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The role of sense of ownership in rural community mini-grid management: qualitative case study from Tanzania

Irene F. Ngoti[1,2,3*]

Abstract

Background The majority of mini-grids in Tanzania are managed by private entities, faith-based institutions, and the government. In contrast, a limited number of mini-grids under community management strive to survive. Although the concept of "sense of ownership" is considered crucial for mini-grid sustainability in developing countries, there is limited theoretical exploration of the factors that drive this concept and its effects on community mini-grid management. This paper assesses the relationship between the sense of ownership among electricity users and the effective management of two solar community-based mini-grids with different sustainability experience.

Results A sense of ownership plays a role in establishing the decision-making process of mini-grids among village energy committee members toward sustainable or unsustainable management. The mechanisms behind the sense of ownership among community members toward managing mini-grids are largely expedited by the strong leadership of village energy committee members, community participation in decision-making and resource mobilisation, especially in the preparation, design and implementation phases of mini-grids.

Conclusions A sense of ownership is found to influence the effective management of community mini-grids in Tanzania. When designing mini-grid project policies and programs that target respective communities as prospective owners, energy practitioners and policy-makers should consider creating an environment that nurtures a sense of ownership.

Keywords Community mini-grids, Community participation, Community management, Sustainability, Solar, Ownership

Background

The electricity access rates in sub-Saharan Africa are among the lowest despite an increase in global electricity access between 2010 and 2020. In fact, a projected 670 million people will continue to lack access to electricity, with 9 out of 10 people expected to live in sub-Saharan Africa [1]. Over the past decade, mini-grids[1] have provided more reliable electricity than national utilities among rural communities in Africa due to the existing sparse rural population [2], less frequent or lengthy outages and voltage fluctuations [3], and fewer challenges with transmission and distribution networks [4]. Tanzania is a sub-Saharan country with a robust mini-grid regulatory framework that supports investments in different

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[1] A mini-grid is a small-scale electricity generation system (from 10 kW to 10 MW) isolated from the main grid, that distributes energy to a limited number of customers.

mini-grid ownership models. These models encompass private entities, communities, national utility, hybrids [3, 5], and faith-based organisations [5]. Community-based mini-grids (CBMs) stand out as unique models whose operation and management rely on beneficiary local communities [6, 7]. Local community involvement in the mini-grid preparation and design phase[2] is thought to facilitate both smooth management [8, 9] and long-term sustainability of mini-grids [10], which further creates a strong sense of ownership among users [11].

A sense of ownership, which is defined as a psychological state in which people feel that a particular community infrastructure system is "theirs" [12], and is, however, revealed to enhance the effective management of community infrastructure, such as water systems [13, 14] and community mini-grids [15]. A sense of ownership arguably develops a common vision among electricity users towards mini-grid governing [16] and increases their sense of responsibility, which can be associated with successful management [15]. However, no qualitative or quantitative analysis has yet examined the role of a sense of ownership in rural mini-grid community management. Moreover, prior research has partially highlighted the causes of a sense of ownership among mini-grid users without detailed theoretical analysis. This study, therefore, seeks to fill both research gaps by using the cases of Leganga and Silale in Tanzania to primarily analyse the role of a sense of ownership in community mini-grid management. To achieve this, the study specifically uses the following guiding research questions: (RQ1) Which factors affect a sense of ownership among CBM users? (RQ2) In which mini-grid phase does a sense of ownership among users arise? To answer these research questions, this paper focuses on CBMs whose respective community members are responsible for all plant management practices.

This article makes two main contributions to the literature. First, while previous studies on CBMs management have focused on institutional aspects to manage maintenance [6] and overall mini-grid management [17, 18], technical aspects [19], and financial aspects [10], this study contributes to both the community mini-grids and psychological ownership literature by using the "routes" to theoretical psychological ownership framework to analyse the mechanism behind the sense of ownership in the mini-grid context. This paper then develops an analytical framework of the sense of ownership routes for rural community mini-grids. Second, a systematic qualitative analysis of the mini-grid development lifecycle in relation to the sense of ownership is conducted to determine the most important mini-grid phase in which the sense of ownership matters for the successful management of rural community mini-grids.

The remainder of this article is organised as follows. "Conceptual framework: sense of ownership in community mini-grid management" section presents conceptual guidance on analysing a sense of ownership in community mini-grid management. The methods used are outlined in "Methods" section. The results of the empirical analysis are presented in "Results" section, followed by a detailed discussion in "Discussion" section. Finally, "Conclusions" section concludes the paper.

Conceptual framework: sense of ownership in community mini-grid management

Conceptual background of sense of ownership

This paper provides a theoretical basis for understanding the sense of ownership to explain its role in community mini-grid management. A sense of ownership among users of different resources is one of the essential catalysts for sustaining different infrastructures [15, 20]. It is also a powerful component among employees of both public [21, 22] and private organisations [23] and individual households [20] and a significant factor for policy and programmes [24] in different sectors. Nevertheless, few studies have provided a theoretical framework for the relationship between sense of ownership and the sustainable management of rural community mini-grids. The organisational and behavioural sciences provide a useful theoretical umbrella for explaining the gap identified.

Pierce et al. [12] define a sense of ownership as a "state in which individuals feel as though the target of ownership (material or immaterial in nature) or a piece of it is "theirs". Later, it was argued that a sense of ownership is expressed in feelings and explanations related to the words 'my or mine and our' towards the target [25]. As such, a sense of ownership indicates an individual's possessiveness and connection to the target as his or her own. In other words, an individual has recognition, beliefs, and thoughts towards the target. This target can be a company, organisation, project, idea, or output. Pierce et al. [25] further clarified that such possessiveness can also be expressed towards people. One of the seminal studies conducted by Furby [26] also used possessive attitudinal words such as 'my, mine and our' as measurements associated with a sense of ownership. Van Dyne et al. [27] used the same vocabulary and created a seven-item instrument to measure a sense of ownership. Several empirical studies have developed other instruments to quantitatively measure a sense of ownership by adding new criteria based on [27], for instance [28], who constructed 12 items [29].

[2] Other phases in mini-grid life cycle are implemented together with monitoring and evaluation.

The sense of ownership theory is further advanced to cover the collective sense of ownership, which involves the shared mentality among group members who regard themselves as 'us' and develop feelings of ownership towards a target as theirs [30]. Pierce and Jussila [30] define a collective sense of ownership as "collective (feeling) that this target (or a piece of that target) of ownership is collectively 'ours'" and further claim the near impossibility of a collective sense of ownership to existence without an individual's sense of ownership existence. Implicitly, feelings of collective ownership of a shared target start at the individual level. This study uses the possessive expressions pronouns 'my, mine, our, or theirs' [12, 25] in analysing a sense of ownership and considers both positive and negative possessive statements as attitudinal measurements of a sense of ownership, as stated by [12, 25, 26]. The paper also applies 'our' to indicate individuals' collective sense of ownership. A detailed sense of ownership exploration is given in "Data analysis" section.

Factors enabling a sense of ownership

Pierce et al. [12] theorise three main causal paths through which individuals develop a sense of ownership towards a target: self-investing in the target, having control over the target, and intimately knowing the target. These routes explain how a sense of ownership comes to exist among individuals toward the target.

Self-investing in the target is linked to the money or time an individual spends either working or taking care of the target, energy or skills set applicable during physical labour provision, and interests in the target [22, 25]. Individuals who expend their energy, time, and care in producing goods and services tend to become possessive towards what they work for and the corresponding targets. Even though these individuals may not be legal owners of the target, a sense of ownership is likely to arise [11, 12]. As Dawkins et al. [29] contend, a sense of ownership is self-driven, unlike legal ownership, which normally sets boundaries from its set. A sense of ownership can, hence, exist exclusively without legal ownership (or vice versa) or can coexist [31, 32] but originates and depends on the feelings of individuals towards the target [25]. This conception of a sense of ownership distinguishes it from legal ownership, as the former is perceived by the person whose feeling is expressed, whereas the latter is based on legality [25].

Having control over the target can also cause a sense of ownership because individuals can make decisions that affect the outcomes of a given target, including shouldering enormous obligations and being responsible for influencing strategies that may induce the development of feelings of control over the target and, hence, a sense of ownership [12]. Subsequently, having control over a certain idea and work to yield the desired outcome, for example, an organisation, may increase the sense of ownership towards a particular organisation even when an individual is not a legal owner.

Ultimately, knowing the target is connected to how well individuals possess sufficient knowledge of a target by associating with it. Knowledge may be acquired through long- or short-term attachment to the target, although the more individuals associate with a particular target, the more knowledge is extracted and the more the sense of ownership may develop [12, 25]. The resultant knowledge may increase personal interests and, eventually, feelings of responsibility towards the target. The routes explained here tend to independently cause a sense of ownership, although going through more than one route can occasion a greater sense of ownership [25].

Conceptualising a sense of ownership in the mini-grid context

As already stated, a sense of ownership is a feeling a person has towards something or target (such as project, company, organisation) as his or her own. This study treats mini-grids as the target of ownership since, from their inception, different stakeholders (donors, investors, developers, government agents, community members, etc.) are involved. As noted earlier, Tanzania has five common mini-grid ownership models: private entities, community, national utility (owned by government), hybrid and faith-based organisations. Community-based mini-grids, the main concern of this study, are managed, owned, operated, and maintained by local community members. Thus, community members' sense of ownership of mini-grids is defined as a psychological state in which electricity users have an impression and feelings that the mini-grid is their own. No studies have discussed the role of a sense of ownership in community-based mini-grid management in-depth; therefore, this study addresses this gap.

Mini-grid development involves various phases in its lifespan. The three common phases that are considered and highlighted in this study are preparation and designing, implementation, and monitoring and evaluation. In the preparation stage, the donor, investor, or community identifies the location and community for the envisaged mini-grid, collaborating with the governmental energy agency. This stage covers discussions and agreements on the needs assessment, the boundaries of who is going to benefit from the project, project values between community members and the developer or investor, and the follow-up of licence approvals. The community also participates in this phase financially or non-financially by offering land to construct mini-grids. Empirical evidence

affirms that this phase is crucial for developing ownership among community members in both community energy projects [33, 34] and noncommunity-owned projects [15, 16], as a collective vision geared towards the successful management of mini-grid projects has developed [9]. Mini-grid design—also under the first phase—involves mostly a mini-grid's technical aspects and financial feasibility planning. The salient features at this stage include the choice of technology for application in correlation with the energy sources available and size, the preparation of sustainable technical operational plans, and the development of a sustainable business model for running the mini-grids [15]. Mini-grid developers and communities are mostly involved in this phase, together with the respective energy regulatory agencies, which are responsible for reviewing and approving the licence and feasibility study. The community can decide to support or sabotage mini-grid plans during the preparation and design phase.

Implementation is an action phase that entails installing the mini-grid at the site and operationalising it. The phase also covers operations and maintenance (O&M). The mini-grid operator can be in-house (i.e. the community can manage O&M matters by hiring technicians within the locality) or outsourced. Moreover, the tariff design agreed upon during the design phase is also applicable in this phase. Furthermore, the operator, community members or both can execute this phase of a mini-grid project independently or collaboratively, depending on the mini-grid ownership model. Community members can engage in this phase by providing communal labour during construction. Additionally, community members' participation in decision-making during this phase may promote a sense of ownership [20]. Finally, the monitoring and evaluation (M&E) phase helps check for user satisfaction levels, socioeconomic impacts of the mini-grid, and electricity reliability status. Since the community sense of ownership may develop in any of these phases, this study examines the phase(s) in which a sense of ownership arises and matters the most.

Based on the theoretical foundation explained in the previous subsection, this subsection further presents the mechanisms behind a sense of ownership in the mini-grid context, which are summarised in the developed

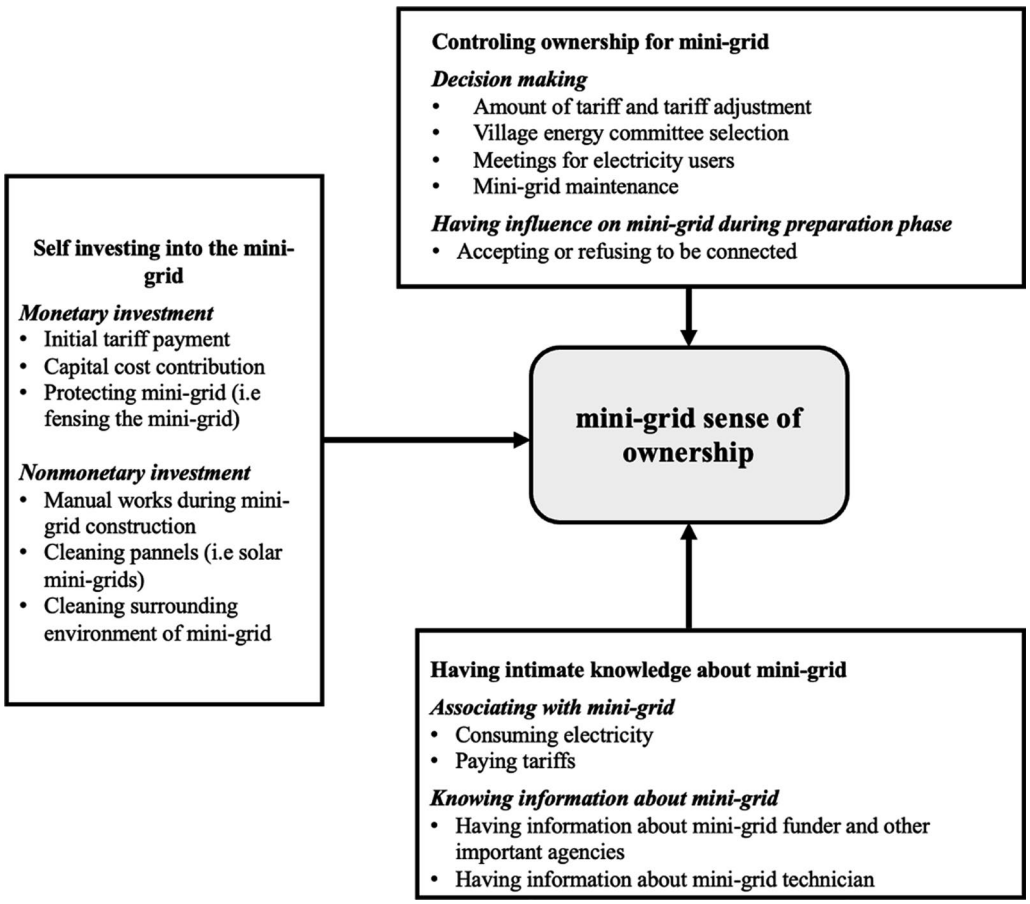

Fig. 1 Analytical framework: sense of ownership routes for rural community mini-grids (Source: Author)

analytical framework (see Fig. 1). Self-investing in the mini-grid constitutes the initial monetary investment that electricity users contribute to managing mini-grid O&M. This contribution is mostly in the form of tariffs and capital costs. There are also nonmonetary contributions from community members, such as providing land for installing the mini-grid and offering manual labour during the construction stage without pay. Users can also care for mini-grids by cleaning the panels without payment, cleaning the surroundings of the mini-grid, and watching out for jeopardising events against mini-grids, such as throwing stones at the panels. These are some forms of investment that electricity users dedicate to mini-grids, which can increase their sense of ownership. Resource mobilisation is another form of self-investment in mini-grids carried out by electricity users independently (for community-owned mini-grids) and/or by mini-grid operators collaborating with electricity users (for private, faith-based and community-owned mini-grids). This resource mobilisation can occur because users mobilise funds for O&M by paying tariffs and setting rules to guide them in managing the mini-grid.

The ownership of mini-grids is controlled by users involved in the mini-grid's decision-making, for example, on the amount of tariffs to pay, the adjustment of tariffs and the selection of energy committee members. This correlates with convening meetings for users to discuss mini-grid matters. In addition, electricity users have control over mini-grids by perceiving that they have influenced mini-grids since the preparation phase and can accept or refuse their houses to be connected with electricity.

Having intimate knowledge of mini-grids speaks of users' associations with mini-grids through using them. Apparently, the more they consume electricity, the more they learn about different aspects of mini-grid operations, for instance, by getting to know their technician, revenue collection model, and project funder, developing closer relationships between users and the mini-grid; hence, they have a stronger sense of ownership towards the mini-grid. The more information that is derived from the mini-grid, the more attached to it they become. Mini-grid users exposed to more elements described in these routes can develop a greater sense of ownership. Figure 1 summarises the explained routes through which individuals' sense of ownership towards the mini-grid develops.

Methods

Research setting

Tanzania was selected as a case study for several reasons: (1) national electricity access has increased over the past decade (by 37.7% by 2020), but the gap between urban areas (73.2%) and rural areas (24.5%) has remained high; (2) over the past 3 years, Tanzania has attracted a large number of investors and developers to invest in private, faith-based and community-based mini-grids (CBMs); to date, however, extremely few CBMs have survived; and (3) despite the mini-grid market having taken off earlier than other East African countries, Tanzania lags behind Kenya in mini-grid deployment and has few operational CBMs relative to the latter.

In an effort to electrify rural communities, the government of Tanzania, through its Ministry of Energy and Minerals, received a soft loan from the Austrian government and constructed 14 community solar mini-grids across 10 villages in three regions: Dodoma, Katavi, and Tabora [5]. This was a pilot project that targeted unelectrified villages (selected by the Ministry of Energy and Minerals) that were unlikely to be connected to the main grid electricity in the near future and had relatively concentrated houses. A contract was signed between the Ministry of Energy and Minerals and Elektro Merl Company from Austria to instal all mini-grids, connect all targeted customers, and perform maintenance services to all mini-grids. The company consulted the respective Village Energy Committees (VECs) and the village governments, which were supervisors and guardians for mini-grid projects, following guidelines developed by the Ministry of Energy and Minerals [35]. The aim of this pilot project was to attain experience from this model of operation and management and later deliver it to other unelectrified villages in other parts of Tanzania. Legal ownership of mini-grids was with the government and would be transferred to the respective villages after the contract with Elektro Merl company to oversee mini-grid maintenance expired.

Of the 14 mini-grids in 10 villages, the Silale and Leganga mini-grids located in the Dodoma region were the only surviving mini-grids when this study was conducted, both of which are included in the empirical analysis. Due to different reasons, such as battery failures and poor management by the beneficiary communities, the remaining 12 mini-grids stopped operating within the first 4 years of their commencement. Despite their non-operational status, mini-grid assets such as solar panels, electricity poles, wires, and production systems (inverters, batteries, and energy generation technologies inside containers) are still at the sites to date. After the cessation of these mini-grids, some villages were connected to the main grid electricity, and others switched to alternative energy sources such as home solar systems and generators.

The two cases were selected for this study because (1) there is a limited number of operating CBMs across Tanzania and (2) operational CBMs from other energy

sources are absent in addition to solar energy. Therefore, the two cases met the potential CBM criteria needed for this study (beneficiaries are solely responsible for mini-grid management).

With fewer than 400 inhabitants in each village, agriculture is the primary economic activity in Silale and Leganga. Few businesses, such as shops, restaurants, and hair salons, exist in the villages. Institutions such as a dispensary in Leganga, a primary school, and a church in each village also contribute to the local landscape. The two villages benefited from the aforementioned mini-grid projects due to the absence of anticipated connections to the national grid in the foreseeable future.

A total of 60 connections were made to each village. The connections included households, businesses, and institutions. Businesses with higher energy consumption, such as welding machines, were not connected. As described in Fig. 2, the original setups for the two mini-grids are similar in several ways: technical setting, financial investment (funder), management arrangement, and number of connected customers; however, the operational sustainability outcomes differ. Unlike Silale, the Leganga mini-grid ceased operations 3 years after its commencement and remained without electricity until 2021, when another organisation revitalised it. The survey on Leganga mini-grid, therefore, is based on the period prior to its cessation. The current management of Leganga mini-grid is entirely under Elico Foundation, with no community involvement in the O&M. Despite the outlined similarities, the most interesting feature of both cases is the difference in sustainability outcomes. In the first 3 years, the Elektro Merl Company operated both mini-grids specifically on the maintenance side, while VEC members were responsible for collecting tariffs, conducting meetings with electricity users, managing electricity connections and disconnections, controlling illegal connections, and using banned electrical appliances [35]. After 3 years, the Elektro Merl Company (mini-grid operator) left, and the VEC became solely responsible for each mini-grid management, with an additional role in running mini-grid maintenance. The technician who previously served under Elektro Merl continued maintaining both mini-grids. Both communities participated in feasibility studies conducted before the construction of the mini-grids. During the construction phase, both communities provided the land on which the mini-grids were set up and provided manual labour. However, site selection for connected houses was based on prior arrangements between the Ministry of Energy and Minerals and the Elektro Merl Company, with no direct involvement of community members.

Data collection

The qualitative data were collected during field visits to the two mini-grids where 18 in-depth semistructured interviews were carried out. Study tools were developed to gather information from the following list of interviewees: 6 VECs (3 members from each mini-grid); 3 village council leaders (2 from Leganga and 1 from Silale); 8 normal electricity users (3 from Leganga and 5 from Silale) and 1 technician (maintaining both mini-grids). Gender-wise, the interviewees included 6 females (3 from each mini-grid) and 12 males (5 from Leganga, 6 from Silale and 1 technician). The diversity of participants enabled the study to collect balanced opinions on how CBM is initiated, operated, maintained, and managed.

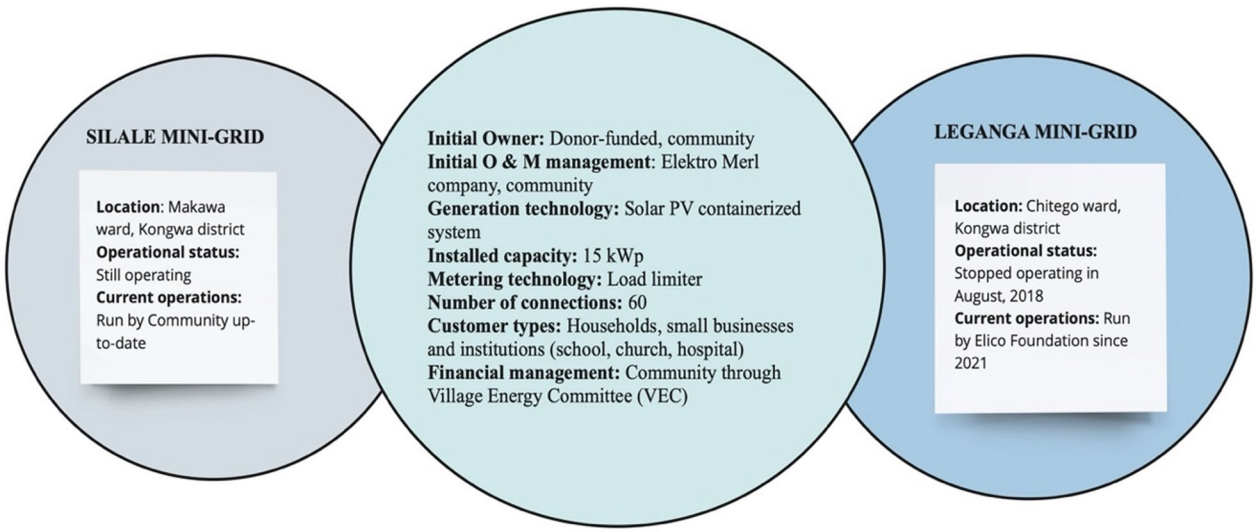

Fig. 2 Key similarities and differences among mini-grid cases (Source: Author)

Five days were spent on each mini-grid site between May and June 2022. All the VEC and village council leaders available during field visits were interviewed. The snowball method was applied to normal household electricity users without leadership titles in the case studies. The technician was interviewed because of his strategic position (the only technician who has served since the commencement of both mini-grids). The study included only 18 participants, mainly because of data saturation during the interviews. Moreover, some previously connected households relocated to other locations. Generally, the sample is representative for ensuring reliable results. During data collection, all the interviews were conducted in Kiswahili before the transcripts were translated into English.

Data analysis

After data collection, the audio was transcribed using the original interview language, Kiswahili. The transcriptions were performed in MAXQDA 2022, a software package for both qualitative data analysis and mixed-methods research.

A preliminary codebook was then developed based on both theory-driven and data-driven codes. The sense of ownership theme that emerged during data collection was then coded using the coding framework presented in Table 1 to assess its role in rural community mini-grid management. The second round of coding was conducted to capture all aspects and mechanisms of the themes related to a sense of ownership. Finally, the third round of coding was further conducted to assess all the transcripts and ensure that they were well captured by the resulting codebook.

To analyse the research findings, the coding framework for the SO indicators presented in Table 1 was developed based on the above expressions.

Possessive pronouns for mini-grids were derived from [12, 25, 26] by the use of 'our and their' [12, 25] combined with words such as projects or containers that are directly connected to mini-grids as targets. The sense of ownership indicators were further broken down into possessive expressions for people connected with mini-grids such as the VEC, technicians and electricity users. Apart from the person–object relationship as an expression of a sense of ownership, [25] acknowledged how a sense of ownership can also be expressed in connection with nonphysical entities such as people. Since feelings of possessiveness can be demonstrated either positively or negatively towards the target [12, 36], negative and positive possessive expressions towards mini-grids were subjected to further analysis to measure the sense of ownership and make the results more robust.

Use of the words 'my, mine, our, or their' without being attached to mini-grids' elements was ignored and

Table 1 Sense of ownership coding framework. Source: Author

Indicators	Description	Keywords	
		Kiswahili	English
Possessive expressions towards mini-grid	Use of possessive words towards mini-grid as a target and its maintenance fund that is used for mini-grid operations and maintenance	Umeme wetu	Our electricity
		Mradi wetu	Our project
		Mtambo wetu	Our plant
		Mali yao	Their asset (i.e. mini-grid)
		Akaunti/Hela yetu	Our account/money
		Mfuko wetu	Our fund
Possessive expressions towards people	Use of possessive words towards people connected to mini-grid such as VEC, users and technician(s)	Fundi/mafundi wetu	Our technician(s)
Negative possessive expressions	Demonstration of negative expressions towards ownership of mini-grid	Umeme wa bure, hatutakiwi kuulipia	It is free electricity; we do not need to pay for it
		Umeme tumeletewa na wazungu	Electricity was brought by whites/foreigners
		Hatukuomba mradi uje	We did not ask for the project to come
Positive possessive expressions	Demonstration of positive expressions towards ownership of mini-grid	Hatujakabidhiwa mradi rasmi lakini tunajua ni wa kwetu	We have not been officially handed over the project, but we know it is ours
		Tunaupenda umeme/mradi wetu	We love our electricity/project
		Lazima tuulinde mradi wetu	We must protect our project

considered to lack a sense of ownership. In addition, words such as "mini-grid plant", "project", or "container", without the attachment of possessive expressions listed earlier, were considered to lack ownership. The third and fourth columns in Table 1 present keywords of possessive pronoun expressions indicating a sense of ownership, both in the original interview language, Kiswahili, and in the language of translation, English. The last indicator is a composite of several expressions geared towards mini-grid management and sustainability.

To determine the factors affecting electricity users' sense of ownership, this study assessed the co-occurrence and relationship between a sense of ownership and its routes (investing the self in the mini-grid, controlling ownership of the mini-grid and having intimate knowledge about the mini-grid). Visual mapping of the relationship between a sense of ownership and its routes was also performed (see Fig. 3).

It becomes evident that the sense of ownership is affected differently by its routes. Resource mobilisation, frequency of meetings, and decision-making appeared most frequently in connection with the sense of ownership indicated by "our, mine, theirs, my". This implies a strong relationship among these variables. A low sense of ownership indicated by "negative possessiveness" is highly related to initial investment (12 interview documents) followed by "resource mobilisation". It is also evident that "positive possessiveness" intersects with the indicator "ours, mine, theirs, my" in describing the concept of a sense of ownership.

Interview transcripts from both VECs and household users were thus thoroughly reviewed to identify any significant connections among them. The approach to measuring a sense of ownership in this study employed few of the measurement items of sense of ownership available in the literature. Nevertheless, the study managed to extract in-depth insights from the data.

Results

Sense of ownership for Leganga and Silale mini-grids

Given the similar setup of the Leganga and Silale mini-grids (Fig. 2), the sense of ownership was first examined to determine whether the results were also similar. Surprisingly, the sense of ownership differed between

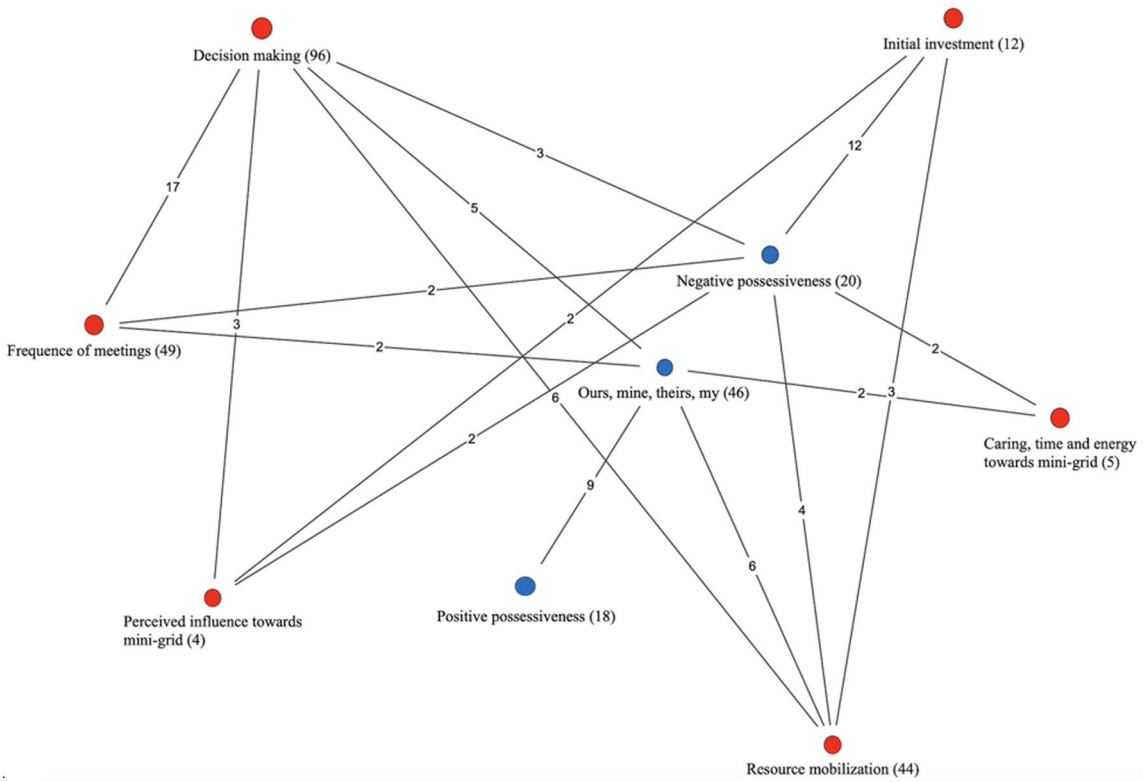

Fig. 3 Relationship between sense of ownership and its routes. The numbers next to the nodes represent frequencies for the respective codes, while the numbers next to the lines represent the number of interview documents mentioning both connected concepts. For example, 46 is the number of times "ours, mine, theirs, my" was used as an indicator for sense of ownership, while five interview documents refer to "decision-making" and "our, mine, theirs, my" together. The blue nodes represent ownership indicators, and the red nodes represent the routes (Source: Author)

the two mini-grids. According to the indicators for a sense of ownership in Table 1, Silale had a greater sense of ownership than Leganga. More interviewees at Silale demonstrated both possessive expressions and positive expressions towards mini-grids and people related to mini-grids.

Most respondents at Silale reported a strong sense of ownership towards the mini-grid project by expressing how they treat it as theirs, even without an official transfer of ownership to them by the government: "Not officially handed over. We know the project belongs to us […]" (Interviewee 4).

Through possessive expressions, a sense of ownership emerged not only for the mini-grid, but also for the technicians and the tariffs collected. Some energy committee members interviewed for both mini-grids treated electricity users as 'their' customers. Participants in both Silale and Leganga shared the following views:

> *"…in case the electricity is off for 'our' customer, we call them [technicians], after calling them they would come. They would go to the customer to determine if there is any equipment damaged [...]" (Interviewee 17).*
> *"…therefore, as a committee, we observed and said, let us balance bills for 'our' customers so that… since problems had already begun during collection because of high tariff rates […]" (Interviewee 5)*

A low sense of ownership for the Leganga mini-grid is reflected in its users' more negative possessive expressions and less positive possessive expressions. Most respondents claimed that foreigners—donors—had introduced the project for free power distribution; hence, there was no need to pay tariffs to manage it or be disconnected from it: "*… And we were told when this project was brought, we have been told that this is a free project […]*" (Interviewee 11).

> *"…people started saying, electricity was just brought to us […]" (Interviewee 14)*
> *"…another person says, the whites brought me the electricity, therefore I should not be disconnected […]" (Interviewee 12)*

Such statements demonstrate a negative sense of belonging attached to the project by most of the users in Leganga. This analysis revealed that the sense of ownership for Silale mini-grid users was greater than that for Leganga mini-grid users. The analytical status of a sense of ownership between these cases is a foundation for answering the research questions raised in this study.

Factors affecting community mini-grids' sense of ownership

Given the different sense of ownership status between the two cases, this section answers research question (1) by utilising the analytical framework presented in Fig. 1. The absence of initial investment through tariff payments emerged as the strongest factor causing a low sense of ownership among electricity users at Leganga. Unlike at Silale, electricity users at Leganga consumed electricity freely almost 7 months after the project started. When the time came for them to start paying tariffs, a significant number declined, asserting that electricity is to be consumed without charges: *"…Technicians are disconnecting the electricity, when they tell you it is because you don't pay tariffs, the reply is I am not paying for a free electricity […]"* (Interviewee 11).

Not paying tariffs from the beginning of the project emerged as a challenge to revenue collection later on, and users felt offended when instructed to pay for electricity: *"… the biggest challenge was in tariff collection. People used to say that the electricity was just freely brought to us […]"* (Interviewee 14).

These statements indicate that the low sense of ownership towards the Leganga mini-grid was strongly affected by the absence of initial monetary investment in the mini-grid through tariff payments.

Perceptions of users having influence on mini-grids from the initial preparation and design phase are found to affect the sense of ownership in both cases. It is worth mentioning that households connected to both projects were already under a map designed by the Ministry of Energy and Mineral in collaboration with the Elector Merl Company. This prearrangement ignored the autonomy of selected households to accept or reject the project. These households are more likely to have a low sense of ownership towards the project because they have had little control of the mini-grid since its inception. In this regard, Interviewee 7 said:

> *"…this electricity is connected to few houses…first-of-all, the first time they came, there were other people who were connected and did not see its importance, and they are the ones who caused problems in paying tariffs. However, only if they came because they came with a map, which was designed to connect just a small village piece. So in that piece, there were others who were in that map who were not even in need of it, but they were connected. However, there were others who were highly in need of being connected, and they were left out of the map, you see".*

This indicates the limited influence of users on mini-grids, as their consent to access electricity connections was not investigated from the beginning. It may seem an excuse to avoid paying tariffs, but it reflects users' perceptions of the project—feelings of having no influence over certain aspects of mini-grid management—which consequently affects their sense of ownership.

The ability of electricity users to influence decision-making pertaining to mini-grids also affects their sense of ownership because it makes them feel that they control the mini-grid. Mini-grid users at both Leganga and Silale participated in different decision-making processes, for instance, adjusting tariff amounts and selecting energy committee members. However, some decisions at the Silale Mini-grid were approved by all users via village quarterly meetings after proposals from the VEC and village council. Such decisions included expenditures on maintenance matters and expenditures for non-electricity village matters. The VEC and village council at Silale exhibited greater autonomy in dealing with defiant electricity users who defaulted to pay tariffs. Interviewee 5 explained:

> *"Challenges were being resolved, for example, bill collection emerged to be a major challenge, so when you meet with a long-term stubborn electricity beneficiary, and you called him and you talked to him and he still seems unwilling to pay the electricity bill…therefore the challenge was normally resolved, for example you can call him, you talk to him as a committee. If you are not successful with such people, then you forwards the information to village council leaders. The village government will make a statement and talk to him on how to solve that problem and agree on the date that he will pay the debt. If he fails, the electricity will be disconnected, but he must pay the money."*

At Leganga, meetings on mini-grid matters were infrequently held, and rule breakers were rarely punished. VECs, together with village councils, were reluctant to take action against rule breakers. Generally, participation in decision-making on management and technical and financial mini-grid matters was greater at Silale than at Leganga, which contributed to the greater sense of ownership at Silale than at Leganga.

Another factor affecting the sense of ownership among mini-grid users is the knowledge they have about their technicians and donors, along with establishing connections with the project through electricity consumption and tariff payments. Users in both mini-grids clearly understood mini-grid funding sources, the existing revenue collection model, and whom to consult when the mini-grids malfunctioned. This level of knowledge and association with mini-grids fostered a sense of ownership among mini-grid users.

Mini-grid phases and sense of ownership

As previously explained, the mini-grid lifecycle undergoes different phases. To answer research question (2), this section examines the crucial phase for fostering a sense of ownership among electricity users in CBM. Most interviewees lived in the respective villages during the preparation and design phase for both mini-grids and clearly remembered what occurred at that time. As mentioned earlier, households connected to the mini-grids in both cases were already on the planned map designed by the Ministry of Energy, which collaborated with the Elektro Merl Company. In this context, users asserted that they were not engaged in the initial planning of the projects, as they were not consulted about their preference for the projects. Based on this, the obligation to pay for electricity consumed is deemed irrelevant to users:

> *"... they said they have a map, yes they said they have a map of which they came to put those electricity poles and those people to get electricity, those 64 houses. However, it is not that asked to be connected, no… Therefore, people said, since it is a trial project, let us just be connected. However, later they it came to be associated with payment […]". (Interviewee 16)*

During this phase, the sense of ownership among users was likely to decline despite their participation in other ways, such as providing their land for mini-grid construction.

In the implementation phase, electricity users at both Leganga and Silale offered their labour for construction and participated in protecting mini-grids against any jeopardising circumstances and at different levels of decision-making. (Interviewee 5):

> *"…for example, the project that we are given is a solar project, so it needs to be taken care of. We do not want to see someone, for instance, walking with a catapult, eeh shooting birds from the streets, around the mini-grid area. If we see such a person, we warn him, and if he is a troublemaker, we handle him in accordance with the rules because 'our' projects are solar power. Therefore, such solar projects need be handled with care […]".*

Such community participation during the implementation phase appears to be related to a sense of ownership, as users are directly associated with the mini-grid. In this phase, users in Leganga paid no tariff in the first 7 months, which was previously found to have weakened the sense of ownership towards the project.

After the mini-grid operated for a particular period, mini-grid users tend to realise the socioeconomic impacts. For example, more children could study at night, the number of electricity-consuming businesses increased, and village dispensaries were equipped with reliable services such as vaccine storage facilities. At Leganga, for instance, the sense of ownership was already low during the first and second phases and continued to diminish during the monitoring and evaluation phase until the mini-grid ceased operation in 2018, despite harnessing mini-grid benefits. In contrast, Silale had a greater sense of ownership than Leganga did in the first and second phases; the sense of ownership even increased during the M&E phase. Some interviewees appreciated the benefits of the mini-grid and insisted they were willing to do everything in their power to make it survive even longer.

Sense of ownership and mini-grid management

A sense of ownership among VEC members of mini-grids is also found to increase the sense of ownership among other electricity users; hence, (un)sustainable mini-grid management depends on the type of effect. Participation in decision-making among normal electricity users, the VEC, and local village leaders helped promote a sense of ownership of mini-grid management. Mini-grid decision-making included VEC election, tariff adjustments, mini-grid repair and maintenance, revenue management for O&M, and disciplinary action(s) for refractory electricity users. Leganga, for instance, rarely conducted meetings, and VEC elections were based on "blood brotherhood" rather than individual leadership capability. Interviewee 11 explained this as follows:

> *"As for me, I can select the one I know is more capable, but another person may elect relatives because they are relatives. He may do that just because they are relative but not because of his capabilities".*

Moreover, the study revealed that VEC motivation to mobilise resources for O&M at Leganga was negatively affected by users' disruptive behaviours. Users used threats and rude responses when VECs were collecting tariffs to prevent them from fulfilling their obligations. However, no punitive action was taken against such disorderly energy users. Implicitly, community mini-grid management can be negatively affected by both users and leaders. As a countermeasure, strong leadership and collaboration between users and VECs can create a greater sense of ownership and, consequently, smoother mini-grid management.

In contrast, Silale had three rounds of VEC leadership, and elements of "blood brotherhood" elections (based on nepotism) were somewhat subdued. In addition to tariff adjustment and VEC elections, decision-making among users at Silale was greater in terms of overall mini-grid management than at Leganga. Indeed, the higher users' participation in decision-making was notable as a stimulus of the sense of ownership at Silale. Interviewee 4 said:

> *"...and later they realised that this project is real 'our' property because the money collected is not going to be taken by anyone, the government, or the company; they manage the revenues and expenditure by themselves; they dawned on them that it is 'their' property".*

Regarding technical management matters, the VEC at Silale, which collaborates with village councils, usually consulted technicians with queries on the mini-grid system and proceeded to solve the problem without involving the normal users. Normal users usually become involved in decision-making for monetary resource mobilisation, particularly fundraising, during an emergency amidst a mini-grid failure requiring contingency measures. Specifically, they would raise funds to help technicians reach the mini-grid site and buy the required spare parts or equipment.

The sense of ownership in mini-grid management among users in this study is also found to be connected to the sense of ownership among VEC members. The evidence shows that VEC members with strong decision-making and resource mobilisation skills in Silale exhibited a high sense of ownership. This positively affected the sense of ownership of normal users compared to their VEC counterparts at Leganga. As normal electricity users admitted, strong leadership skills among VEC members in managing the mini-grid are among the factors that contributed to mini-grid survival. One user explained,

> *"The current committee is good, as there are some die-hard defaulters who insist on using powers [from the mini-grid] but do not want to pay the tariff. The committee usually disconnects such users from the power supply. You may find that the committee is working for our development. How can you consume such service without paying for it? Who will run this project if not ourselves!" (Interviewee 8).*

Some VEC members at Silale also acquired some technical skills from the mini-grid technician who helped address user electricity needs. As Interviewee 7 noted,

> *"...in the first phase, we depended on the technician to do everything. However, now we are lucky that we have elected young people unlike at the beginning where we elected the elderly ... right now the elected*

VEC has been taught by the technician some stuff and they can even climb the electricity poles in case of a problem. The technician will give them instructions on what to do, but not inside the container, only outside. For instance, when there is someone with an electricity problem in his or her house, a technician can instruct the VEC to check the problem. Some other problems can be solved without the technician paying them physical visits."

Evidently, the sense of ownership among VEC members at Silale increased the sense of ownership among normal users and made mini-grids more manageable and sustainable. In contrast, at Leganga, the VECs were on the receiving end for failing to serve as role models for normal users; instead, they failed to pay tariffs and did not punish defaulters. Consequently, there was also a low sense of ownership among normal users. One of the normal users said:

"At first, the committee collected tariffs without any problems. It later became a problem when tariff collectors started saying that they would not pay tariffs. Now, if the collector says that he or she is not going to pay when he or she should be leading as an example, how will I pay?"

Overall, this incident illustrates the low sense of ownership among VECs, which further translated into poor mini-grid management at Leganga.

Generally, the relationship between a sense of ownership and CBM management is explained by the factors described in Fig. 1 and analysed in the results. In turn, these factors lead to a sense of ownership among users and are also found to affect management, as Fig. 4 illustrates.

The results revealed that the more multiple factors were prevalent, the stronger the sense of ownership among users and the better the management of community-based mini-grids and vice versa. The Silale mini-grid exhibited more factors that led its users to develop a stronger sense of ownership and better management and sustainability than did the Leganga mini-grid. A

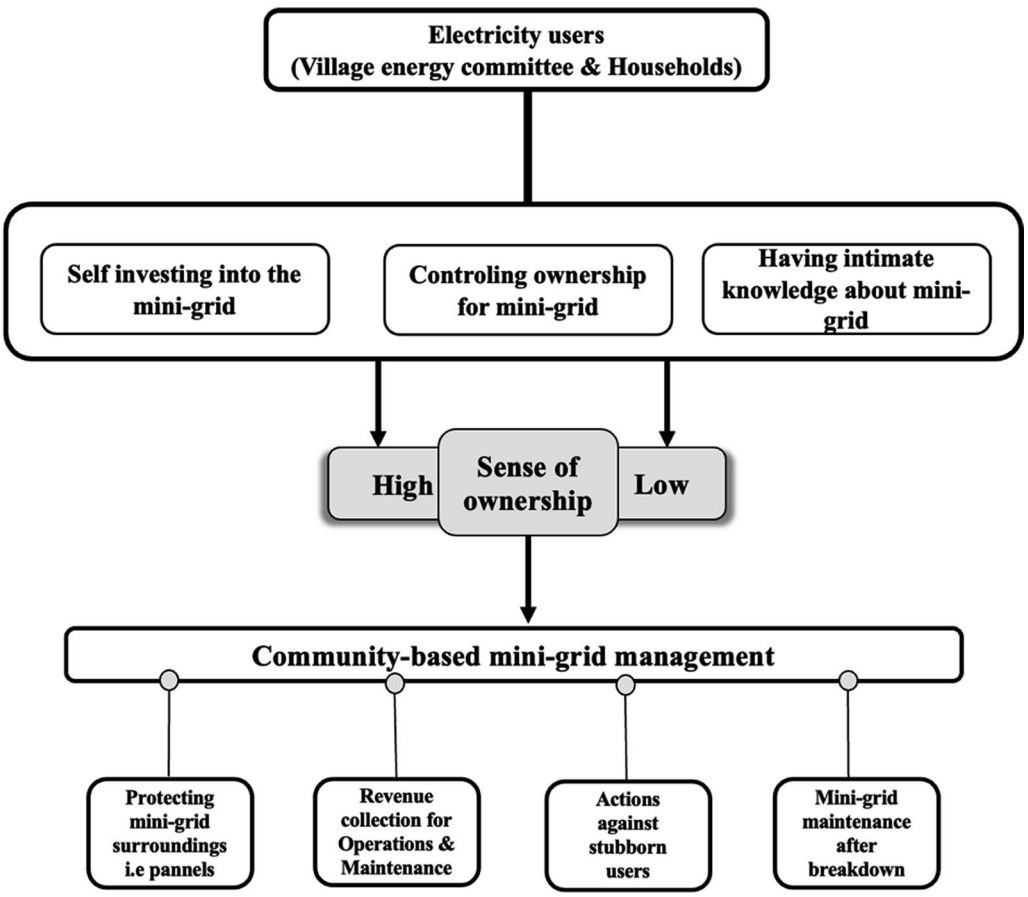

Fig. 4 Relationship between sense of ownership among electricity users and rural community mini-grid management (Source: Author)

greater sense of ownership positively affects overall CBM management. Thus, with good mini-grid management, the successful collection of tariffs for mini-grid operation and maintenance (O&M), the implementation of punitive actions against defaulters in accordance with the set rules, the use of mini-grids in the event of failure through repairs and maintenance, and the good protection of mini-grids by all the users.

Discussion

This paper explores the role of the sense of ownership in community-based mini-grid management in Dodoma, Tanzania. Understanding the factors affecting the sense of ownership among mini-grid users and mini-grid phases in which a sense of ownership arises is important for this study. The findings of this study showed that a sense of ownership exists for a mini-grid as an ownership target, for its users, and for accounting management elements such as tariffs. This finding implicitly shows that a sense of ownership is not only about feelings directly towards mini-grids (objects), but also indirectly through the people related to the mini-grids [25]. It is also evident from this study that the sense of ownership for community mini-grids soars even when the projects are not officially transferred to the community or when users are not legal owners of the mini-grid [11].

By analysing the factors affecting the sense of ownership among community mini-grid users, this study revealed that tariff payments from the beginning of community mini-grid projects are essential for stimulating a sense of ownership and for later smooth mini-grid management even in the absence of capital contributions from community members. Even though tariffs may constitute payments for a product (i.e. electricity service), they are far more a form of self-investment for electricity users [22]. Initial tariff payments further instil a greater sense of ownership by allowing users to intimately understand that tariff management matters in addition to accommodating their efforts in mini-grid survival [22, 25]. Self-investing in the target in terms of offering time, energy, and care towards the target [25] was practised in both mini-grids, as community members freely volunteered their time by cleaning panels and areas surrounding the mini-grids, protecting panels from kids throwing stones and providing lands where mini-grids were installed. However, the initial monetary investment emerged as a fundamental factor affecting the sense of ownership of community mini-grid users in this study. Users reported their own contributions and efforts from the beginning and became easily attached to the mini-grid for a longer period; in contrast, the lack of initial monetary investment towards the mini-grid had the opposite effect.

Along with a lack of initial monetary investment in mini-grids, low participation in decision-making on managerial, financial, and technical matters among users was also found to negatively affect the sense of ownership and vice versa. This finding is supported by [6, 37], who also found that participatory decision-making in financial and management matters increases the sense of ownership of users of community infrastructure. Associations and sufficient knowledge of mini-grids found in both case studies also fostered a sense of ownership among users [25]. However, traveling through multiple sub-elements via multiple routes or through multiple factors by users in one mini-grid tends to affect their corresponding sense of ownership compared with that of mini-grid users with fewer factors [25]. This is observed in the analysis when sense of ownership was greater for users at the Silale mini-grid because it was more strongly affected by factors than were the users at the Leganga mini-grid.

The study findings further revealed that the sense of ownership among mini-grid users is negatively affected if community engagement in the design and preparation phase is ignored. Engaging communities by seeking their consent to be connected with projects from the early stage, for example, was found to be important in this study. Users' consent to be connected to the electricity supply creates less room for future disagreements in mini-grid management. It also stimulates a sense of ownership because users' interest in electricity connection was integral to the prerequisites and developed from the beginning. In this context, users are placed in a position to perceive ownership of the project. In [38], Shi and Yao likewise found it important for both users and development agencies to be engaged in the preparing and designing phase of different infrastructure developments, as a sense of ownership is normally created and serves as a stepping stone for smooth operations in the later phases of such projects. Community engagement during the design phase is also found to be correlated with the sustainability outcomes of projects [39].

It is further revealed that any financial commitment by users in community-managed mini-grid projects should be introduced during the preparation stage and rigorously enforced as soon as the implementation phase begins. The sense of ownership among users is also induced by their upfront payment of dues and labour and capital contributions to the project [20]. The greater the different forms of participation (monetary and non-monetary) among electricity users in the implementation phase, the stronger the sense of ownership towards the mini-grid.

Therefore, the sense of ownership in the preparation and design phase provides a strong foundation for

a stronger sense of ownership in the later stages of the mini-grid life cycle and eventually positively impacts general mini-grid management. During the M&E phase, the sense of ownership tends to become stronger if it has already existed in the previous two phases. Users become more attached to the mini-grid, exerting efforts to ensure its effective management and sustained operations. Conversely, if the sense of ownership is initially low or absent in the first and second phases, it is also likely to remain low during the M&E phase. These results reinforce claims regarding the importance of local community involvement from the initial phase [6], preparation and design to the implementation phases of community mini-grids, as involvement and experience bring people together [11] to create a strong foundation for a sense of ownership once communities are equipped with the autonomy to design their rules [6, 10, 11, 38], which in turn facilitates sustainability [10, 11].

The extant literature has associated the sense of ownership of different rural community infrastructures, such as water systems, with proper management [14], user participation [20] and sustainability [13], and with energy systems, such as community mini-grids [11] and off-grid systems [8, 9, 38]. Similarly, the current study's findings reaffirm how users' sense of ownership is related to mini-grid management through their participation in decision-making and resource mobilisation [8]. Similarly, prior research has shown that the ability of users, VECs, and village leaders to discuss and make decisions on various matters relating to their energy systems is essential for instilling ownership among users and making the management of such projects effective and successful [6]. The literature also shows that resource mobilisation through monetary contributions to community-based projects further enhances the sense of ownership [6, 37] and that strong characteristics and behaviours among VECs affect the sense of ownership of other users, which may also have an impact on the general management of different infrastructure systems [37].

Generally, there has been limited theoretical discussion on the relationship between the sense of ownership among electricity users and rural community mini-grid management. This study highlights the factors that facilitate developing a sense of ownership among community mini-grid users that, in turn, affect the management of those projects. This study revealed that this relationship exists through all psychological ownership routes, as described by [12, 25]. Individual self-esteem and self-characteristics among VEC members are found to affect their sense of ownership towards mini-grids and other mini-grids.

Conclusions

Overall, this study shows that a sense of ownership among electricity users plays a crucial role in promoting the successful management of rural community mini-grids in Tanzania. This study has developed a sense of ownership analytical framework in the community mini-grid context. This framework analyses the routes that facilitate ownership among rural mini-grid users while establishing a theoretical foundation for analysing the management of community mini-grids. The analysis shows that a sense of ownership may arise in any of the mini-grid phases; however, the earlier it develops, the better the mini-grid management in the subsequent phases. The existence of a sense of ownership in the preparation and design phase further strengthens the sense of ownership in the implementation and M&E phases. Community engagement and participation in decision-making also varyingly bolster the sense of ownership in each phase of the community mini-grid lifecycle. As such, the users' initial investment in the mini-grids by paying tariffs for O&M from the inception stage helps to develop a sense of ownership, which further engenders a sense of responsibility for mini-grid management among users. The study also shows that a high sense of ownership among VEC members has positive spillover effects on the electricity users and that strong mini-grid leadership is essential for its sustainable management. Additionally, the planning and design of community mini-grids should go hand-in-hand with obtaining user consent to connect and educate community members on selecting energy leaders who are capable of managing mini-grids.

These findings suggest that efforts to electrify rural areas in Tanzania using the CBM ownership model should focus on creating an environment that supports instilling a sense of ownership when designing and developing rural electrification programs. Policy designs should strategically include monetary contribution designs (e.g., paying tariffs), full community participation and engagement, and other drivers explored in the study to instil a sense of ownership of such projects among users, even though capital investments are commonly known to come fully from funders.

The analytical framework developed in this study stems from the qualitative exploration of two community mini-grids. Testing this analytical framework on other mini-grid ownership models and using quantitative research are important for future research. The questions for future inquiry should also comprise how different forms of community participation affect community sense of ownership for mini-grid users and analyse the drivers of sense of ownership among VEC members in managing

community mini-grids. In its aim to examine the role of a sense of ownership among electricity users in rural community mini-grid management, the study was limited by the employed measurement method of sense of ownership. While the unidimensional items utilised in this study have partially captured the wide range of sense of ownership indicators, other studies suggest that sense of ownership is a multidimensional construct. Thus, research involving multidimensional measurements of a sense of ownership is essential to address this gap.

Abbreviations

CBM	Community-based mini-grids
M&E	Monitoring and evaluation
O&M	Operations and maintenance
SDG	Sustainable Development Goal
VEC	Village energy committee

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Availability of data and materials
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Declarations

Ethics approval and consent to participate
The author declares that all ethical standards of the research have been met. Participation in the study was voluntary, and informed consent was obtained from all participants. No compensation was provided to the participants for their involvement; hence, there was no incentive to influence their participation.

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