites – Create direct communication channels with the management – Increase awareness about the implications of the tariff reduction for the quality of supply – Engage with local leaders or respected members of the community

Cont'd.

Type of risk	Evidence	Risk-mitigation strategies
Incorrect sizing	– The mini-grid was adequately sized for the initial tariff level, but undersized for the increased demand at ultra-low prices – Tariff reductions lead to an increase in electricity consumption, while making unaffordable the use of diesel generation to meet the peak load. Solar PV alone cannot cover increased demand, and the lifetime of batteries decreases – When the mini-grid is undersized, consumption and connections need to be restricted	– Analyse consumers' ability to pay and design tariffs accordingly – Conduct awareness campaigns to explain to the community the implications of tariff reductions for the quality of supply – Rationing supply and freezing connections are good coping strategies, but lead to disgruntled consumers

Source: Authors' own.

9. Conclusions

Mini-grids are expected to contribute significantly to universal electrification in sub-Saharan Africa. They are particularly suitable for remote populations that are difficult to reach with the main grid but have a substantial productive demand. Development institutions and private corporations have increased their involvement in the mini-grids sector, attracted by their broad potential for universal access. However, to date, mini-grids have not achieved economic feasibility and scalability in sub-Saharan Africa. Several business models have been tested, such as public and private models, subsidised and self-sustained, and serving residential or productive loads. However, none has proved widely successful, indicating that success is highly context-specific.

This report aimed to document the experience of a Tanzanian company implementing the Keymaker business model for mini-grids in the context of the island of Maisome in Lake Victoria. Under this model, the mini-grid developer not only sells electricity but also procures raw materials from the local community, uses electricity to process them, and sells them to the urban market to complement the electricity revenue. This solves a typical stumbling block in the viability of mini-grids, which is the lack of sufficient productive demand. The action-research project we have documented here supported the implementation of a gender-inclusive Keymaker model. It provided electric equipment for fish processing, aquaculture and other local businesses, as well as capacity building and awareness, targeting women when appropriate.

The implementation of the Keymaker model in Tanzania suffered several setbacks, reinforcing the idea of the context specificity of a business model. The report has explained the design and implementation process of the Keymaker model and has identified strengths, weaknesses and risk factors affecting its success.

First, the business model followed a private ownership, for-profit model. Its main strength was the ability to attract foreign private investment, which propelled the company's growth in Tanzania. An additional strength was the large demand for electricity in the villages involved, and the evident benefits of electricity for local businesses. However, the need to recover costs and make a profit required setting tariffs at a much higher level than the heavily subsidised national tariff. The Tanzanian small power producers regulatory framework allowed cost-recovery tariffs for mini-grids below 100kW, and the country had been favourable to private investment in the electricity sector for over a decade. Therefore, the mini-grid developer

was confident of the sustainability of its tariff. However, the large tariff differential between grid and mini-grid customers introduced a sense of energy injustice, and high vulnerability to regulatory changes.

The regulatory risk materialised when a new president took charge with a state-led development agenda. The new administration mandated a uniform tariff across the country, at the level of the national grid, slashing the mini-grid company's revenues by over 90 per cent. Cash-flow problems led to a decline in the quality of service, and exposed other vulnerabilities. These included poor corporate governance, lack of community engagement, and poor control over the Keymaker model activities of fish commercialisation and aquaculture. Some of these vulnerabilities were teething problems and a consequence of fast growth; others, such as regulatory risks, were harder to mitigate. Drawing from the experience of the implementation of the Keymaker model in Maisome, we outline four key recommendations for policymakers and developers in the mini-grid sector:

- **Set affordable tariffs for your customers**. Affordability of electricity is defined in three main ways, as ability to pay, willingness to pay, and cost as compared to other electricity supply alternatives, primarily the national grid. A preliminary survey to determine ability and willingness to pay can support tariff design, but developers should be wary of the dynamic character of WTP. When the service is not yet available, or at the start of operations, customers are typically willing to pay a high price for a high-quality electricity service they did not have before. But WTP evolves downwards as they take the new energy services for granted and compare the price they pay to the grid tariff (IED 2013). To account for this, developers should plan for a downward review of tariffs to get closer to the grid after a few years in operation.
- **Stay close to the political pulse of the country**. Undertake a political economy analysis to identify powerful actors and the interests they protect. Align with those actors supporting the universal and sustainable provision of high-quality electricity supply to rural areas. Engage with policymakers at the local, regional and national levels.
- **Do not underestimate the complexity of agro-processing activities**. Partner with local companies with a strong track record to mitigate this risk. Pursue simple agro-processing activities, such as fish trading, over fish farming, at least until the business model has been well tested.
- **Ensure a stable source of consumption subsidies** if required to bridge the gap between financial sustainability and affordability.

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Annexes

Annexe 1 Evidence of success in business model components in sub-Saharan Africa

Table A1.1 Summary of evidence of success in business model components in sub-Saharan Africa

Business model	Evidence of success	References
Ownership models		
Public utility model	The evidence is strong in suggesting that the role of the utility model is essential to provide electricity access to low-income communities. As a result, state-owned mini-grids are relatively common in sub-Saharan Africa (SSA). However, the insolvency of the public utilities in many SSA countries makes them unable to scale mini-grid projects effectively.	(AfDB 2016; ARE 2014; Bloomberg New Energy Finance 2020; ECREEE 2016; IED 2013)
Private model	The evidence is strong in suggesting that the role of the private sector is vital for achieving rural electrification. However, few initiatives have attained financial sustainability due to the lack of cost-reflective tariffs covering investment and operational costs. Access to subsidies or grants may enable the expansion of this business model. For instance, Kenya and Tanzania have incentivised the private mini-grid developer's participation in off-grid rural electrification.	(AfDB 2016; ARE 2014; Bloomberg New Energy Finance 2020; IED 2013; Knuckles 2016; Peters *et al.* 2019; Safdar 2017; Weston *et al.* 2018)
Community model	The evidence is strong in recognising the benefits of the community model. This model dominates development aid electrification projects. However, the literature is inconsistent on the sustainability of this business model. While some experiences suggest that fully funded projects are the only way to extend access to low-income communities, others indicate the significant challenge of donor dependency. In many rural areas of SSA, donors and NGOs operate community business models.	(AfDB 2016; ARE 2014; Bloomberg New Energy Finance 2020; Knuckles 2016; Safdar 2017)

Cont'd.

Business model	Evidence of success	References
Hybrid model	The evidence about the benefits of hybrid models is strong. In particular, the PPP structures can overcome the government's budgetary constraints, diversify the project risk between actors, and optimise the expertise and efficiencies of the private sector. The implementation of these models depends on a clear regulatory framework that enables private participation and guarantees the roles and responsibilities of both parties. For example, while Kenya and Tanzania actively promote the involvement of the private sector in hybrid mini-grid structures, Senegal promotes public ownership models.	(AfDB 2016; ARE 2014; Bloomberg New Energy Finance 2020; ECREEE 2016; ESMAP 2019; Franz *et al*. 2014; Peters *et al*. 2019; Safdar 2017; Weston *et al*. 2018)
Cost-recovery models		
For-profit	Weak evidence of the scalability of this business model. The low ability to pay for cost-recovery tariffs in rural areas challenges the viability of this model in SSA.	(Knuckles 2016)
Partially subsidised	Strong and consistent evidence of the need for subsidies to guarantee competitive tariffs and ensure the continuous operations of mini-grids. Approaches that involve the public sector as a stakeholder in mini-grid projects allow implementing cross-subsidised tariffs. In Nigeria, the results-based subsidies provide payments per number of connections achieved.	(Knuckles 2016)
Fully subsidised	Strong evidence about the need for subsidies, but inconsistent evidence about the required level of subsidisation. While financial support may allow the application of affordable tariffs, the fully subsidised models challenge the developer's autonomy and set a dependency on the donor.	(Knuckles 2016)
Revenue-generation strategies		
ABC model	Strong and consistent evidence of the ABC model as the most promising approach to financial sustainability. Experiences with telecom and agro-processing industries have shown that the model works. However, the lack of availability of large businesses in rural areas may limit the scalability of this model in SSA.	(AfDB 2016; Energy and Environment Partnership 2015; ESMAP 2019; Franz *et al*. 2014; Knuckles 2016; Ogeya *et al*. 2021; Safdar 2017; Weston *et al*. 2018)

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Business model	Evidence of success	References
Households and small businesses	Weak evidence to demonstrate that a customer focus on households and small businesses can achieve financial sustainability in the long term. However, many authors suggest integrating productive users into the load to improve the business model's viability.	(AfDB 2016; Bloomberg New Energy Finance 2020; Knuckles 2016)
Keymaker model	JUMEME, under guidance from INENSUS, set up a Keymaker model around Tilapia fish trading in a mini-grid on Ukara island, Lake Victoria, Tanzania. The model was initially successful and generated a financial margin that exceeded the revenue generated by electricity sales in the mini-grid. However, as this report shows, a change in the national regulatory framework jeopardised the success of the project. There is therefore no proof of the model being viable and scalable.	(Bloomberg New Energy Finance 2020; Peterschmidt 2019)
Implementation models		
Clustering approach	This model establishes opportunities for economies of scale. However, the literature indicates the need for strong managerial and operational skills to succeed, limiting its scalability capacity in SSA. There is as yet no evidence that this model is viable and ready to be scaled up.	(Safdar 2017)
Operational bundling	Weak and inconsistent evidence.	(Weston *et al*. 2018)
Franchise approach	Weak and inconsistent evidence.	(Safdar 2017)
Portfolio diversification	The lack of examples of success in the literature limit the ability to conclude on the scalability of the model in SSA.	(ESMAP 2019; Weston *et al*. 2018)

Annexe 2 Key performance indicators

Table A2.1 Summary of key performance indicators

Research objective	Metrics		Closing target	Final result
1 Promote women's economic empowerment through the productive use of energy	1a	Input: Number of awareness-raising campaigns in the community about the opportunities to use electricity productively	> 2 awareness campaigns	TANGSEN had several meetings with village leaders and entrepreneurs to raise awareness about PUE Aida to raise awareness about the need for cost-recovery tariffs for sustainability
	1b	Input: Number of champions selected to promote productive activities identified among women	2 champions	5 women leaders of women's business group, constituted in April 2022: Veneranda Abdon, Adelina Dioniz, Hilder Kamugisha, Cecilia Francisco, Neema Abdon
	1c	Input: Number of men and women attending awareness campaigns involved in technology transfer mission for the PUE	At least 40% women representation	This goal was achieved in the meetings held
	1d	Input: Number of training sessions and FGDs held (business and technical)	4 activities	– Training for preparation of business plans and identification of PUE activities – Training for women tailors – Training and mentoring for Ms Kalunde ahead of her business start-up – Business development training
	1e	Output: Number and share of men and women in the Keymaker activities supply chain	7:3 Men to women ratio in Keymaker model	The goal has been achieved. Women have been donated freezers to become fish traders, one woman is going to start a fish food production business, and several women farmers will supply her with grain and sardines

Cont'd.

Research objective		Metrics		Closing target	Final result
		1f	Output: Quality of roles of men and women involved in the Keymaker activities supply chain	At least 4 women take roles within the fishing value chain as part of the model	Roles taken by women, as described above, are profitable, with the donation of productive equipment
		1g	Output: Number of enterprises owned by men and women per sector of activity	218 enterprises. 31% female-owned businesses	114 were identified in our baseline census. The number of enterprises has grown to 218, exceeding initial expectations
2	Viability of the gendered Keymaker business model for mini-grids supporting rural electrification scale-up	2a	Input: Number of partnerships created to support enterprises in different capacities	2 partnerships	Partnership with SIDO for training of tailors JUMEME partnering with organisations to start and learn the aquaculture business
		2b	Output: Number of electric appliances in men's and women's enterprises	46	There were 36 appliances at the baseline. We provided 6 women tailors with electric machines, and introduced freezers, and high-capacity millers and pelletiser for fish food, so the number of appliances has increased. The increase was not as high as we anticipated, because no new productive connections were granted
		2c	Output: Number of small loans acquired by enterprises supported to purchase business electrical appliances	0	No loans were provided, as the project did not have the management structure and length to establish a lending operation
		2d	Output: Number of men- and women-run enterprises connected to electricity	157	87 businesses were connected at baseline. Of the 218 enterprises identified in the census, 72% are connected to the mini-grid
		2e	Output: Mini-grid capacity utilisation factor	Capacity utilisation factor of 9% at endline	The capacity utilisation factor decreased from 10% at baseline to 9% at endline

Cont'd.

Research objective		Metrics		Closing target	Final result
		2f	Output: Number of electrical appliances in use by enterprises	90% of appliances still in use after 1 year	n.a.
		2g	Output: Electricity consumption per enterprise	Electricity demand from commercial customers increased from 190kWh to 572kWh	With the imposed low tariffs, demand has risen, but at the same time, restrictions on consumption have been implemented
		2h	Output: Number and duration of outages	Restrictions on supply and outages	Based on the lower tariffs, restrictions on supply have been imposed. Customers also report multiple power outages
		2i	Output: Viability gap between cost-recovery tariffs and actual (average) tariff	Not achieved	Mini-grid operators have been mandated to apply the national tariff, hence they cannot close the viability gap with cost-recovery tariffs at the moment
3	Poverty reduction and increased standard of living in the community	3a	Output: Average increase in enterprise income	Average income decreased	The pandemic and the electricity supply problems make incomes unlikely to increase. As a result, the average income in the high season decreased by 21.7%, and 3.8% during the low season
		3b	Output: Increased number of enterprises with improved access to services, appliances provided by partners	10 in addition to JUMEME's transfers to the community	Appliances provided: 7 tailoring machines 5 freezers 1 milling plant 1 fish food equipment 1 pelletiser
		3c	Output: Number of men and women employed by enterprises supported	10, with at least 70% being women	At least 7 women tailors and 5 women fish traders, so the goal has been achieved

Table A2.2 Cross-cutting research aspects

Research objective		Metrics		Closing target	Final result
1	The project will improve energy access for more people and will substitute other energy sources	1a	Change in number of people with access to electricity source that is provided through the project	No change	New connections were stopped due to tariff reduction
		1b	Average usage hours of the electricity source provided through the project	4 hours per day	n.a.
		1c	Average usage hours of the electricity sources other than the one provided through the project	2 hours per day	n.a.
		1d	Hours of uptime of electricity source provided through the project	18 hours per day	Availability of electricity has decreased from 24 hours per day to 18
2	The project will increase the number of beneficiaries that benefit from productive use activities	2a	Number of entities (businesses, households, etc.) that received productive use appliances	Only the 10 detailed above plus JUMEME	7 tailors, 5 fish traders, 1 fish food production, plus aquaculture equipment for JUMEME
		2b	Number of appliances distributed	Over 15	
		2c	Number of beneficiaries[13] directly benefiting from productive use products and services	Customers could include all the village	A total of 157 businesses were using electricity from the mini-grid. Besides, 15 businesses had received support from the project, or from JUMEME to purchase productive electric equipment
3	The project will increase the number of businesses	3a	Number of businesses created	4 additional businesses	Goal partially met

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13 To be defined for each project what a beneficiary should be (e.g. micro-entrepreneurs and their families as well as customers buying the products).

Research objective		Metrics		Closing target	Final result
4	The project will create more long-term jobs	4a	Additional permanent jobs[14] created on energy provider/ productive use company level	3 from the start of the project	These are at JUMEME's company level
		4b	Additional temporary jobs[15] created on energy provider/ productive use company level	4 from the start of the project	
		4c	Additional permanent jobs created on beneficiary level	2	The prospective jobs are taking very long to materialise, as they will come from the fish food operations
		4d	Additional temporary jobs created on beneficiary level	2	These include jobs for construction of the structure for Ms Kalunde
5	The project will enhance revenues of beneficiaries as well as project partners	5a	Change in average revenue of beneficiary	+0% from baseline	Average revenue of businesses in Maisome has decreased both in high and low seasons
		5b	Change in average revenue of productive use company	+0% from initial dataset	Average revenues have not increased for productive users
		5c	Change in average revenue of energy provider	+0% from initial dataset	Revenues have decreased 90% from the baseline. From 3,871,790 TSh to 569,698 TSh
		5d	Change in average revenues of employees/ partners	+0% from initial dataset	Average revenues have not increased
		5e	Average estimated LCOE reduction demonstrated by project, either through decreased costs or increased revenue	-0% from initial dataset	No significant changes, as OPEX has reduced, but generation as well

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14 'Permanent job' is defined as any kind of job that lasts for at least one month and the person hired did get a monthly salary.

15 'Temporary job' is defined as any kind of job that did not consecutively last for one month and the person hired did not get a monthly salary.

Research objective		Metrics		Closing target	Final result
		5f	OPEX	n.a.	The OPEX decreased, as JUMEME could no longer afford to use the diesel generator due to the tariff reduction
		5g	CAPEX	No extension is planned (CAPEX=0)	
6	Productive use applicants will increase consumption of electricity	6a	Average estimated consumption increases per month per connection	No increase due to tariffs well below cost recovery	Although demand for electricity has increased, the low tariffs have made it impossible for the mini-grid to match with a reliable supply
7	The project will enhance co-funding	7a	Additional private sector co-funding received	JUMEME £232,001.6	
		7b	Additional public sector co-funding received	None	There is an expectation that the district will provide funding to women entrepreneurs in Maisome
		7c	Number of private sector investors entering the PUE financing sector	1-2	RP Global entered as majority shareholder in JUMEME but is now planning its exit
		7d	Number of public sector investors entering the PUE financing sector	0	
8	The project will enable innovative business models and technologies	8a	Number of new innovative business models tested	1	Keymaker model tested
		8b	Number of technologies prototyped and/or demonstrated	1	Aquaculture technologies tested

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Research objective		Metrics		Closing target	Final result
9	The project will enable new and enhanced partnerships	9a	Number of new partnerships formed and lasting beyond PREO funding	2	Aquaculture partnerships broke down
		9b	Number of new companies or initiatives created as a result of partnership	1	Aquaculture business by JUMEME, fish trading activities, fish food production
10	The project will empower and enhance ratio of women engaged in PUE activities	10a	Change in number of women engaged in PUE activities on beneficiary level	At least 30% of entrepreneurs supported	Tailors, fish food production, fish traders, women farmers
		10b	Change in number of women engaged on energy provider/ productive use company level	2 from baseline	JUMEME has hired a woman chief executive officer, and there are several women entrepreneurs supported by the project
11	Carbon emissions	11a	Cut carbon emissions and pollution from petrol/diesel conversion[16]	No carbon emissions inventory done	Improvement due to no use of diesel generator
		11b	Cut carbon emissions and pollution from new electrification	No carbon emissions inventory available	Millers switching from diesel to electricity would have reduced emissions, but these have not been measured

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16 According to the **Clean Energy Emission Reduction Tool** calculation methodology.

Annexe 3 Interviewees

Table A3.1 Interviewees at baseline

No.	Name of interviewee	Area of engagement	Sex
1	Anastazia Nyangi Magoma	Sardine boat owner	Female
2	Veronica Ncheiye	Purchaser and seller of sardine	Female
3	Magaye Masolo	Cold bin owner and agent of car owner fish sellers	Male
4	Alex Japhet Mathayo	Boat and bin owner and also agent of car owners	Male
5	Elias Jackson Tahond	Bin owner	Male
6	Herrieth Elias	Cook in the fishing camp	Female
7	Isack Ongubo	Sardine fisherman	Male
8	Shida Faustine	Restaurant – fry fish and sale	Female
9	Restituta Masuka	Fish smoker and seller	Female
10	Peter Madaraka	Fish wholesaler	Female
11	Joseph Peter	Fish camp supervisor and seller of Nile perch	Male
12	Samwel Everist	Fisherman	Male
13	Lazaro Michael	JUMEME Keymaker model supervisor	Male
14	Grace Sumela	Ice business	Female
15	Mr Abinnony	Boat manufacturer	Male
16	Lazaro Simon	Fisherman	Male
17	Marium Kisaka Makoye	Seller	Female
18	James Mbugi Mwachai	Boat owner, bin owner, wholesaler	Male
19	Prisca Dotto	Cook in fishing camp	Female
20	Marium John Lucas	Restaurant – fish fryer	Female
21	Emelda Visent	Seller	Female
22	Elia Deocratius Raphale	Seller	Male
23	Cecilia Francisco	Seller	Female
24	Kalunde	Keymaker model presumed feedstock manufacturer	Female
25	Sarafina Lameck Tungaraza	Supplier of Tilapia to JUMEME	Female
26	Davide Ceretti	JUMEME project director and Cluster II manager	Male
27	Onesmo Daudi	Maisome ward officer	Male
28	Uhuru Zagalaza Manyaga	Fishery officer in Maisome	Male
29	Amina Mwezi Ramadhan	Fish processor in Mwanza	Female
30	Amina Liwanda	Fish processor in Mwanza	Female
31	Grace Emmanuel	Fish processor in Mwanza	Female

Table A3.2 Interviewees at endline

No.	Name of interviewee	Area of engagement	Sex	PUE status
1	Restituta Masuka	Fish selling (fresh, smoked, and fried)	Female	Freezer owner
2	Cecilia Francisco	Micro-business selling cassava, sweet potatoes, green potatoes, sardines	Female	Freezer owner
3	Adelina Dioniz	Tailoring	Female	Tailoring
4	Neema Abdon	Currently housewife but previously was frying fish	Female	Freezer owner
5	Derick Sabastian Mkolo	Barber shop	Male	Other entrepreneurs
6	Domitila Crispin	With their husband collecting fish and owning the milling machines	Female	Freezer owner
7	Gidion Jonas	The motorcycle spare workshop, welding, laboratory microscope for testing malaria	Male	Potential entrepreneur
8	Grace Alex	Small businesses, selling ice cream, juice and clothes	Female	Potential entrepreneur
9	Kalunde Joseph Masanja	Previously an employee of the government fishing training centre, currently owning shop mainly selling cereals, agriculture for horticultural crops	Female	Owner of the fish feed production machines
10	Lazaro Michael Matesi	Milling machines	Male	Milling machine owner
11	Pamela Daniel Kiriko	Restaurant	Female	entrepreneurs
12	Eliudi Samweli Misana	Busikimbi chairman	Male	
13	Tyson Lwelenja Aspo	Kanoni village chairman	Male	
14	Zuberi Yahaya Zabaga	Kisaba village chairman	Male	
15	Ahamed Rajab, Mussa Kayombo	JUMEME staff	Male	
16	Lazaro Michael	Village Energy Committee chairman and JUMEME staff in Maisome	Male	
17	Mikaya Furaha Masanyi	Poultry and owner of chick incubator	Male	Potential entrepreneur
18	Victor S. Labaa	EWURA senior engineer – renewable energy	Male	
19	Hilder Kamugisha	Tailor (beneficiary of the embroidering machine and training at SIDO)	Female	

No.	Name of interviewee	Area of engagement	Sex	PUE status
20	Veneranda Abdon	Tailor (beneficiary of the embroidering machine and training at SIDO)	Female	
21	Staff JA	JUMEME general manager	Female	
22	Staff JN	JUMEME director	Male	
23	Staff JD	JUMEME ex-project director	Male	
24	Staff JR	JUMEME ex-head of marketing and sales	Male	
25	Staff JL	JUMEME staff in Maisome	Male	

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