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Community ownership models for decentralised renewables in the global south: a review and research agenda

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ABSTRACT

Community ownership models for decentralised renewable energy (DRE) have been applied in various contexts across global south countries. However, their characteristics, effectiveness and limitations remain understudied. Understanding these ownership models is of interest in the context of bridging the persistent electricity access gap in the global south, particularly present among remote populations, and the imperative to achieve Sustainable Development Goal 7 by 2030. This study addresses this research gap through a scoping literature review and expert interviews. The findings shed light on the diverse definitions of community ownership in the context of decentralised renewables in the global south and on experiences of applying community ownership models in the global south, and identify four recurring themes: regulation, financing, roles and power, and capacities and skills. Through the lens of the multi-level perspective, we discuss the implications of our findings for energy access, socio-economic development policies and initiatives, and research.

Keywords

Community ownership models;
Decentralised renewable energy;
Rural electrification;
Energy access;
SDG7

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1. Introduction

Despite global efforts, a significant energy access gap persists in the global south, particularly in Sub-Saharan Africa (SSA) which accounts for 85% of the global population without electricity. Comparably, Asia, Latin America and the Caribbean reduced the electricity access gap steadily within the past years but still lack electricity for remote populations [1]. This persistent gap stems from interconnected challenges such as financial constraints, limited renewable energy technology development, and a lack of effective policies [2, 3]. Addressing these barriers is critical, as expanding the share of renewable electricity in the total electricity production is expected to serve as a driver of economic development [2].

Sustainable Development Goal 7 (SDG 7) which calls for affordable, reliable, sustainable and modern energy for all by 2030 underscore the region's ambitions. However, current projections indicate that SDG 7 will not be reached by 2030 [1] and that, under a Business as Usual scenario, there will still be 660 million people without access to electricity in 2030 (560 of which in SSA) [4]. The International Energy Agency (IEA) notes that approximately 135 million new electricity connections are required annually to meet the 2030 target.

Decentralised renewable energy systems (DRE), such as mini-grids and standalone solar solutions, offer a cost-effective and scalable pathway to addressing this challenge, particularly for rural and underserved communities [1]. These systems may be owned and managed by private companies, public utilities, local governments, communities, or a combination of the above. Community engagement and participation in DREs has been researched in depth globally and is commonly recognized as one key aspect for sustainable renewable energy interventions [5-8]. Non-involvement or passive involvement of the community and provision of too little information of the technology implemented to the

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List of Abbreviations

CBOs	*Community-based Organisations*
DRE	*Decentralised Renewable Energy*
EU	*European Union*
MHP	*Micro Hydropower*
SSA	*Sub-Saharan Africa*
SDG 7	*Sustainable Development Goal 7*
VEC	*Village Electricity Committee*
MLP	*Multi-level perspective*

community limits the success of renewable energy interventions [6, 7]. However, community engagement should be clearly distinguished from community ownership. While full community participation involves the aspect "sense of ownership" [6], community ownership implies a more formalised role in governance and financial control.

Whether such ownership models flourish, however, depends on the broader policy and market context. One key factor influencing the success and adoption of community-owned renewable energy models is the alignment of political frameworks and market support systems with such initiatives. When these frameworks favour larger projects or corporate entities, community-owned models face significant disadvantages, reducing their likelihood of success [12]. Additional challenges include limited access to start-up financing, gaps in community skills, and issues surrounding land ownership rights [11]. However, studies examining the impact of community ownership in renewable energy projects across Denmark, Austria, and Scotland highlight significant benefits, including increased citizen participation, greater acceptance of renewable energy initiatives, and enhanced community empowerment [11, 15, 16]. Stable energy policies and support during the operational phase are needed to keep up the stream of renewable energy income that functions as a source of independent income and thus reduces the community's vulnerability [16].

Among the many forms of ownership, community ownership models are of interest in the context of bridging the existing electricity access gap and have played an important role in the energy transition of economies in the global north and south[1]. While no strict definition exists, community ownership models are generally characterised by the fact that users and local stakeholders own the system fully or partly and have voting rights or a certain quantity of stakes [9]. Legal forms in the community ownership model may be co-operatives, community trusts, or housing associations, among others. They may also take the form of partnerships with municipalities, and private or public energy utilities.

In the global north, community ownership models of decentralised energy are relatively well studied in literature [10-12]. Much of the literature regarding the characteristics and impacts of community ownership models is based on studies in the context of Energy Communities in the European Union (EU), which emerged thanks to supportive policy frameworks, such as the EU's Clean Energy Package [13]. Research in the EU context, as well as in the United States and Australia, revolves around many topics, including definitions, access to finance for community owned models, governance, the impacts on social equity [18, 10-12].

In contrast, the body of literature analysing community ownership models in the global south is significantly smaller, despite the existence of specific cases in operation today, and the past experience of relatively large-scale national programmes that promoted community ownership models for mini-grids in the past, for instance in Indonesia [17], Thailand [18], and Nepal [19]. Given the urgent need to expand sustainable, affordable electricity access, particularly in the global south, strengthening research on how these community-based arrangements can be adapted, replicated, and integrated into mainstream electrification efforts is critical if they are to move from promising local experiments to standard practice.

While scholarship in the global north, particularly Europe, shows growing interest in how community ownership models can be scaled, replicated and diversified [20-23], comparable research focused on the global south remains limited. The aim of this paper is therefore to understand how community-ownership models can be adapted, replicated, and integrated into mainstream electrification efforts in low- and lower-middle-income settings, progressing from local experiments to standard practice. Rather than exploring detailed replication strategies, we begin by identifying the factors that are crucial to the upscaling process for community-ownership models.

To meet this aim, the study pursues three main objectives:

1. Elaborate on how community ownership is defined and conceptualised for decentralised renewable energy (DRE) in the global south. In many global north settings (for example the EU's support for Energy Communities) community ownership is specified in policy and law; in the global south the term is used more loosely and informally. Without a shared working definition, evidence from different contexts cannot be compared or used to guide replication at scale.
2. Catalogue existing country-level experiences with community-owned DRE systems.
3. Analyse the key drivers of success and persistent barriers to their diffusion, translating these insights into actionable recommendations for policy and practice to help close the energy-access gap.

The remainder of this section is organised as follows. Section 1.1 reviews the existing research landscape on community ownership models in the global south. Section 1.2 introduces the theoretical framework (socio-technical transitions, multi-level perspective, and strategic niche management) that informs our analysis. Section 2 then presents the methodology, including the scoping literature review and expert interviews. Section 3 reports the results: we synthesise definitions of community ownership, provide a non-exhaustive set of country experiences in the global south, and analyse four recurring themes in the literature and interviews. Section 4 discusses the implications of the results towards our research aim and what it means for policy, practice and future research. Section 5 concludes this study.

1.2 Existing Research

Existing scholarship on community ownership in the global south remains largely confined to single-country investigations that offer detailed but highly localised insights. Well-documented examples include Nepal's programme of community-managed micro-hydro plants, Thailand's micro-hydro cooperatives established with support from the Department of Alternative Energy Development and Efficiency, and Indonesia's NGO-facilitated village hydro schemes (see Section 3.2). Comparable depth is evident in studies of West Bengal's solar mini-grids and Tanzania's LUMAMA utility, yet each of these analyses is focused on one national context and one technology. As a result, the evidence base is fragmented, and lessons drawn from one setting are difficult to generalise elsewhere.

Broader reviews are available, but few examine ownership as a discrete variable. Holstenkamp, for instance, surveys rural-electrification cooperatives worldwide but touches only briefly on how legal form influences long-term viability [24]. Koirala et al. discuss "energetic communities" across multiple regions without separating ownership from participation [25], while Ambole et al. identify common barriers in Sub-Saharan Africa yet blend privately run, NGO-managed and community-managed projects, leaving the ownership dimension underexplored [26].

To overcome these limitations, our review examines community-owned initiatives across a range of socio-political and cultural settings and asks how those settings shape both the form and the performance of ownership models observed. Particularly, by mapping each case onto a common decision-power–benefit spectrum of definition and interpreting the patterns through the multi-level perspective, the study distils lessons that are broadly applicable. These transferable insights support our broader aim of identifying the conditions under which community-ownership models can be adapted, replicated and ultimately integrated into mainstream electrification strategies in low- and lower-middle-income countries.

1.3 Theoretical Framework

The multi-level perspective (MLP) is one of the most widely used frameworks in sustainability-transition research [27] and is adopted here to identify the factors that enable community-owned DRE initiatives to move from scattered local projects to forms that can be replicated and integrated into mainstream electrification. The MLP is an analytic heuristic that renders complex transition processes more tractable by distinguishing three nested analytical levels: landscape, regime and niche (Figure 1).

The landscape comprises slowly changing external structures such as physical geography, prevailing cultural values and long-term economic trends. These factors lie largely beyond the direct influence of actors within the energy sector, yet shocks or gradual shifts in the landscape can filter down to affect activities at lower levels. The socio-technical regime consists of the dominant practices, rules and institutions that coordinate technological, policy, market, scientific and socio-cultural subsystems. Lock-in created by sunk investments and vested interests means that change at the regime level tends to be incremental and path-dependent [28]. Niches are relatively

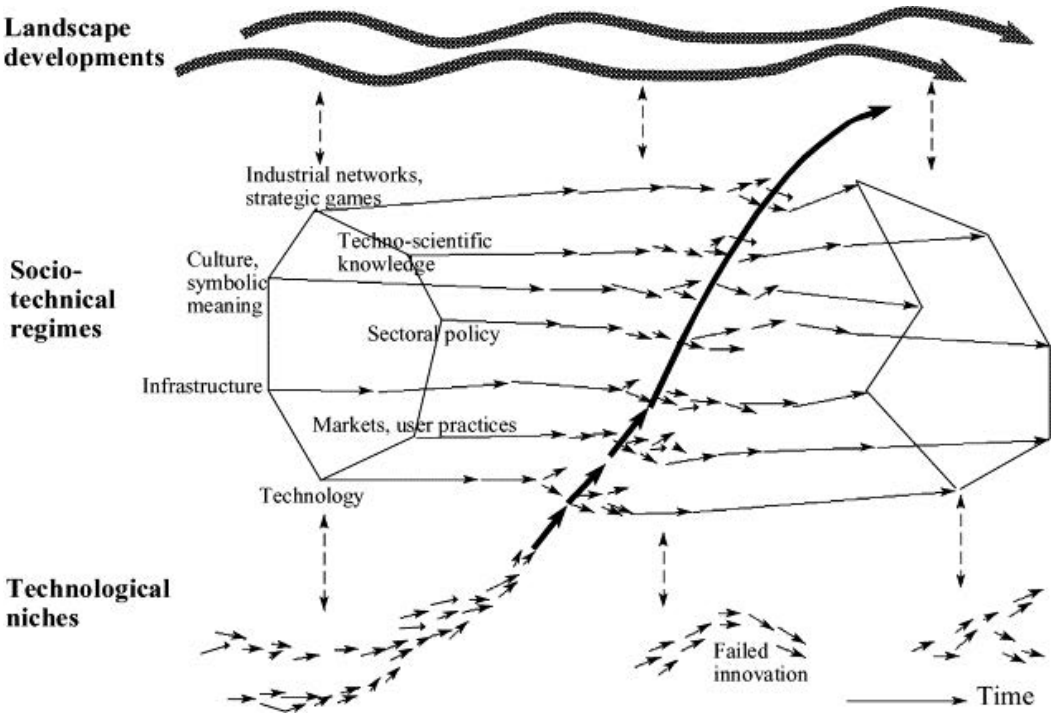

Figure 1: Dynamic multi-level perspective on technological transitions [27].

protected spaces in which novel socio-technical configurations, such as community ownership models for DRE systems, can be tested. They provide arenas for experimentation, learning and network building. Innovations that originate in niches can move through stages of emergence, stabilisation, diffusion and eventual institutionalisation, although success in reshaping the regime or landscape is never guaranteed.

The three levels respond to change at different speeds. Niches are the most dynamic and uncertain, regimes are more resistant to alteration, and landscapes change only slowly. Nevertheless, feedback operates in both directions: landscape developments influence regime and niche activities, while sustained niche progress can create pressure for adjustments in the higher layers [27].

Given our research aim, MLP offers a structured way to examine the factors that are most critical to replicating and integrating community ownership models into mainstream electrification in low- and lower-middle-income settings. MLP highlights where those factors sit in the wider socio-technical system and how they interact. In the MLP, transitions occur when developments at the three levels align so that novelties emerging in protected niches can enter mainstream markets and compete with existing regime practices [29]. Mapping our empirical findings onto these levels therefore clarifies how community-owned DRE can move from local experiments to routine elements of national electrification strategies. Moreover, the field of Strategic Niche Management (SNM) is also in understanding how niches can be protected and appropriately built, so that they can trigger broader socio-technical transitions [30].

Nevertheless, it is important to consider the limitations of applying socio-technical transition frameworks in the context of developing countries. Scholars have highlighted issues such as differing interpretations of sustainability, fragmented and less technology-bound regimes, and a strong presence of informal institutions [31-32].

2. Methodology

To examine existing experience and the perceptions of experts regarding community ownership models for DRE in the global south, we use two complementing methods: a scoping review and a series of semi-structured interviews with key informants (Figure 2).

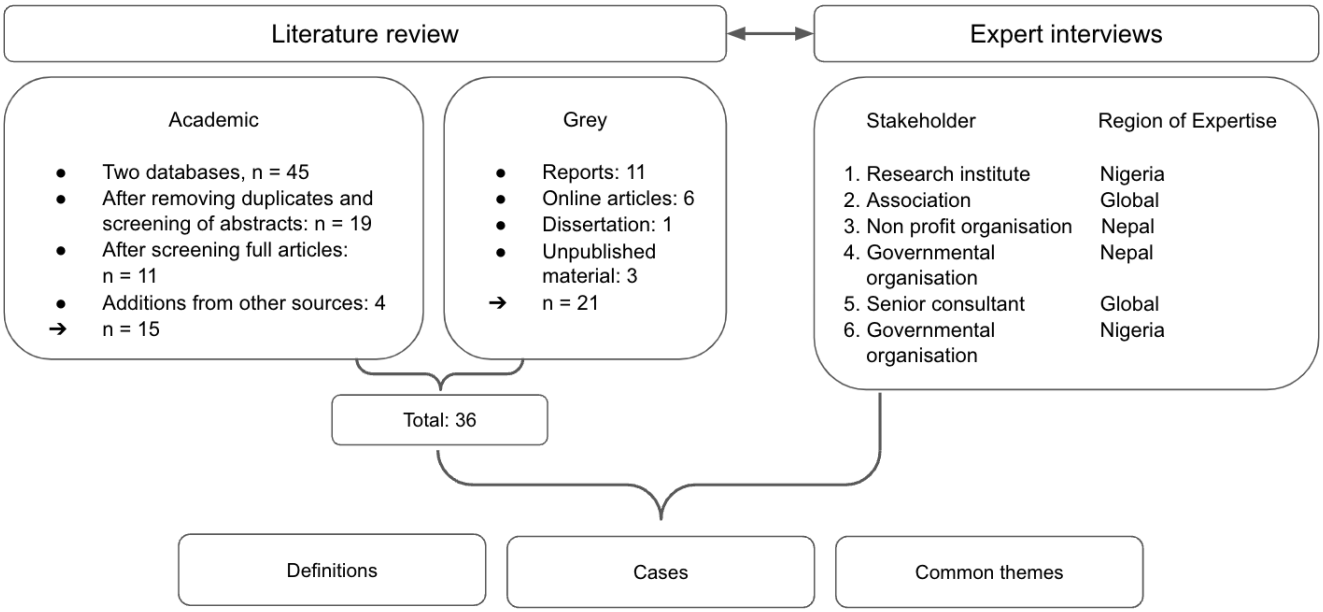

Figure 2: Overview of the methods.

2.1 Scoping Review

This scoping review followed the five-step methodological framework suggested by Arksey and O'Malley [33].

Step 1: Identifying the Research Questions

The following research questions guided this scoping review:

1. How does the research community define community ownership in the context of decentralised renewable energy in a global south context?
2. To what extent have community ownership models for decentralised renewable energy systems been tested in the global south?
3. What are the main barriers and drivers for the development of community ownership models for decentralised energy in the global south?

Step 2: Identifying relevant studies

We searched two databases: ScienceDirect and Web of Science. The searches were performed on 26 November 2023 and 02 October 2023 and targeted the title, abstract, and keywords, without a time limit. We used two search strings:

1. (Decentralised electricity OR Mini grid) AND (Community ownership OR Cooperative ownership OR Cooperative) AND (global south OR Developing countries OR Africa)
2. (Community ownership OR cooperative) AND (Energy access OR SDG7)

The search strings cover the three components: technology, ownership model, and geographical scope. The terms "community ownership" and "cooperative" were chosen as they are commonly used in theoretical and applied studies as well as policy discussions in the global north and south, thus providing a solid foundation to explore the topic. This resulted in 45 academic articles.

Step 3: Study selection

The review includes literature that discusses community ownership specifically, in the context of DRE systems in the global south, i.e. countries that were either low- and lower-middle-income countries during the time period that the research referred to. We screened the titles and abstracts of the records retrieved under Step 2 to exclude those that did not fit these inclusion criteria. After eliminating duplicates and initial screening, the full texts were imported in Zotero reference manager for eligibility screening and to streamline the review process. During the process of reviewing papers, we added four more articles that were cited and that fulfil the eligibility criteria.

Table 1: Overview of included academic literature.

No.	Author	Year	Description	Publication source
1	Holstenkamp	2019	A literature review on the cooperative ownership model in sustainable electrification in the global South	Renewable and Sustainable Energy Reviews
2	Duran and Sahinyazan	2021	A review of 104 renewable mini-grid projects for rural electrification installed across the globe	Socio-Economic Planning Sciences
3	Bhandari et al.	2020	Analysis of the impacts of collaborative consumption and community ownership on willingness to pay for solar PV electricity in rural Niger	Renewable Energy
4	Yadoo and Cruickshank	2010	A review of various rural electrification delivery models with a detailed case study of a Nepali rural electric cooperative	Energy Policy
5	Dall-Orsoletta et al.	2022	A systematic literature review to identify impacts of social innovation and bottom-up initiatives on sustainable energy transitions	Energy Research & Social Science
6	Bertheau et al.	2020	Identification of implementation risks faced by the Romblon Electric Cooperative in installing one of the Philippines' first off-grid, hybrid energy system in the small and remote island of Cobrador	Environmental Innovation and Societal Transitions
7	Sovacool	2013	A qualitative factor analysis of renewable energy access programs in the Asia-Pacific	Energy Policy
8	Katre and Tozzi	2019	An investigation of the role of power to establish and govern long-lasting community-owned DRE systems in remote India	Energy Research & Social Science
9	Poudel et al.	2021	Qualitative assessment of factors influencing the performance and sustainability of micro-hydro projects in Nepal	Renewable and Sustainable Energy Reviews
10	Katre et al.	2019	Sustainability assessment of 24 community-owned solar mini-grids in India	Energy Sustainability and Society
11	Kirchhoff et al.	2016	Identification of success factors for microgrids supplied by renewable energies derived from case studies of microgrids in the Global South and in communities of Germany	Journal of Cleaner Production
12	Ahlborg and Sjöstedt	2015	A qualitative case study on the NGO-led implementation of a small-scale off-grid hydropower system in Tanzanian villages	Energy Research & Social Sciences
13	Ambole et al.	2021	A systematic review of research on energy communities in 46 countries in Sub-Saharan Africa	Sustainability
14	Guerreiro and Botetzagias	2018	An assessment of the impacts of community-owned renewable energy projects and identification of the internal and external drivers and barriers to their success through an exploratory case-study approach of two community micro-hydro projects in Indonesia.	The International Journal of Justice and Sustainability
15	Rospriandana et al.	2023	A historical review of small hydropower projects in Indonesia.	Energy, Sustainability and Society

After the screening process, 15 academic articles were considered relevant for inclusion in the analysis (Table 1).

We complemented the academic literature by non-systematic searches from grey literature from databases and resource libraries of multilateral research, finance, and development institutions, blog posts, and material recommended by the interviewees, as well as google searches. This resulted in 21 additional resources.

Step 4: Data charting process

Based on the literature selected, we conducted an in-depth qualitative thematic analysis to extract and categorize key information, aiming to address our research questions comprehensively. This process was organised into two primary phases. First, we developed a structured Excel database to systematically capture relevant information from each paper. The database was designed with four broad categories:

1. Definitions of community ownership: If and how community ownership is defined within the context of each study.
2. Practical applications: Instances where community-owned models for DRE have been implemented in the global south.
3. Drivers of success: Factors contributing to the success of community-owned DRE models in the global south.
4. Barriers to implementation: Challenges hindering the effectiveness of these models.

Each paper was thoroughly reviewed, and relevant information was extracted and entered into the corresponding categories in the database. In a second step, the research team convened for an in-person workshop aimed at synthesizing the extracted data. Data entries were collaboratively analysed to identify recurring patterns and themes. Through iterative discussion, the team identified four central themes emerging from the data: regulation, financing, roles and power, and capacities and skills.

Step 5: Summarising results

The scoping review resulted in 15 academic papers and 21 resources from grey literature. The thematic analysis process shed light on the diversity of definitions of community ownership in the context of decentralised renewables and revealed four main recurring themes, as described in Step 4. These were classified and discussed through the lens of the MLP.

2.2 Expert interviews

2.2.1 Selection of interviewees

To gather a range of views and cover key experiences and perceptions, we conducted six semi-structured interviews with experts that have experience in the management of programmes promoting community ownership models in decentralised renewables in the global south, or who had researched them (Appendix 1). This mix ensured that the study captures both detailed, first-hand accounts from those directly involved and analytical perspectives from those who have studied the processes in depth. We followed a snowball sampling strategy to identify relevant interviewees. The initial list of three interviewees was based on desk research and was supplemented by interviewees who referred to other actors relevant to our study. This allowed us to gain access to key individuals who were not considered at the initial stage of the research.

2.2.2 Data collection

The interviews were conducted online between November 2023 and June 2024. All conversations were recorded and guided by an interview guide. The interview guide reflected the research questions to be answered and was informed by an initial literature review.

2.2.3 Data analysis

All interviews were transcribed using a voice-recognizing tool and were reviewed by the research team. We applied a thematic analysis to identify, analyse, organise and describe themes that were found within the data set.

2.3 Integration of methods

We integrated the research findings from both methods by identifying common themes between the findings from the literature review and the qualitative interviews. This combination helps to get a richer understanding of the topic and to include different perspectives. The triangulation of multiple data sources increases the validity of the research findings [34].

3. Results

This section presents the empirical findings in three steps. Section 3.1 synthesises how the literature and interviewees describe community ownership, positioning each case on a continuum that ranges from “soft” benefit-sharing arrangements to “hard” legal ownership.

Section 3.2 catalogues past and current applications of these models across the global south, illustrating the breadth of experience through eight country examples. Section 3.3 distils four cross-cutting themes: regulation, finance, roles and power, and capacities and skills, all of which recur across the literature and interviews and help explain both successes and failures. Together, these results provide the foundation for the discussion that follows.

3.1 Defining community ownership

The diversity in ownership structures and the varying interpretations of ownership across different contexts have led to the absence of a single, concrete definition for community ownership models in DRE [24]. This lack of a standardised definition poses an obstacle in evaluating the extent to which they have been tested in the global south [35] and how they might be replicated. Our examination of the academic literature sheds further light on this issue. We found no instances in the academic literature reviewed where an explicit definition of community ownership is given, and only a few instances in the grey literature [36, 37]. The literature implicitly defines community ownership by discussing various components that characterise them (e.g. legal ownership, control, voting rights, formal or informal community-based organisation). Taken together, these components cluster around two main dimensions: community decision power (the extent of formal control over assets and governance) and community benefit (the extent to which revenues or other benefits accrue locally). Notably, we observe from the literature that the discussion of these models unfolds along a spectrum of "hard" and "soft" definitions of community ownership, a distinction also noted by one of the interviewees [Personal communication, 20 October 2023].

A "hard" definition of community ownership can be understood as one where the communities hold legal ownership of the assets for generation, transmission and distribution, wholly or partially (high decision power) and capture the financial flows linked to system performance (high benefit). While none of the literature analysed explicitly defined community ownership along these lines, we find that the characteristics of the models they described aligned with this "hard" definition. Eight papers from the academic literature included in our study mentioned community ownership as communities owning the infrastructure [19, 24, 38-43]. Most of them discussed community ownership through a cooperative structure, where "the people who receive power from the infrastructure, own the infrastructure itself" [Personal communication, 7 November 2023]. Cooperatives function on a one-member, one-vote basis, promoting equal participation and benefiting from self-regulatory forces derived from direct accountability to their customer base [19, 44].

Nevertheless, achieving a "hard" definition of community ownership does not solely rely on a cooperative approach. For instance, in Tanzania's LUMAMA minigrid, a non-profit community-based local utility was established and owned the assets [38]. In other cases, informal community organisations governed by constitutions or by-laws own and manage the systems [43]. Therefore, we observe that a "hard" definition of community ownership can encompass various organisational structures, provided they ensure legal ownership and control by the community.

On the other end of the spectrum, we find discussions around a "soft" definition of community ownership, local actors have a right to a share of the revenues from the DRE system but ownership of the assets remains with another actor such as the private developer or operator [37, 45-47]. Under this "soft" definition, communities do not legally own any stake in the system but the governance structure incentivises a certain level of control and financial management by the communities [Personal Communication, 20th Oct 2023]. Models that fall under this definition illustrate how benefit can be present even when formal control or community decision power is limited. An example of this community ownership model is the partially community-owned mini-grids in Nigeria, where the benefit-sharing mechanism enshrined in formal by-laws, gives the community a 10% share in the project's profits [48].

3.2 Experience with community ownership models across the global south

Past and current applications of community ownership models for decentralised renewables offer important insights. On the one hand, there have been long-standing national or sub-national programmes that incorporated community ownership elements into their design, primarily implemented in South and Southeast Asia (e.g., Nepal, Indonesia, Thailand, Bangladesh). On the other hand, there are also some individual projects in various countries that are either fully community-owned or integrate an element of community ownership. The

following section describes a number of these examples. While not an exhaustive list of examples, this section provides a picture of the variety of cases and regions and the evolution in the use of these models over the past decades.

3.2.1 Thailand

Between 1983 and 2001, the Department of Alternative Energy Development and Efficiency (DEDE) within the Ministry of Science of the Thai government supported the construction of 59 community micro-hydro power (MHP) systems of a size less than 200kW [18]. Communities owned a share of the system, based on the contribution of labour, materials, or on a monetary contribution, and established a cooperative of consumers. The cooperatives were responsible for operations, maintenance, and management of generation, distribution and sales. The DEDE provided a supervisor to oversee construction. The share of ownership differed across communities but on average the community tended to have a minority share (30 to 40%).

The experience was relatively short-lived. By 2004, only 25 of the community-owned MHP systems remained in operation [18]. Moreover, these systems represented only a small fraction of the almost 70,000 Thai villages that were electrified via grid extension during the same two decades. Nevertheless, their study offered valuable lessons on the management of community-owned systems. Greacen [18] finds that the systems were cost-effective and fundamentally viable, but also points to a range of interlinked challenges, such as poor technical design of equipment, collective over-consumption leading to frequent blackouts or brownouts, and limited state support. A series of "missed opportunities" are identified, in particular at the time of grid arrival, when interconnection between the MHP systems and the grid may have been possible had there been a stronger incentive from the side of the Thai rural electrification agency to make use of the existing generation assets and functioning community-owned structures.

3.2.2 West Bengal, India

In the Indian state of West Bengal, the West Bengal Renewable Energy Development Agency (WBREDA) supported the development of 23 mini grids in the islands of the Sundarbans region. The mini grids ranged in size from 25 kWp to 100 kWp and were built between 1996 and 2006. These mini grids primarily used solar PV technology, though other renewable energy technologies are also employed. The financing model involved public funds covering the capital costs, while consumer tariffs covered daily operations and maintenance, with a 20% surcharge included in tariffs to create a fund for unforeseen future expenses. WBREDA supported the formation of local cooperatives or beneficiary committees for each mini-grid, ensuring community ownership and local management of the system [49].

Today, however, most of the mini grids are not operational and the solar assets on the islands are abandoned. Moreover, over the course of WBREDA's programme, the role of the cooperatives declined in favour of village beneficiary committees, who had fewer responsibilities. One of the reasons was the challenges in governance [49]. The arrival of grid power and the lack of regulation that supported the connection of existing systems to the grid also played a role [50].

3.2.3 Indonesia

In Indonesia, since the 1990s, over 1,300 isolated micro-hydro projects were implemented by both governmental and non-governmental agencies mainly with the purpose to electrify rural areas, many of which had an element of community ownership. These programs were typically supported by grants from international donors to local NGOs, which often served as project-implementing entities. In government-funded projects, the assets were owned by the local (district or provincial) government, whereas NGO-built projects were owned and operated by community-based organisations (CBOs) [17]. From the 2000s onwards, donors increasingly focused on community capacity building to train communities in the operation, maintenance and management of community-owned systems [51]. Revenues generated would be shared through a community fund and used to cover maintenance but also to improve village infrastructure, healthcare, and education opportunities. NGOs would support the local management committees in the design of sustainable tariffs, but these were found to often be insufficient to pay for repair services when needed.

The community ownership element of Indonesian isolated mini grids also posed a challenge when the grid arrived. In 2018, only around 50 community-owned mini grids continued to sell electricity on the mini grids' distribution systems, but they remained physically separate from the grid system (i.e., not interconnected). Another nine community-owned mini grids succeeded in becoming interconnected mini grids and pioneered

the regulatory and technical process. The reasons why some community-owned mini grids survived included their capacity to deal with regulatory hurdles, the lower tariffs, and the fact that some households were unwilling or unable to pay the fees to connect to the main grid [17].

3.2.4 Nepal

In Nepal, CBOs and cooperatives have long been a feature of social organisation and played a vital role in providing local social services and public goods [19]. This was also the case in rural electrification, and as a result, over 3,000 community-managed MHP systems were installed over several decades, since the 1960s [52]. In a series of government programmes, the National Electricity Authority (NEA) provided up to 80% of the capital investments, communities contributed at least 20% to the total investment, either financially or in-kind [Personal communication, 20 March 2024, Personal communication, 21 May 2024]. Additionally, UNDP supported the formalising of CBOs managing community-level MHPs into cooperatives. The National Association of Community Electricity Users in Nepal (NACEUN), established in 2006, has also provided technical training, administrative support, and policy advocacy for CBOs formally registered as a cooperative.

The Nepalese experience demonstrated the viability of the community-owned model and its role in diversifying local economies and increasing incomes. However, many community-owned MHPs in Nepal faced challenges and were abandoned. Many of the challenges related to financial management, such as the lack of sufficient savings to deal with repairs. The extension of the national grid during the 2010s was also a significant obstacle, despite some successful examples of grid interconnection of MHP. Today, there remain a number of successful cases of decentralised community-owned MHPs in Nepal, such as the Khumbu Bijuli cooperative.

3.2.5 Tanzania

Tanzania has considerable experience of community-ownership models for DRE, with varying degrees of success [53]. As of 2017, 19 mini-grids were community-owned, including the LUMAMA hydro mini-grid in Ludewa and 10 villages served by containerized solar mini-grids. In most cases, the mini grids are managed by a village electricity committee which is elected by consumers and is responsible for operation and maintenance, revenue collection and connection of consumers. A number of challenges have been identified including tariff setting, financial management and sizing of the systems.

The LUMAMA hydro mini grid was installed in the Ludewa district in 2009. This 300 kW system was built by an Italian NGO in collaboration with the local church, with funding from international and national donors. The NGO planned from the start to transfer ownership of the hydropower plant to the local communities [38]. To facilitate this, the community-based utility LUMAMA (named after the initials of the three connected villages) was created, and the ownership was handed over in 2010. All customers are LUMAMA members, and local ownership has been found to promote efficient load management and infrastructure security [38]. As of 2017, the system served over 1,600 customers across 10 villages [53].

3.2.6 Côte d'Ivoire

Between 2013 and 2016, seven solar-PV mini grids were rolled out in remote villages in the Zanzan region of Côte d'Ivoire [54, 55]. The combined systems have a total capacity of 214 kWp along with battery storage, and a load of 17 MWh/month. The delivery model includes a strong element of community ownership by the mini grid users: on the one hand, local associations (created within the frame of the project) manage the mini grids, including the productive uses that were encouraged (community fridges, freezers and mills). On the other hand, an overarching mini-grid federation and technicians association centrally manages the financial and technical tasks for all seven villages. Upfront costs were financed through a mix of grants (UNIDO, Ministry of Finance of Cote d'Ivoire, the EU and a local NGO), private equity and in-kind contributions, including from end-users [37]. Each village has a local user committee of 10 members responsible for administration, the management of user contracts and collection of fees. A participatory approach and the training of local actors at the project sites were two key guiding principles of this project [54].

3.2.7 Liberia

In 2018, USAID's Cooperative Development Program partnered with the National Rural Electric Cooperative Association (NRECA) International to design, purchase, and construct a community-led solar mini grid system in

the community of Totota, Liberia [56]. The Totota Electric Cooperative (TEC) was the first private power producer to be licensed by the Liberia Energy Regulatory Commission (LERC) to generate, distribute and sell electricity in Liberia. Fro\m the beginning, the system was owned and operated by TEC, which is now financially self-sustaining. Due to growing memberships and increased peak loads, the mini grid was expanded in 2021 to include 72kW of solar, 120 of kWh lithium-ion batteries, an 80 kVA diesel generator and an 8km distribution network. The Totota community consists of over 500 households of which 400 have joined the cooperative. The largest customers of the cooperative are cold storage facilities for agricultural produce. TEC has voted on a time of use tariff that increases the cost of electricity for these large customers to cover the high night-time electricity consumption that relies on diesel fuel [44].

3.2.8 Nigeria

A recent programme has tested a community co-ownership approach to mini grid deployment for the first time in Nigeria's mini grid sector [Personal communication, 20th Oct 2023, 57, 58]. The goal of the programme is to test the hypothesis that co-ownership by the community (in the form of the ownership of a certain stake in the mini grid, and a benefit sharing mechanism) can contribute to the financial sustainability of the mini grids and drive socio-economic development in the host communities. With the support of the project, agreements were struck between communities and mini grid developers in four communities of different characteristics. These communities now own a 11% stake of the project and receive 11% of revenues accruing to the mini grid after all operational costs and expenses have been settled. To reach the agreements the existing village electricity committees were supported in their transition to a formal structure and in drawing up by-laws that stipulated governance and how the proceeds from the mini grids would be reinvested in the community for projects of common interest. The project has been running since 2023, and to date it has shed light on the potential positive impacts on system performance and economic development (growth in electricity demand, creation of new businesses), as well as underlined the key role of building capacity in the community and of training intermediaries that are able to facilitate the process. In the future, the project aims to expand into new communities and test the capacity of communities to leverage their own financing.

3.3 Common themes

The following section discusses four recurring themes that emerged from the literature review and analysis of the expert interviews and classifies them along the MLP: regulation, financing, roles and power, capacities and skills (Figure 3). It is important to note that all four

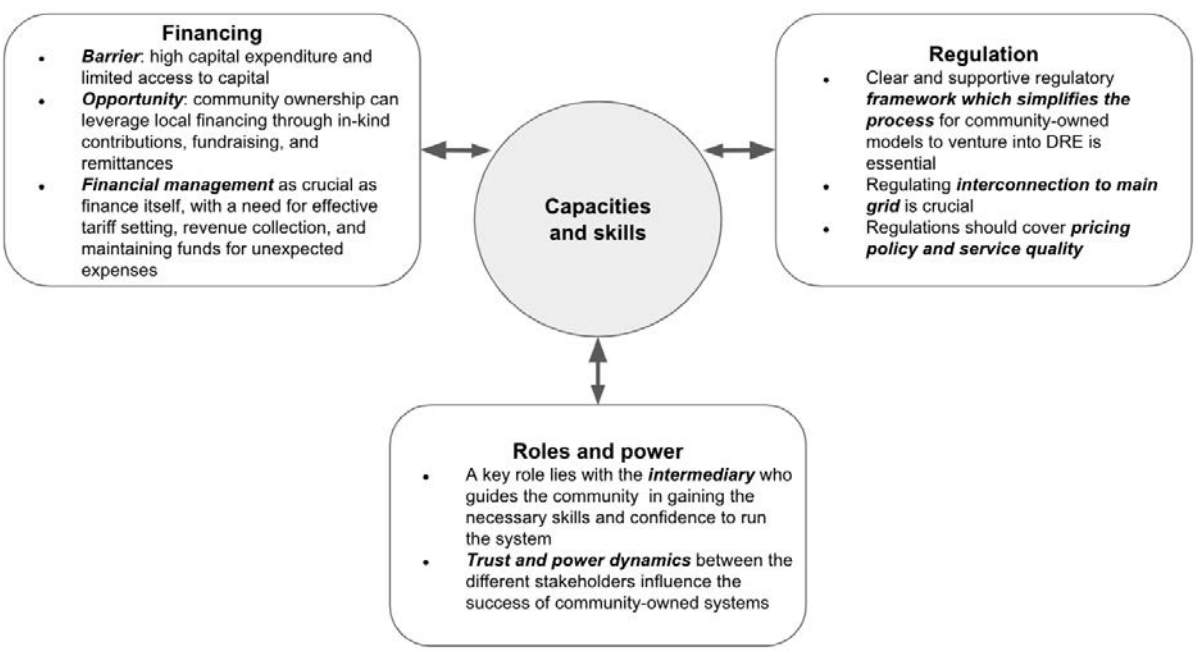

Figure 3: Common themes derived from the literature and interviews.

themes show interlinkages and overlaps. Moreover, we find that the theme "capacity and skills" is both a recurring theme and a cross-cutting theme, because it bears directly on the other three other recurring themes.

3.3.1 Regulation

The role of clear and supportive regulatory frameworks in the successful deployment of community-owned DRE systems was a recurring theme in literature and emerged frequently in expert interviews. In multi-level-perspective terms, regulation belongs to the socio-technical regime because it sets the formal rules against which local community niches must operate and eventually scale. Regulatory frameworks define property rights, significantly influencing ownership structures. Consequently, community ownership models vary extensively across countries, depending on their specific legal structures and related regulations [24].

The role of regulation should be to simplify the process for communities to venture into ownership of DRE systems [39]. Especially for smaller-sized systems, it is recommended to adopt an evolving, light-handed approach and streamline the process of obtaining licensing, approvals and permits [59]. However, in SSA, the regulatory frameworks necessary to incentivize community engagement in energy projects are often lacking [26].

An excess of regulation, as well as the lack of legislation, can impede the emergence of community ownership models [41]. Conflicting regulations can be particularly challenging [24, 39, 47]. Therefore, an appropriate coordinating or regulatory agency with a strong mandate and well-defined responsibilities must provide the necessary coordination of the regulatory environment for community-owned projects to thrive [19, 60].

The review also highlights that regulatory clarity regarding the arrival of the primary grid is paramount for the longevity of community-owned systems. In Sri Lanka, Indonesia, and India the extension of the main grid to areas previously powered by community-owned isolated mini-grids often resulted in the abandonment of many of these isolated systems [17], despite many of them being suitable for interconnection to the grid [50]. Regulations should therefore specify the conditions under which community-owned systems should be built to grid-ready standards. Additionally, pricing regulations are crucial in community-owned projects, as tariff setting determines the economic viability of a project and ultimately impacts its financing [24]. While in several cases community-owned projects are allowed to determine the type and level of tariffs, in some instances, governments either determine or approve the tariffs set for these models [24, 37].

The review also highlights the intersection of regulation with more informal institutional factors such as power dynamics (see section 3.3.3). Community-based models are susceptible to local power brokers, whose political interference can affect management decisions and financial distributions, thus undermining the efficacy of projects [24]. This can tarnish perception of and trust in community-owned models, further impacting the long-term sustainability of these projects [39]. Therefore, strong and effective regulations are essential to ensure service quality by preventing the exacerbation of existing power imbalances [19].

It is essential to replicate community ownership models in contexts where they have been untested, along with replicating and tailoring regulatory frameworks that led to success in other contexts in the past [24].

Viewed through the MLP, clarifying and streamlining these regime-level rules is a prerequisite for community-owned niches to exit their protected spaces and influence the mainstream electricity system.

3.3.2 Financing

The development of decentralised electricity systems in the global south is challenged by their high share of capital expenditure in project costs, the lack of access to capital and the high cost of capital in emerging markets and developing economies [61]. These financing barriers apply to all ownership models, but our findings indicate that this may be a particularly strong challenge for community-owned systems [39, 26, 62]. One reason for this is that traditional and concessional financing mechanisms are often inaccessible to communities due to a lack of awareness and established business cases [39, 63]. As reported by one interviewee, financing programmes that invest in decentralised electrification infrastructure, such as mini-grids, often exclude cooperatives and not-for-profit community-owned structures in favour of for-profit electrification models. This causes an entry barrier for community ownership models and prevents them from substantially replicating. There are currently no funds or financing mechanisms dedicated to financing rural energy cooperatives in SSA regionally [Personal communication, 7 November 2023]. Within the MLP, finance operates at the interface of niche and

regime: capital is organised through regime-level instruments, yet it determines which local experiments survive long enough to diffuse.

On the other hand, community ownership of DRE can potentially offer advantages in terms of financing. A study by Bhandari et al. [40] concluded that the willingness to pay for electricity from DRE with PV systems increases with adopting a community ownership model. Furthermore, our findings indicate that communities themselves can also be a potential source of financing. This is the case in the Nepal programme, where communities financed at least 10% of the micro-hydro systems, either with in-kind contributions (labour, materials), or by raising their own funds through loans [Personal communication, 20 March 2024, Personal communication, 21 May 2024]. Practitioners in SSA also suggest that remittances from the diaspora could be a promising way to complement subsidies, finance energy access projects in Nigeria and contribute to community ownership [Personal communication, 20th Oct 2023].

In addition to raising finance, the management of finances itself is a recurring theme in literature regarding community-owned DRE in the global south. A number of sources state that due to a lack of skills (see more on this under section 3.3.4 below), the financial management of a community-owned electrification project can be challenging for communities [43, 45]. This entails tariff setting [Personal communication, 7 November 2023, 38] revenue collection [Personal communication, 7 November 2023, 26, 45], monthly billing, deposit of savings, regular audits and indirectly related tasks such as demand estimation and stimulation [43]. Tariffs need to be set at a rate that is affordable for community members as well as being sufficient to operate the system [Personal communication, 7 November 2023]. However, raising tariffs can be a main challenge because end users are not incentivised to raise their own electricity bills [Personal communication, 22 May 2024].

A common challenge related to financial management of community-owned systems is the lack of savings to cover unexpected infrastructure failures [Personal communication, 7 November 2023, Personal communication, 20 March 2024]. There are however examples where this risk is intentionally addressed by the governance arrangements of the community owned system. For example, in the case of solar PV mini-grids in remote settlements in Côte d'Ivoire, the monitoring committee avoids this problem by keeping funds to cover replacement of spare parts and more expensive maintenance in a blocked account, in addition to having an open bank account to meet daily operational expenses [37]. This approach integrates financial management with governance structures to enhance the long-term viability of community-owned systems.

3.3.3 Roles and power

The roles of actors involved in community-owned DRE systems in the global south tend to differ from those of a purely privately-owned system (Figure 4). Firstly, the role of communities is - by definition - stronger. The end users of the system are central to the model, alongside the formal structure that represents them and that is responsible for governing the model. Moreover, our findings indicate that the figure of the intermediary appears as a necessary role. Intermediaries act as external entities which guide the communities in aligning and leveraging their capacities (referred to as internal factors) with external factors, such as social, technical, economic and political influences [64], thereby developing the necessary skills and confidence to run the system [39, 64]. Ambole et al. [26] suggest that NGOs or think tanks knowledgeable in local energy issues and committed to community involvement can serve as community energy intermediaries, while in some cases, the solution provider (private developer, or public institution) plays this role [37]. Governmental institutions, who define and enforce the regulatory and legal framework, are also fundamental, though in this case not very different in level of influence to their equivalent role in privately owned models.

From a socio-technical transitions perspective, this constellation of actors illustrates a niche configuration in development, in which intermediaries coordinate learning and foster networks. These functions are essential for niche stabilization [65]. The diversity in intermediaries' roles observed in this study supports the idea that intermediary functions are context-specific and evolve over time.

Our review shows that trust and power between all stakeholders involved play a major role in the development and long-term success of community-owned systems. Katre and Tozzi [46] examined power dynamics between external entities (intermediaries and solution providers) and local actors (communities and Village Electricity Committees (VECs)) in community-owned mini grids in India. The authors emphasise the importance of a 'hugs' approach, involving consensus-building among the actors through persuasion, education, and

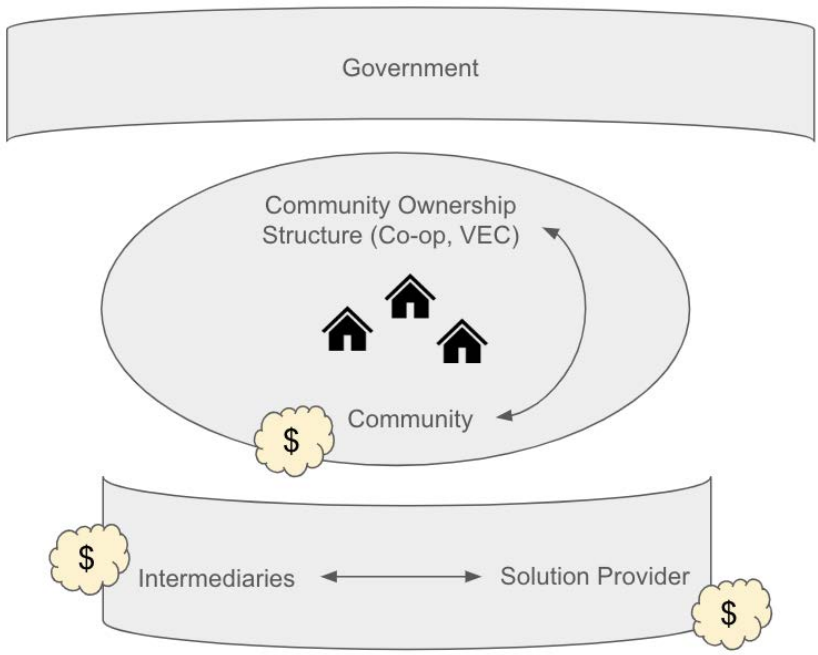

Figure 4: Actors involved in community-owned DRE systems. The USD sign indicates possible sources of financing for the DRE system.

facilitation by intermediaries to foster trust and transparency. However, this approach also bears the risk of taking too long to achieve a broader electrification target through community-owned DRE systems.

The importance of trust extends beyond external relationships to intra-community dynamics. Strong and trustworthy relationships among the community members [39] and between the community members and governance structures, such as the VEC [38] are considered as important success factors. In community ownership models, this can be challenging as local ownership means that members of the committee are well-known in the community, which goes along with certain expectations. Our findings indicate that committee members may feel conflicted between operating independently and maintaining social cohesion [38], revealing the multi-scalar nature of governance tensions within niche experimentation.

Compared to private ownership models, community ownership models can be seen as an alternative to change the power dynamics, resulting in more power for the communities and counteracting private investors' tendencies to prioritise wealthier, less electrified areas [Personal communication, 7 November 2023]. For example, in the case of the Mokoloki mini grid in Nigeria, the developer and operator expect that once the legal framework for the community association is finalised, the community will have voting rights on most issues other than tariffs [48].

Community ownership models also offer operational benefits. For example, they have the potential to reduce vandalism of infrastructure and energy theft, as local ownership fosters a sense of responsibility among end users [Personal communication, 13 June 2024, 38]. In case misuse still occurs, this model also makes it easier to hold individuals responsible for damage [38].

3.3.4 Capacities and skills

Our findings reveal that capacities and skills, their development, and retention, are a central recurring theme in the literature around community-owned models for DRE in the global south. This is because creating strong local capacity in the areas of governance, leadership, technical and financial management is essential to sustaining a community-owned system [24, 43, 45, 62, 64, 66]. These skills and resources are essential in enabling the development and maturation of community energy niches.

What becomes evident from the literature review and the interviews is that one key bottleneck is the capacity to set up and govern a formal or informal management structure such as a cooperative or a VEC. This includes the ability to plan and account properly by creating and enforcing mechanisms for the collection of payments,

deposits, and penalties [Personal communication, 20th Oct 2023, 46]. Katre et al. [45] state that when communities are able to define governance procedures themselves and take over the financial management, they are able to develop solutions suitable to the local context.

Intermediaries such as NGOs play a key role in training the community to successfully operate a system in the long-run, acting as bridges between external expertise and local knowledge [42, 43, 64]. Throughout the two-year implementation process of MHP systems in Indonesia, intermediaries helped in recognizing the need for various capacities - personal, organisational, infrastructural, and cultural - and in identifying shortcomings as well as opportunities to address needs with existing capacities [64]. One interviewee reported that in a program to build rural cooperatives in Zambia, the intermediary engaged in capacity building with the communities for five years [Personal communication, 7 November 2023]. The LUMAMA community-based utility in Tanzania, and the solar PV mini-grids in the Zanzan region of Côte d'Ivoire (see section 3.2) also show the role of training on administration, governance, and technical management of the system. The training has enabled the communities to operate successfully [37, 38]. In both cases, after the handover period and the creation of an organisational structure, the communities were fully responsible for running the system.

An additional challenge is to keep the personnel in the community once they are trained. In the case of a Nepali rural electric cooperative, around 7% of skilled workers have migrated away to work in the cities or abroad to earn higher salaries after they have been trained by the National Association of Community Electricity Users Nepal [19]. This issue emphasises the need for strategies that not only build but also sustain capacities.

4. Discussion

Community ownership models for DRE in the global south can be viewed as niche experiments situated within an incumbent electricity regime and influenced by broader landscape forces. At the landscape level, international commitments such as SDG 7, the decline in solar PV costs, and regional ambitions (for e.g. African Union's Agenda 2063) have enhanced the legitimacy of decentralised solutions and opened a window of opportunity for alternative ownership models. However, these pressures alone are not sufficient for community initiatives to be widely diffused.

The regime, understood in transition theory as the dominant configuration of infrastructures, markets, and formal institutions, presents two decisive barriers to scaling community ownership: regulation and finance. Regulatory frameworks in many countries are unclear or inconsistent. In Sri Lanka, Indonesia, and India the absence of grid-interconnection rules led to the abandonment of community systems even where technical interconnection was feasible. By contrast, in the global north, supportive measures such as the European Union's Clean Energy Package have enabled community governance structures and facilitated renewable-energy income streams. Finance is the second constraint at the regime level. Although funding is a common challenge for all DRE projects, it is especially acute for community initiatives because concessionary instruments often exclude cooperatives and commercial loans are expensive. Unless community entities receive formal recognition and access to suitable capital, they are unlikely to grow beyond scattered, grant-supported pilots.

At the niche level, our thematic analysis highlights roles and power, together with capacities and skills, as factors that determine whether community projects endure long enough to challenge the current regime. Village committees, cooperatives, and user associations possess greater local authority than privately owned schemes, yet they often lack legal standing and must rely on intermediaries to negotiate with national agencies or donors. Examples from Tanzania and Côte d'Ivoire reinforce the notion that intermediaries act as transition "brokers", a term from transition theory describing actors who mediate between niche and regime levels by facilitating capacity transfer and aligning diverse stakeholder interests [65]. Community ownership also shifts local power dynamics. Granting communities formal rights, as in the Mokoloki mini-grid in Nigeria, produces governance innovations that challenge prevailing utility-led logic and exemplifies the agency found in many grassroots initiatives.

Nevertheless, sustaining these systems ultimately depends on strong local governance, technical expertise, and financial-management capacities, supported by intermediaries. These capacities and skills are essential and crosscut all the considerations discussed above. While the challenge of building these skills is not unique to the global south, its magnitude is intensified by higher rates of skilled migration and limited access to formal training resources. Without such long-term capacity building, community systems struggle to maintain assets or repay loans.

A notable challenge encountered in our examination of the literature was the absence of a concrete definition of community ownership models. By distinguishing community ownership along the twin dimensions of decision power and community benefit, and by locating individual cases on a spectrum from soft to hard arrangements, the study supplies a vocabulary that regulators, financiers, and practitioners can use consistently. Without this shared frame of reference, evidence remains fragmented and lessons cannot be generalised. The same spectrum also signals the presence of different socio-technical niches, each calling for a specific mix of shielding, learning, and network building, as described in Strategic Niche Management.

4.1 Limitations and future research

The findings of this research are limited by the scope of the research. The number of expert interviews was limited and the literature review is not exhaustive, in particular concerning grey literature. Therefore, the findings should be interpreted with caution and further research is necessary to validate and expand upon these results by applying a more comprehensive approach.

To identify relevant literature, this review utilised the terms “community ownership” and “cooperatives”. We acknowledge that these terms are more commonly used in global north contexts and may not fully capture the diverse local terminologies and concepts employed in different regions of the global south. This could introduce a potential bias in the scope of the studies reviewed and as a result, we may have unintentionally overlooked relevant literature from other regions such as Latin America.

While this research identified factors influencing the success of the community-owned models in DRE, future research could investigate the identified factors in more detail to explore how they may produce mechanisms with the ability to unleash the growth of these models through multiple scales and dimensions. In addition, future research could benefit from incorporating region-specific terms to ensure a more comprehensive representation of community ownership models across diverse geographical contexts.

4.2 Recommendations for policy and practice

The research findings provide a number of recommendations that may inform policy and practice in this field. In order to bridge the energy access gap, it is necessary to consider additional approaches to private and public ownership models. To date, the potential of community ownership models has not been fully realised, and there is currently no roadmap or guidance that developers, financiers or governments can follow.

To facilitate the scale up of this model, three key concerns must be addressed. Firstly, financing barriers need to be removed (e.g. current ineligibility of cooperatives and community structures in grant and concessional finance programmes). Secondly, regulations must be adapted in such a way that the process for community ownership models to enter the DRE sector is streamlined, while at the same time ensuring that important aspects such as pricing policy, service quality and interconnection to the main grid are adequately addressed. Thirdly, there is a need to focus on building local capacities of communities and intermediary agents to facilitate community-owned DRE projects.

In addition, there is a need to reduce the confusion surrounding the term “community ownership” and to clearly distinguish it from other terms such as “community involvement,” “community engagement,” and “community-driven.” While flexibility in defining community ownership models is recognised for testing diverse models, especially in the early stages of development [67], the absence of clarity has posed practical challenges. It is therefore recommended that the concept of community ownership should be clearly defined and communicated in research or practice-related project. A balanced approach that combines flexibility with clarity can help foster innovation while addressing barriers such as the lack of a clear business case, which has been a challenge in securing financing as discussed earlier, as well as limited awareness in certain contexts.

5. Conclusion

Achieving universal access to affordable, reliable, sustainable, and modern energy depends on the rapid deployment of DRE. Solar and hydro mini-grids are increasingly recognised as key to bridging the electricity access gap, particularly in SSA and in last-mile communities. Given the slow progress towards energy access goals, it is essential to explore and integrate new models alongside the existing private and public ones. Community ownership models offer a promising complementary pathway by embedding DRE solutions within local contexts, empowering communities and potentially improving the sustainability of DRE projects. The results of this study suggest that, when well

supported, these models can help increase electricity connections.

However, realising this potential requires targeted action to address persistent barriers. These include: (1) unclear or restrictive regulatory frameworks that do not formally recognise community entities; (2) limited financing mechanisms tailored to the specific needs of community-owned projects; and (3) ongoing capacity constraints in areas such as governance, technical operation and maintenance, and financial management.

To overcome these obstacles, enabling conditions must be actively cultivated. National governments and donors should adopt supportive legal frameworks and provide accessible financing that de-risks community participation. Long-term partnerships with trusted intermediaries, such as NGOs or cooperatives, are not only critical for delivering technical training, but also for mediating between local practices and institutional structures. As emphasised by the MLP on socio-technical transitions, such actors play a pivotal role in connecting innovations at the community (niche) level with broader regime structures. Finally, a key challenge in this area is the lack of appropriate definitions of community ownership models. Looking ahead, researchers must work toward a more precise conceptualization of community ownership to ensure clarity and consistency in the understanding and implementation of community-owned models.

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Appendix

Appendix 1. Overview of interviews.

Type of stakeholder	**Region of expertise**	**Date**	**Reference in text**
Research institute	Nigeria	20 October 2023	Personal communication, 20 October 2023
Association	Global	7 November 2023	Personal communication, 7 November 2023
Non profit organisation	Nepal	20 March 2024	Personal communication, 20 March 2024
Governmental organisation	Nepal	21 May 2024	Personal communication, 21 May 2024
Senior consultant	Global	22 May 2024	Personal communication, 22 May 2024
Governmental organisation	Nigeria	13 June 2024	Personal communication, 13 June 2024